RESEARCH CENTER

FIELD

Activity Report 2019

Section Partnerships and Cooperations

Edition: 2020-03-21

ALGORITHMICS, PROGRAMMING, SOFTWARE AND ARCHITECTURE

ANTIQUE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. AnaStaSec

Title: Static Analysis for Security Properties

Type: ANR générique 2014

Defi: Société de l'information et de la communication

Instrument: ANR grant

Duration: January 2015 - September 2019

Coordinator: Inria Paris-Rocquencourt (France)

Others partners: Airbus France (France), AMOSSYS (France), CEA LIST (France), Inria Rennes-Bretagne Atlantique (France), TrustInSoft (France)

Inria contact: Jérôme Feret

See also: http://www.di.ens.fr/ feret/anastasec/

Abstract: An emerging structure in our information processing-based society is the notion of trusted complex systems interacting via heterogeneous networks with an open, mostly untrusted world. This view characterises a wide variety of systems ranging from the information system of a company to the connected components of a private house, all of which have to be connected with the outside.

It is in particular the case for some aircraft-embedded computer systems, which communicate with the ground through untrusted communication media. Besides, the increasing demand for new capabilities, such as enhanced on-board connectivity, e.g. using mobile devices, together with the need for cost reduction, leads to more integrated and interconnected systems. For instance, modern aircrafts embed a large number of computer systems, from safety-critical cockpit avionics to passenger entertainment. Some systems meet both safety and security requirements. Despite thorough segregation of subsystems and networks, some shared communication resources raise the concern of possible intrusions.

Some techniques have been developed and still need to be investigated to ensure security and confidentiality properties of such systems. Moreover, most of them are model-based techniques operating only at architectural level and provide no guarantee on the actual implementations. However, most security incidents are due to attackers exploiting subtle implementation-level software vulnerabilities. Systems should therefore be analyzed at software level as well (i.e. source or executable code), in order to provide formal assurance that security properties indeed hold for real systems.

Because of the size of such systems, and considering that they are evolving entities, the only economically viable alternative is to perform automatic analyses. Such analyses of security and confidentiality properties have never been achieved on large-scale systems where security properties interact with other software properties, and even the mapping between high-level models of the systems and the large software base implementing them has never been done and represents a great challenge. The goal of this project is to develop the new concepts and technologies necessary to meet such a challenge.

The project ANASTASEC project will allow for the formal verification of security properties of software-intensive embedded systems, using automatic static analysis techniques at different levels of representation: models, source and binary codes. Among expected outcomes of the project will be a set of prototype tools, able to deal with realistic large systems and the elaboration of industrial security evaluation processes, based on static analysis.

9.1.2. DCore

Title: DCore - Causal Debugging for Concurrent Systems

Type: ANR générique 2018

Defi: Société de l'information et de la communication

Instrument: ANR grant

Duration: March 2019 - February 2023

Coordinator: Inria Grenoble - Rhône-Alpes (France)

Others partners: IRIF (France), Inria Paris (France)

Inria contact: Jérôme Feret

See also: https://project.inria.fr/dcore/

Abstract: As software takes over more and more functionalities in embedded and safety-critical systems, bugs may endanger the safety of human beings and of the environment, or entail heavy financial losses. In spite of the development of verification and testing techniques, debugging still plays a crucial part in the arsenal of the software developer. Unfortunately, usual debugging techniques do not scale to large concurrent and distributed systems: they fail to provide precise and efficient means to inspect and analyze large concurrent executions; they do not provide means to automatically reveal software faults that constitute actual causes for errors; and they do not provide succinct and relevant explanations linking causes (software bugs) to their effects (errors observed during execution).

The overall objective of the project is to develop a semantically well-founded, novel form of concurrent debugging, which we call "causal debugging", that aims to alleviate the deficiencies of current debugging techniques for large concurrent software systems.

Briefly, the causal debugging technology developed by the DCore project will comprise and integrate two main novel engines:

1. A reversible execution engine that allows programmers to backtrack and replay a concurrent or distributed program execution, in a way that is both precise and efficient (only the exact threads involved by a return to a target anterior or posterior program state are impacted);
2. a causal analysis engine that allows programmers to analyze concurrent executions, by asking questions of the form "what caused the violation of this program property?", and that allows for the precise and efficient investigation of past and potential program executions.

The project will build its causal debugging technology on results obtained by members of the team, as part of the past ANR project REVER, on the causal semantics of concurrent languages, and the semantics of concurrent reversible languages, as well as on recent works by members of the project on abstract interpretation, causal explanations and counterfactual causal analysis.

The project primarily targets multithreaded, multicore and multiprocessor software systems, and functional software errors, that is errors that arise in concurrent executions because of faults (bugs) in software that prevents it to meet its intended function. Distributed systems, which can be impacted by network failures and remote site failures are not an immediate target for DCore, although the technology developed by the project should constitute an important contribution towards full-fledged distributed debugging. Likewise, we do not target performance or security errors, which come with specific issues and require different levels of instrumentation, although the DCore technology should prove a key contribution in these areas as well.

9.1.3. REPAS

The project REPAS, Reliable and Privacy-Aware Software Systems via Bisimulation Metrics (coordination Catuscia Palamidessi, Inria Saclay), aims at investigating quantitative notions and tools for proving program correctness and protecting privacy, focusing on bisimulation metrics, the natural extension of bisimulation on quantitative systems. A key application is to develop mechanisms to protect the privacy of users when their location traces are collected. Partners: Inria (Comete, Focus), ENS Cachan, ENS Lyon, University of Bologna.

9.1.4. SAFTA

Title: SAFTA Static Analysis for Fault-Tolerant distributed Algorithms.

Type: ANR JCJC 2018

Duration: February 2018 - August 2022

Coordinator: Cezara Drăgoi, CR Inria

Abstract: Fault-tolerant distributed data structures are at the core distributed systems. Due to the multiple sources of non-determinism, their development is challenging. The project aims to increase the confidence we have in distributed implementations of data structures. We think that the difficulty does not only come from the algorithms but from the way we think about distributed systems. In this project we investigate partially synchronous communication-closed round based programming abstractions that reduce the number of interleavings, simplifying the reasoning about distributed systems and their proof arguments. We use partial synchrony to define reduction theorems from asynchronous semantics to partially synchronous ones, enabling the transfer of proofs from the synchronous world to the asynchronous one. Moreover, we define a domain specific language, that allows the programmer to focus on the algorithm task, it compiles into efficient asynchronous code, and it is equipped with automated verification engines.

9.1.5. TGFSYSBIO

Title: Microenvironment and cancer: regulation of TGF-β signaling

Type: Plan Cancer 2014-2019

Duration: December 2015 - September 2019

Coordinator: INSERM U1085-IRSET

Others partners: Inria Paris (France), Inria Rennes-Bretagne Atlantique (France),

Inria contact: Jérôme Feret

Abstract: Most cases of hepatocellular carcinoma (HCC) develop in cirrhosis resulting from chronic liver diseases and the Transforming Growth Factor β (TGF-β) is widely regarded as both the major pro-fibrogenic agent and a critical inducer of tumor progression and invasion. Targeting the deleterious effects of TGF-β without affecting its physiological role is the common goal of therapeutic strategies. However, identification of specific targets remains challenging because of the pleiotropic effects of TGF-β linked to the complex nature of its extracellular activation and signaling networks.

Our project proposes a systemic approach aiming at to identifying the potential targets that regulate the shift from anti- to pro-oncogenic effects of TGF-β. To that purpose, we will combine a rule-based model (Kappa language) to describe extracellular TGF-beta activation and large-scale state-transition based (Cadbiom formalism) model for TGF-β-dependent intracellular signaling pathways. The multi-scale integrated model will be enriched with a large-scale analysis of liver tissues using shotgun proteomics to characterize protein networks from tumor microenvironment whose remodeling is responsible for extracellular activation of TGF-β. The trajectories and upstream regulators of the final model will be analyzed with symbolic model checking techniques and abstract interpretation combined with causality analysis. Candidates will be classified with semantic-based approaches and symbolic bi-clustering technics. All efforts must ultimately converge to experimental validations of hypotheses and we will use our hepatic cellular models (HCC cell lines and hepatic stellate cells) to screen inhibitors on the behaviors of TGF-β signal.

The expected results are the first model of extracellular and intracellular TGF-β system that might permit to analyze the behaviors of TGF-β activity during the course of liver tumor progression and to identify new biomarkers and potential therapeutic targets.

9.1.6. VeriAMOS

Title: Verification of Abstract Machines for Operating Systems

Type: ANR générique 2018

Defi: Société de l'information et de la communication

Instrument: ANR grant

Duration: January 2019 - December 2022

Coordinator: Inria Paris (France)

Others partners: LIP6 (France), IRISA (France), UGA (France)

Inria contact: Xavier Rival

Abstract: Operating System (OS) programming is notoriously difficult and error prone. Moreover, OS bugs can have a serious impact on the functioning of computer systems. Yet, the verification of OSes is still mostly an open problem, and has only been done using user-assisted approaches that require a huge amount of human intervention. The VeriAMOS proposal relies on a novel approach to automatically and fully verifying OS services, that combines Domain Specific Languages (DSLs) and automatic static analysis. In this approach, DSLs provide language abstraction and let users express complex policies in high-level simple code. This code is later compiled into low level C code, to be executed on an abstract machine. Last, the automatic static analysis verifies structural and robustness properties on the abstract machine and generated code. We will apply this approach to the automatic, full verification of input/output schedulers for modern supports like SSDs.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

Type: IDEAS

Defi:

Instrument: ERC Proof of Concept Grant 2018

Objectif: Static Analysis for the VErification of Spreadsheets

Duration: January 2019 - June 2020

Coordinator: Inria (France)

Partner: None

Inria contact: Xavier Rival

Abstract: Spreadsheet applications (such as Microsoft Excel + VBA) are heavily used in a wide range of application domains including engineering, finance, management, statistics and health. However, they do not ensure robustness properties, thus spreadsheet errors are common and potentially costly. According to estimates, the annual cost of spreadsheet errors is around 7 billion dollars. For instance, in 2013, a series of spreadsheet errors at JPMorgan incurred 6 billion dollars trading losses. Yet, expert reports estimate about 90 % of the spreadsheets contain errors. The MemCAD ERC StG project opened the way to novel formal analysis techniques for spreadsheet applications. We propose to leverage these results into a toolbox able to safely *verify*, *optimize* and *maintain* spreadsheets, so as to reduce the likelihood of spreadsheet disasters. This toolbox will be commercialized by the startup MatrixLead.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

Xavier Rival has a long standing collaboration with Bor-Yuh Evan Chang (University of Colorado, Boulder, USA), on the abstraction of symbolic properties and of complex memory data-structures.

Xavier Rival has a long standing collaboration with Sukyoung Ryu (KAIST, Daejeon, South Korea), on the analysis of dynamic programming languages. Xavier Rival has a set up a collaboration with Hongseok Yang (KAIST, Daejeon, South Korea), on the verification of probabilistic programs such as programs built in the Pyro framework.

Xavier Rival has started a collaboration with Shinya Katsumata, Jérémy Dubut, and Ichiro Hasuo (NII, Tokyo, Japan) on the formalization of abstract domains.

Xavier Rival has been working with Kwangkeun Yi on the writing of a book that should serve as an introduction to the field of static analysis, for students and engineers.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

9.4.1.1. Internships

Marc Chevalier and Jérôme Feret have supervised the L3 internship of Jérôme Boillot (L3 at ENS Lyon).

Jérôme Feret has ksupervised the M2 internship of Yvan Sraka (M2 UPMC).

Xavier Rival has supervised M1 Internships of Guillaume Reboullet and of Luc Chabassier (M1 at DIENS).

Xavier Rival has supervised M2 Internships of Josselin Giet (MPRI at ENS) and of Vincent Rébiscoul (M2 at ENS Lyon).

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

Xavier Rival has visited KAIST and Seoul National University in November 2019.

ARIC Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR FastRelax Project

Participants: Nicolas Brisebarre, Guillaume Hanrot, Vincent Lefèvre, Jean-Michel Muller, Bruno Salvy.

FastRelax stands for “Fast and Reliable Approximation”. It is a four year ANR project (started in October 2014 and extended till September 2019). The web page of the project is http://fastrelax.gforge.inria.fr/. It is headed by B. Salvy and involves AriC as well as members of the Marelle Team (Sophia), of the Mac group (LAAS, Toulouse), of the Specfun and Toccata Teams (Saclay), as well as of the Pequan group in UVSQ and a colleague in the Plume group of LIP.

The aim of this project is to develop computer-aided proofs of numerical values, with certified and reasonably tight error bounds, without sacrificing efficiency. Applications to zero-finding, numerical quadrature or global optimization can all benefit from using our results as building blocks. We expect our work to initiate a “fast and reliable” trend in the symbolic-numeric community. This will be achieved by developing interactions between our fields, designing and implementing prototype libraries and applying our results to concrete problems originating in optimal control theory.

9.1.2. ANR ALAMBIC Project

Participants: Benoît Libert, Fabien Laguillaumie, Ida Tucker.

ALAMBIC is a four-year project (started in October 2016) focused on the applications of cryptographic primitives with homomorphic or malleability properties. The web page of the project is https://crypto.di.ens.fr/projects:alambic:description. It is headed by Damien Vergnaud (ENS Paris and CASCADE team) and, besides AriC, also involves teams from the XLIM laboratory (Université de Limoges) and the CASCADE team (ENS Paris). The main goals of the project are: (i) Leveraging the applications of malleable cryptographic primitives in the design of advanced cryptographic protocols which require computations on encrypted data; (ii) Enabling the secure delegation of expensive computations to remote servers in the cloud by using malleable cryptographic primitives; (iii) Designing more powerful zero-knowledge proof systems based on malleable cryptography.

9.1.3. RISQ Project

Participants: Chitchanok Chuengsatiansup, Rikki Amit Inder Deo, Hervé Tale Kalachi, Fabien Laguillaumie, Benoît Libert, Damien Stehlé.

RISQ (Regroupement de l’Industrie française pour la Sécurité Post – Quantique) is a BPI-DGE four-year project (started in January 2017) focused on the transfer of post-quantum cryptography from academia to industrial poducts. The web page of the project is http://risq.fr. It is headed by Secure-IC and, besides AriC, also involves teams from ANSSI (Agence Nationale de la Sécurité des Systèmes d’Information), Airbus, C& S (Communication et Systèmes), CEA (CEA-List), CryptoExperts, Gemalto, Orange, Thales Communications & Security, Paris Center for Quantum Computing, the EMSEC team of IRISA, and the Cascade and Polsys Inria teams. The outcome of this project will include an exhaustive encryption and transaction signature product line, as well as an adaptation of the TLS protocol. Hardware and software cryptographic solutions meeting these constraints in terms of security and embedded integration will also be included. Furthermore, documents guiding industrials on the integration of these post-quantum technologies into complex systems (defense, cloud, identity and payment markets) will be produced, as well as reports on the activities of standardization committees.

9.2. European Initiatives

9.2.1. PROMETHEUS Project

Participants: Fabien Laguillaumie, Benoît Libert, Octavie Paris, Damien Stehlé.

PROMETHEUS (Privacy-Preserving Systems from Advanced Cryptographic Mechanisms Using Lattices) is a 4-year European H2020 project (call H2020-DS-2016-2017, Cybersecurity PPP Cryptography, DS-06-2017) that started in January 2018. It gathers 8 academic partners (ENS de Lyon and Université de Rennes 1; CWI, Pays-Bas; IDC Herzliya, Israel; Royal Holloway University of London, United Kingdom; Universitat Politècnica de Catalunya, Spain; Ruhr-Universität Bochum, Germany; Weizmann Institute, Israel), 4 industrial partners (Orange, Thales, TNO, Scytl). The goal of this project is to develop a toolbox of privacy-preserving cryptographic algorithms and protocols (like group signatures, anonymous credentials, or digital cash systems) that resist quantum adversaries. Solutions will be mainly considered in the context of Euclidean lattices and they will be analyzed from a theoretical point of view (i.e., from a provable security aspect) and a practical angle (which covers the security of cryptographic implementations and side-channel leakages). The project is hosted by ENS de Lyon and Benoît Libert is the administrative coordinator while Orange is the scientific leader.

9.3. International Initiatives

9.3.1. Participation in Other International Programs

9.3.1.1. IFCPAR grant: "Computing on Encrypted Data: New Paradigms in Functional Encryption"

Participants: Benoît Libert, Damien Stehlé.

3-year project accepted in July 2018. Expected beginning on January 1, 2019. Benoît Libert is co-PI with Shweta Agrawal (IIT Madras, India). Budget on the French side amounts to 100k€.

Functional encryption is a paradigm that enables users to perform data mining and analysis on encrypted data. Users are provided cryptographic keys corresponding to particular functionalities which enable them to learn the output of the computation without learning anything about the input. Despite recent advances, efficient realizations of functional encryption are only available for restricted function families, which are typically represented by small-depth circuits: indeed, solutions for general functionalities are either way too inefficient for pratical use or they rely on uncertain security foundations like the existence of circuit obfuscators (or both). This project will explore constructions based on well-studied hardness assumptions and which are closer to being usable in real-life applications. To this end, we will notably consider solutions supporting other models of computation than Boolean circuits – like Turing machines – which support variable-size inputs. In the context of particular functionalities, the project will aim for more efficient realizations that satisfy stronger security notions.

9.3.1.2. Inria International Chairs

- **TUCKER Warwick**
- Department of Mathematics - Uppsala University - Sweden
- Title: Attracteur de Hénon et intégrales abéliennes liées aux 16e problème de Hilbert
- 2018 – 2022

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Ron Steinfeld, Monash University (June)
- Amin Sakzad, Monash University (June)
- Shi Bai, Florida Atlantic University (June and July)
- David Wu, University of Virginia (July)
- Olivier Bernard, Université Rennes 1 and Thalès (October and November)
- Gautier Eberhart, Université Rennes 1 (October and November)
- Federico Savasta, Università degli Studi di Catania (October)

AROMATH Project-Team

7. Partnerships and Cooperations

7.1. European Initiatives

7.1.1. FP7 & H2020 Projects

7.1.1.1. ARCADES

Program: Marie Skłodowska-Curie ETN

Project acronym: ARCADES

Project title: Algebraic Representations in Computer-Aided Design for complEx Shapes

Duration: January 2016 - December 2019

Coordinator: I.Z. Emiris (NKUA, Athens, Greece, and ATHENA Research Innovation Center)

Scientist-in-charge at Inria: L. Busé

Other partners: U. Barcelona (Spain), Inria Sophia Antipolis (France), J. Kepler University, Linz (Austria), SINTEF Institute, Oslo (Norway), U. Strathclyde, Glascow (UK), Technische U. Wien (Austria), Evolute GmBH, Vienna (Austria).

Webpage: http://arcades-network.eu/

Abstract: ARCADES aims at disrupting the traditional paradigm in Computer-Aided Design (CAD) by exploiting cutting-edge research in mathematics and algorithm design. Geometry is now a critical tool in a large number of key applications; somewhat surprisingly, however, several approaches of the CAD industry are outdated, and 3D geometry processing is becoming increasingly the weak link. This is alarming in sectors where CAD faces new challenges arising from fast point acquisition, big data, and mobile computing, but also in robotics, simulation, animation, fabrication and manufacturing, where CAD strives to address crucial societal and market needs. The challenge taken up by ARCADES is to invert the trend of CAD industry lagging behind mathematical breakthroughs and to build the next generation of CAD software based on strong foundations from algebraic geometry, differential geometry, scientific computing, and algorithm design. Our game-changing methods lead to real-time modelers for architectural geometry and visualisation, to isogeometric and design-through-analysis software for shape optimisation, and marine design and hydrodynamics, and to tools for motion design, robot kinematics, path planning, and control of machining tools.

7.1.1.2. POEMA

Program: Marie Skłodowska-Curie ITN

Project acronym: POEMA

Project title: Polynomial Optimization, Efficiency through Moments and Algebra

Duration: January 2019 - December 2022 (48 months)

Coordinator: B. Mourrain (Aromath, Inria Sophia Antipolis)

Other partners: LAAS - CNRS, Toulouse (France), Sorbonne Université, Paris (France), Centrum Wiskunde & Informatica, Amsterdam (The Netherlands), Stichting Katholieke Universiteit Brabant, Tilburd (The Netherlands), Universität Konstanz (Germany), Università degli Studi di Firenze (Italy), University of Birmingham (United Kingdom), Friedrich Alexander University Erlangen-Nuremberg (Germany), Universitet I Tromsø (Norway), ARTELYS SAS, Paris (France).

Webpage: http://poema-network.eu/

Abstract: Non-linear optimization problems are present in many real-life applications and in scientific areas such as operations research, control engineering, physics, information processing, economy, biology, etc. However, efficient computational procedures, that can provide the guaranteed global optimum, are lacking for them. The project will develop new polynomial optimization methods, combining moment relaxation procedures with computational algebraic tools to address this type of problems. Recent advances in mathematical programming have shown that the polynomial optimization problems can be approximated by sequences of Semi-Definite Programming problems. This approach provides a powerful way to compute global solutions of non-linear optimization problems and to guarantee the quality of computational results. On the other hand, advanced algebraic algorithms to compute all the solutions of polynomial systems, with efficient implementations for exact and approximate solutions, were developed in the past twenty years. The network combines the expertise of active European teams working in these two domains to address important challenges in polynomial optimization and to show the impact of this research on practical applications.

POEMA aims to train scientists at the interplay of algebra, geometry and computer science for polynomial optimization problems and to foster scientific and technological advances, stimulating interdisciplinary and intersectoriality knowledge exchange between algebraists, geometers, computer scientists and industrial actors facing real-life optimization problems.

7.1.1.3. GRAPES

Program: Marie Skłodowska-Curie ETN

Project acronym: GRAPES

Project title: Learning, Processing and Optimising Shapes

Duration: December 2019 - November 2023

Coordinator: I.Z. Emiris (NKUA, Athens, and ATHENA Research Center, Greece)

Scientist-in-charge at Inria: L. Busé

Other partners: U. Barcelona (Spain), Inria Sophia-Antipolis (France), J. Kepler University, Linz (Austria), SINTEF Institute, Oslo (Norway), U. Strathclyde, Glascow (UK), RWTH Aachen (Germany), U. Svizzera Italiana (Switzerland), U. Tor Vergata (Italy), Vilnius U. (Lithuania), Geometry-Factory SARL (France).

Webpage: http://grapes-network.eu/

Abstract: GRAPES aims at advancing the state of the art in Mathematics, Computer-Aided Design, and Machine Learning in order to promote game changing approaches for generating, optimising, and learning 3D shapes, along with a multisectoral training for young researchers. Recent advances in the above domains have solved numerous tasks concerning multimedia and 2D data. However, automation of 3D geometry processing and analysis lags severely behind, despite their importance in science, technology and everyday life, and the well-understood underlying mathematical principles. GRAPES spans the spectrum from Computational Mathematics, Numerical Analysis, and Algorithm Design, up to Geometric Modelling, Shape Optimisation, and Deep Learning. This allows the 15 PhD candidates to follow either a theoretical or an applied track and to gain knowledge from both research and innovation through a nexus of intersectoral secondments and Network-wide workshops. Horizontally, our results lead to open-source, prototype implementations, software integrated into commercial libraries as well as open benchmark datasets. These are indispensable for dissemination and training but also to promote innovation and technology transfer. Innovation relies on the active participation of SMEs, either as a beneficiary hosting an ESR or as associate partners hosting secondments. Concrete applications include simulation and fabrication, hydrodynamics and marine design, manufacturing and 3D printing, retrieval and mining, reconstruction and visualisation, urban planning and autonomous driving.

7.2. International Initiatives

7.2.1. Participation in Other International Programs

7.2.1.1. PHC Alliance

- Program: PHC Alliance
- Project title: High-order methods for computational design and data-driven engineering
- Duration: 01/2020–12/2021
- Coordinator: Angelos Mantzaflaris
- Other partners: Swansea University, UK
- Abstract: The aim of this project is to develop a mathematical framework for the integration of geometric modeling and simulation using spline-based finite elements of high degree of smoothness. High-order methods are known to provide a robust and efficient methodology to tackle complex challenges in multi-physics simulations, shape optimization, and the analysis of large-scale datasets arising in data-driven engineering and design. However, the analysis and design of high-order methods is a daunting task requiring a concurrent effort from diverse fields such as applied algebraic geometry, approximation theory and splines, topological data analysis, and computational mathematics. Our strategic vision is to create a research team combining a uniquely broad research expertise in these areas by establishing a link between the team AROMATH at Inria Sophia-Antipolis and Swansea University.

7.2.1.2. NSFC

- Program: NSFC
- Project title: "Research on theory and method of time-varying parameterization for dynamic isogeometric analysis",
- Duration: 2018-2021.
- Collaboration project with Gang Xu, Hangzhou Dianzi University, China.

7.3. International Research Visitors

7.3.1. Visits of International Scientists

Gang Xu, Hangzhou Dianzi University, China, visited AROMATH team (9 - 20 Oct.) to work on Isogeometric Analysis and Geometric Modeling.

Ibrahim Adamou, Univ. Dan Dicko Dankoulodo de Maradi, Niger, visited B. Mourrain (28 Oct. - 21 Dec.) to work on medial axes of curve arcs.

7.3.1.1. Internships

Martin Jalard (L3, Ecole normale supérieure de Rennes) for his *introduction to research* internship explored during 6 weeks (May 13th to June 21st) the application of Norton's lemma to the computation of isotypic decompositions.

7.3.2. Visits to International Teams

7.3.2.1. Research Stays Abroad

Evelyne Hubert was awarded a Simons fellowship within the program *Geometry, compatibility and structure preservation in computational differential equations*, from July to December 2019, at the Isaac Newton Institute in Cambridge (UK).

For the month of April, Evelyne Hubert was a guest professor a the University of the Arctic for *Pure Mathematics in Norway*.

Angelos Mantzaflaris visited in April the Computational Foundry, Swansea University, UK in the frame of the College of Science International Visitor Scheme.

CAIRN Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. Labex CominLabs - BBC (2016-2020)

Participants: Olivier Sentieys, Cédric Killian, Joel Ortiz Sosa.

The aim of the BBC (on-chip wireless Broadcast-Based parallel Computing) project is to evaluate the use of wireless links between cores inside chips and to define new paradigms. Using wireless communications enables broadcast capabilities for Wireless Networks on Chip (WiNoC) and new management techniques for memory hierarchy and parallelism. The key objectives concern improvement of power consumption, estimation of achievable data rates, flexibility and reconfigurability, size reduction and memory hierarchy management. In this project, CAIRN is addressing new low-power MAC (media access control) technique based on CDMA access as well as broadcast-based fast cooperation protocol designed for resource sharing (bandwidth, distributed memory, cache coherency) and parallel programming. For more details see https://bbc.cominlabs.u-bretagneloire.fr

7.2. National Initiatives

7.2.1. ANR AdequateDL

Participants: Olivier Sentieys, Silviu-Ioan Filip.

Program: ANR PRC

Project acronym: AdequateDL

Project title: Approximating Deep Learning Accelerators

Duration: Jan. 2019 - Dec. 2022

Coordinator: Cairn

Other partners: INL, CAIRN, LIRMM, CEA-LIST

The design and implementation of convolutional neural networks for deep learning is currently receiving a lot of attention from both industrials and academics. However, the computational workload involved with CNNs is often out of reach for low power embedded devices and is still very costly when run on datacenters. By relaxing the need for fully precise operations, approximate computing substantially improves performance and energy efficiency. Deep learning is very relevant in this context, since playing with the accuracy to reach adequate computations will significantly enhance performance, while keeping quality of results in a user-constrained range. AdequateDL will explore how approximations can improve performance and energy efficiency of hardware accelerators in deep-learning applications. Outcomes include a framework for accuracy exploration and the demonstration of order-of-magnitude gains in performance and energy efficiency of the proposed adequate accelerators with regards to conventional CPU/GPU computing platforms.

7.2.2. ANR RAKES

Participants: Olivier Sentieys, Cédric Killian, Joel Ortiz Sosa.

Program: ANR PRC

Project acronym: RAKES

Project title: Radio Killed an Electronic Star: speed-up parallel programming with broadcast communications based on hybrid wireless/wired network on chip

Duration: June 2019 - June 2023

Coordinator: TIMA

Other partners: TIMA, CAIRN, Lab-STICC

The efficient exploitation by software developers of multi/many-core architectures is tricky, especially when the specificities of the machine are visible to the application software. To limit the dependencies to the architecture, the generally accepted vision of the parallelism assumes a coherent shared memory and a few, either point to point or collective, synchronization primitives. However, because of the difference of speed between the processors and the main memory, fast and small dedicated hardware controlled memories containing copies of parts of the main memory (a.k.a caches) are used. Keeping these distributed copies up-to-date and synchronize the accesses to shared data, requires to distribute and share information between some may if not all the nodes. By nature, radio communications provide broadcast capabilities at negligible latency, they have thus the potential to disseminate information very quickly at the scale of a circuit and thus to be an opening for solving these issues. In the RAKES project, we intend to study how wireless communications can solve the scalability of the abovementioned problems, by using mixed wired/wireless Network on Chip. We plan to study several alternatives and to provide (a) a virtual platform for evaluation of the solutions and (b) an actual implementation of the solutions.

7.2.3. ANR Opticall^2

Participants: Olivier Sentieys, Cédric Killian, Daniel Chillet.

Program: ANR PRCE

Project acronym: Opticall^2

Project title: on-chip OPTIcal interconnect for ALL to ALL communications

Duration: Dec. 2018 - Nov. 2022

Coordinator: INL

Other partners: INL, CAIRN, C2N, CEA-LETI, Kalray

The aim of Opticall^2 is to design broadcast-enabled optical communication links in manycore architectures at wavelengths around 1.3μm. We aim to fabricate an optical broadcast link for which the optical power is equally shared by all the destinations using design techniques (different diode absorption lengths, trade-off depending on the current point in the circuit and the insertion losses). No optical switches will be used, which will allow the link latency to be minimized and will lead to deterministic communication times, which are both key features for efficient cache coherence protocols. The second main objective of Opticall^2 is to propose and design a new broadcast-aware cache coherence communication protocol allowing hundreds of computing clusters and memories to be interconnected, which is well adapted to the broadcast-enabled optical communication links. We expect better performance for the parallel execution of benchmark programs, and lower overall power consumption, specifically that due to invalidation or update messages.

7.2.4. ANR SHNOC

Participants: Cédric Killian, Daniel Chillet, Olivier Sentieys, Emmanuel Casseau.

Program: ANR JCJC (young researcher)

Project acronym: SHNOC

Project title: Scalable Hybrid Network-on-Chip

Duration: Feb. 2019 - Jan. 2022

P.I.: C. Killian, CAIRN

The goal of the SHNoC project is to tackle one of the manycore interconnect issues (scalability in terms of energy consumption and latency provided by the communication medium) by mixing emerging technologies. Technology evolution has allowed for the integration of silicon photonics and wireless on-chip communications, creating Optical and Wireless NoCs (ONoCs and WNoCs, respectively) paradigms. The recent publications highlight advantages and drawbacks for each technology: WNoCs are efficient for broadcast, ONoCs have low latency and high integrated density (throughput/cm^2) but are inefficient in multicast, while ENoCs are still the most efficient solution for small/average NoC size. The first contribution of this project is to study the compatibility of processes to associate the three aforementioned technologies and to define an hybrid topology of the interconnection architecture. This exploration will determine the number of antennas for the WNoC, the amount of embedded lasers sources for the ONoC and the routers architecture for the ENoC. The second main contribution is to provide quality of service of communication by determining, at run-time, the best path among the three NoCs with respect to a target, e.g. minimizing the latency or energy. We expect to demonstrate that the three technologies are more efficient when jointly used and combined, with respect to traffic characteristics between cores and quality of service targeted.

7.2.5. IPL ZEP

Participants: Davide Pala, Olivier Sentieys.

Program: Inria Project Lab

Project acronym: ZEP

Project title: Zero-Power Computing Systems

Duration: Oct. 2017 - Nov. 2020

Coordinator: Inria Socrate

Other partners: Pacap, Cairn, Corse, CEA-LETI

The ZEP project addresses the issue of designing tiny, batteryless, computing objects harvesting energy in the environment. The main application target is Internet of Things (IoT) where small communicating objects will be composed of this computing part associated to a low-power wake-up radio system. The energy level harvested being very low, very frequent energy shortages are expected, which makes the systems following the paradigm of Intermittently-Powered Systems. In order for the system to maintain a consistent state, it will be based on a new architecture embedding non-volatile memory (NVRAM). The major outcomes of the project will be a prototype harvesting board including NVRAM and the design of a new non-volatile processor (NVP) associated with its optimizing compiler and operating system. Cairn is focusing on the microarchitecture of the NVP and on new strategies for backup and restore data and processor state. The ZEP project gathers four Inria teams that have a scientific background in architecture, compilation, operating system and low power together with the CEA Grenoble. Another important goal of the project is to structure the research and innovation that should occur within Inria to prepare the important technological shift brought by NVRAM technologies.

7.2.6. DGA RAPID - FLODAM (2017–2021)

Participants: Joseph Paturel, Simon Rokicki, Olivier Sentieys, Angeliki Kritikakou.

FLODAM is an industrial research project for methodologies and tools dedicated to the hardening of embedded multi-core processor architectures. The goal is to: 1) evaluate the impact of the natural or artificial environments on the resistance of the system components to faults based on models that reflect the reality of the system environment, 2) the exploration of architecture solutions to make the multi-core architectures fault tolerant to transient or permanent faults, and 3) test and evaluate the proposed fault tolerant architecture solutions and compare the results under different scenarios provided by the fault models. For more details see https://flodam.fr

7.3. European Initiatives

7.3.1. H2020 ARGO

Participants: Steven Derrien, Angeliki Kritikakou, Olivier Sentieys.

Program: H2020-ICT-04-2015

Project acronym: ARGO

Project title: WCET-Aware Parallelization of Model-Based Applications for Heterogeneous Parallel Systems

Duration: Feb. 2016 - Feb. 2019

Coordinator: KIT

Other partners: KIT (Germany), UR1/Inria/CAIRN, Recore Systems (Netherlands), TEI-WG (Greece), Scilab Ent. (France), Absint (Ger.), DLR (Ger.), Fraunhofer (Ger.)

Increasing performance and reducing cost, while maintaining safety levels and programmability are the key demands for embedded and cyber-physical systems, e.g. aerospace, automation, and automotive. For many applications, the necessary performance with low energy consumption can only be provided by customized computing platforms based on heterogeneous many-core architectures. However, their parallel programming with time-critical embedded applications suffers from a complex toolchain and programming process. ARGO will address this challenge with a holistic approach for programming heterogeneous multi- and many-core architectures using automatic parallelization of model-based real-time applications. ARGO will enhance WCET-aware automatic parallelization by a cross-layer programming approach combining automatic tool-based and user-guided parallelization to reduce the need for expertise in programming parallel heterogeneous architectures. The ARGO approach will be assessed and demonstrated by prototyping comprehensive time-critical applications from both aerospace and industrial automation domains on customized heterogeneous many-core platforms.

7.3.2. ANR International ARTEFaCT

Participants: Olivier Sentieys, Van-Phu Ha, Tomofumi Yuki.

Program: ANR International France-Switzerland

Project acronym: ARTEFaCT

Project title: AppRoximaTivE Flexible Circuits and Computing for IoT

Duration: Feb. 2016 - Dec. 2019

Coordinator: CEA

Other partners: CEA-LETI, CAIRN, EPFL

The ARTEFaCT project aims to build on the preliminary results on inexact and exact near-threshold and sub-threshold circuit design to achieve major energy consumption reductions by enabling adaptive accuracy control of applications. ARTEFaCT proposes to address, in a consistent fashion, the entire design stack, from physical hardware design, up to software application analysis, compiler optimizations, and dynamic energy management. We do believe that combining sub-near-threshold with inexact circuits on the hardware side and, in addition, extending this with intelligent and adaptive power management on the software side will produce outstanding results in terms of energy reduction, i.e., at least one order of magnitude, in IoT applications. The project will contribute along three research directions: (1) approximate, ultra low-power circuit design, (2) modeling and analysis of variable levels of computation precision in applications, and (3) accuracy-energy trade- offs in software.

7.4. International Initiatives

7.4.1. Inria International Labs

EPFL-Inria

Associate Team involved in the International Lab:

7.4.1.1. IoTA

Title: Ultra-Low Power Computing Platform for IoT leveraging Controlled Approximation

International Partner (Institution - Laboratory - Researcher):

Ecole Polytechnique Fédérale de Lausanne (Switzerland) - Prof. Christian Enz

Start year: 2017

See also: https://team.inria.fr/cairn/IOTA

Energy issues are central to the evolution of the Internet of Things (IoT), and more generally to the ICT industry. Current low-power design techniques cannot support the estimated growth in number of IoT objects and at the same time keep the energy consumption within sustainable bounds, both on the IoT node side and on cloud/edge-cloud side. This project aims to build on the preliminary results on inexact and exact sub/near-threshold circuit design to achieve major energy consumption reductions by enabling adaptive accuracy control of applications. Advanced ultra low-power hardware design methods utilize very low supply voltage, such as in near-threshold and sub-threshold designs. These emerging technologies are very promising avenues to decrease active and stand-by-power in electronic devices. To move another step forward, recently, approximate computing has become a major field of research in the past few years. IoTA proposes to address, in a consistent fashion, the entire design stack, from hardware design, up to software application analysis, compiler optimizations, and dynamic energy management. We do believe that combining sub-near-threshold with inexact circuits on the hardware side and, in addition, extending this with intelligent and adaptive power management on the software side will produce outstanding results in terms of energy reduction, i.e., at least one order of magnitude, in IoT. The main scientific challenge is twofold: (1) to add adaptive accuracy to hardware blocks built in near/sub threshold technology and (2) to provide the tools and methods to program and make efficient use of these hardware blocks for applications in the IoT domain. This entails developing approximate computing units, on one side, and methods and tools, on the other side, to rigorously explore trade-offs between accuracy and energy consumption in IoT systems. The expertise of the members of the two teams is complementary and covers all required technical knowledge necessary to reach our objectives, i.e., ultra low power hardware design (EPFL), approximate operators and functions (Inria, EPFL), formal analysis of precision in algorithms (Inria), and static and dynamic energy management (Inria, EPFL). Finally, the proof of concept will consist of results on (1) an adaptive, inexact or exact, ultra-low power microprocessor in 28 nm process and (2) a real prototype implemented in an FPGA platform combining processors and hardware accelerators. Several software use-cases relevant for the IoT domain will be considered, e.g., embedded vision, IoT sensors data fusion, to practically demonstrate the benefits of our approach.

7.4.2. Inria Associate Teams Not Involved in an Inria International Labs

7.4.2.1. IntelliVIS

Title: Design Automation for Intelligent Vision Hardware in Cyber Physical Systems

International Partner (Institution - Laboratory - Researcher):

IIT Goa (India) - Prof. Sharad Sinha

Start year: 2019

The proposed collaborative research work is focused on the design and development of artificial intelligence based embedded vision architectures for cyber physical systems (CPS). Embedded vision architectures for cyber physical systems (CPS), sometimes referred to as “Visual IoT”, are challenging to design because of primary constraints of compute resources, energy and power management. Embedded vision nodes in CPS, when designed with the application of Artificial Intelligence principles and algorithms, will turn into intelligent nodes (self-learning devices) capable of performing computation and inference at the node resulting in node-level cognition. This would allow only necessary and relevant post processed data to be sent to a human or a computer-based analyst for further processing and refinement in results. However, design and development of such nodes is non-trivial. Many existing computer vision algorithms, typically ported to embedded platforms, are compute and memory intensive thus limiting the operational time when ported to battery powered devices. In addition, transmission of captured visual data, with minimal processing at the node to extract actionable insights poses increased demands on computational, communication and energy requirements. Visual saliency i.e. extraction of key features or regions of interest in images or videos captured by an embedded vision node and related post processing for inference using AI techniques is an interesting and challenging research direction. The primary reason being that such an approach is expected to cover a wider range of application specific scenarios than statically determined approaches specific to each scenario involving remote off-loading of compute or scenario specific data on servers. Apart from a general approach to visual saliency in nodes using AI based methods (machine and deep learning methods), another principal goal of the proposed project is also to examine and propose methods that allow rapid deployment of AI techniques in these nodes. Many AI techniques are data driven and for a node to adapt from one environment or application specific scenario to another, rapid deployment of AI techniques over the air (OTA) would be an interesting and challenging research direction.

7.4.3. Inria International Partners

7.4.3.1. DARE

Title: Design space exploration Approaches for Reliable Embedded systems

International Partner (Institution - Laboratory - Researcher):

IMEC (Belgium) - Francky Catthoor, IMEC fellow

Duration: 2017 - 2021

Start year: 2017

This collaborative research focuses on methodologies to design low cost and efficient techniques for safety-critical embedded systems, which require high performance and safety implying both fault tolerance and hard real-time constraints. More precisely, the objective is to develop Design Space Exploration (DSE) methodology applicable to any platform domain to drive the design of adaptive predictable low cost and efficient error detection techniques. Run-time dynamic control mechanisms are proposed to actively optimize system fault tolerance by exploring the trade-offs between predictability, reliability, performance and energy consumption using the information received from the environment and the platform during execution. In contrast to design-time static approaches the dynamism can then be exploited to improve energy consumption and performance.

7.4.3.2. LRS

Title: Loop unRolling Stones: compiling in the polyhedral model

International Partner (Institution - Laboratory - Researcher):

Colorado State University (United States) - Department of Computer Science - Prof. Sanjay Rajopadhye

7.4.3.3. HARAMCOP

Title: Hardware accelerators modeling using constraint-based programming

International Partner (Institution - Laboratory - Researcher):

Lund University (Sweden) - Department of Computer Science - Prof. Krzysztof Kuchcinski

7.4.3.4. DeLeES

Title: Energy-efficient Deep Learning Systems for Low-cost Embedded Systems

International Partner (Institution - Laboratory - Researcher):

University of British Columbia (Vancouver, Canada) - Electrical and Computer Engineering - Prof. Guy Lemieux

Start year: 2018

This collaboration is centered around creation of deep-learning inference systems which are energy efficient and low cost. There are two design approaches: (i) an all-digital low-precision system, and (ii) mixed analog/digital low-precision system.

7.4.3.5. Informal International Partners

Dept. of Electrical and Computer Engineering, Concordia University (Canada), Optical network-on-chip, manycore architectures.

LSSI laboratory, Québec University in Trois-Rivières (Canada), Design of architectures for digital filters and mobile communications.

Department of Electrical and Computer Engineering, University of Patras (Greece), Wireless Sensor Networks, Worst-Case Execution Time, Priority Scheduling.

Karlsruhe Institute of Technology - KIT (Germany), Loop parallelization and compilation techniques for embedded multicores.

PARC Lab., the University of Auckland (New-Zealand), Fault-tolerant task scheduling onto multi-core.

Ruhr - University of Bochum - RUB (Germany), Reconfigurable architectures.

University of Science and Technology of Hanoi (Vietnam), Participation of several CAIRN's members in the Master ICT / Embedded Systems.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- Bernard Goossens, Univ. Perpignan, July 2019.
- Sharad Sinha, IIT Goa, India, July 2019.

7.5.2. Visits to International Teams

7.5.2.1. Sabbatical programme

Steven Derrien visited Colorado State University for a 6 month sabbatical from January to July 2019, where he collaborated with Sanjay Rajopadhye. This collaboration has led to two joint PhD between Université de Rennes 1 and Colorado State University which both started in late 2019.

7.5.2.2. Research Stays Abroad

- Olivier Sentieys visited Colorado State University, Computer Science Department and gave a seminar on Approximate Computing in November 2019.
- P. Dobias (PhD student) spent 5 months in the Parallel and Reconfigurable Lab. of the Electrical and Computer Engineering department, the University of Auckland, New Zealand, from November 2018 until March 2019.

CAMBIUM Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR projects

8.1.1.1. Vocal

Participants: Armaël Guéneau, Xavier Leroy, François Pottier.

The “Vocal” project (2015–2020) aims at developing the first mechanically verified library of efficient general-purpose data structures and algorithms. It is funded by *Agence Nationale de la Recherche* under its “appel à projets générique 2015”.

A first release of the library has been published in December 2018. It contains a small number of verified data structures, including resizable vectors, hash tables, priority queues, and Union-Find.

In 2019, progress was made on the definition of Gospel, a standard language for annotating OCaml programs with logical specifications, which could be understood and processed by several verification tools, including Why3 and CFML.

8.2. International Research Visitors

8.2.1. Visits of International Scientists

Jacques Garrigue (Nagoya University) is staying with our team in Paris from September 2019 to June 2020. He has long been one of the key designers and implementors of the OCaml type system. We are collaborating on the design of new language features and on a possible re-design of the type-checker implementation.

CAMUS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. ADT SPETABARU-H

Participants: Bérenger Bramas, Vincent Loechner, Paul Cardosi.

Duration: 2019 - 2021

The SPETABARU task-based runtime system is now being developed in CAMUS. This tool is the first runtime system build on the tasks and dependencies paradigm that supports speculative execution. It is at the same time a robust runtime system that could be used for high-performance applications, and the central component to perform research in parallelization, speculation and scheduling.

The SPETABARU-H project started in November 2019 for 2 years aims in improving SPETABARU on several aspects:

- Implement a generic speculative execution model based on the team's research;
- Implement the mechanisms to make SPETABARU supporting GPUs (and heterogeneous computing nodes in general);
- Split the management of the workers and the management of the graph of tasks to allow multiple independent graphs to be used on a single node;
- Use SPETABARU in the Complexes++ application, which is a bio-physic software for protein simulation;
- Maintain and update the code to keep it modern and up to date.

9.1.2. Idex Prim'Eau

Participant: Jens Gustedt [contact].

In the framework of the Prim'Eau project of the University of Strasbourg, we study surface runoff for hydrological periods of several days. We use an efficient domain decomposition method that we apply to a real world example of Mutterbach (Moselle) with geological and flood data from the years 1920, 1940 and 2017. As the time and memory usage for these computations is important, we aim to parallelize them.

9.2. National Initiatives

9.2.1. ANR AJACS

Participant: Arthur Charguéraud.

The AJACS research project is funded by the programme "Société de l'information et de la communication" of the ANR, from October 2014, until March 2019 http://ajacs.inria.fr/.

The goal of the AJACS project is to provide strong security and privacy guarantees on the client side for web application scripts implemented in JavaScript, the most widely used language for the Web. The proposal is to prove correct analyses for JavaScript programs, in particular information flow analyses that guarantee no secret information is leaked to malicious parties. The definition of sub-languages of JavaScript, with certified compilation techniques targeting them, will allow us to derive more precise analyses. Another aspect of the proposal is the design and certification of security and privacy enforcement mechanisms for web applications, including the APIs used to program real-world applications. Arthur Charguéraud focuses on the description of a formal semantics for JavaScript, and the development of tools for interactively executing programs step-by-step according to the formal semantics.

Partners: team Celtique (Inria Rennes - Bretagne Atlantique), team Prosecco (Inria Paris), team Indes (Inria Sophia Antipolis - Méditerranée), and Imperial College (London).

9.2.2. ANR Vocal

Participant: Arthur Charguéraud.

The Vocal research project is funded by the programme "Société de l'information et de la communication" of the ANR, from October 2015 until October 2020 https://vocal.lri.fr/.

The goal of the Vocal project is to develop the first formally verified library of efficient general-purpose data structures and algorithms. It targets the OCaml programming language, which allows for fairly efficient code and offers a simple programming model that eases reasoning about programs. The library will be readily available to implementers of safety-critical OCaml programs, such as Coq, Astrée, or Frama-C. It will provide the essential building blocks needed to significantly decrease the cost of developing safe software. The project intends to combine the strengths of three verification tools, namely Coq, Why3, and CFML. It will use Coq to obtain a common mathematical foundation for program specifications, as well as to verify purely functional components. It will use Why3 to verify a broad range of imperative programs with a high degree of proof automation. Finally, it will use CFML for formal reasoning about effectful higher-order functions and data structures making use of pointers and sharing.

Partners: team Gallium (Inria Paris), team DCS (Verimag), TrustInSoft, and OCamlPro.

9.3. European Initiatives

9.3.1. Collaborations with Major European Organizations

Benjamin Stamm and Muhammad Hassan: Université d'Aix-la-Chapelle RWTH, MATHCCES (Germany). An integral equation formulation of the N-body dielectricspheres problem.

Michael Wilczek and Cristian Lalescu: Max Planck Institute for Dynamics and Self-Organization (Germany). Pseudospectral direct numerical simulations (DNS) of the incompressible Navier-Stokes equations.

Juergen Koefinger: Max Planck Institute of Biophysics, Theoretical Biophysics (Germany). Monte-Carlo simulation for coarse grained protein models.

Pavel Kus: Czech Academy of Sciences, Institute of Mathematics (Tchequia). Direct solver for several matrices at a time.

9.4. International Initiatives

9.4.1. Informal International Partners

The CAMUS team has collaborated with the following entities in 2019:

- Reservoir Labs, New York, NY, USA (See subsection 7.3)
- University of Batna, Algeria (See subsection 7.16)
- Universidad Politécnica de Madrid, Spain (See subsection 7.4)
- Barcelona Supercomputing Center, Barcelona, Spain (See subsection 7.5)

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Internships

Toufik Baroudi is a PhD student under the supervision of Rachid Seghir at the University of Batna (Algeria). He is co-advised by Vincent Loechner, and has been visiting our team as an intern for one year from Nov. 2018 to Nov. 2019, founded by the Algerian *Programme National Exceptionnel (PNE)*. His PhD defense is planned at the beginning of 2020.

Raquel Lazcano is a PhD student under the supervision of Eduardo Juárez Martínez at the University of Madrid. She is also co-advised by Philippe Clauss and has been visiting our team as an intern for three months, from February to April 2019. Her PhD defense is planned at the beginning of 2020.

CARAMBA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. CPER CyberEntreprises

Program: CPER (Contrat de Plan État Région)

Project title: Cyber-Entreprises

Duration: 01/07/2015 - 31/12/2020

Coordinator: Emmanuel Thomé and Marc Jungers (CRAN)

Other partners: Inria, LORIA, CRAN, IÉCL, Centrale Supelec, LCFC.

Abstract: cf web site (in French only).

A high-performance computer cluster was funded by the CPER Cyber-entreprises project (Région Grand-Est, French Ministry of Research and Higher Education, Inria, CNRS). This cluster is also mentioned in 6.3 .

9.2. National Initiatives

9.2.1. FUI Industrial Partnership on Lightweight Cryptography

Program: FUI (Fonds Unique Interministériel)

Project acronym: PACLIDO

Project title: Protocoles et Algorithmes Cryptographiques Légers pour l'Internet Des Objets

Duration: 12/2017 - 12/2020

Coordinator: Airbus Cybersecurity

Other partners: Airbus Cybersecurity, LORIA-CNRS, Rtone, Trusted Objects, CEA, Sophia Engineering, Université de Limoges, Saint-Quentin-en-Yvelines.

This contract is dedicated to the definition of new lightweight cryptographic primitives for the IoT. See web site for a full presentation.

9.2.2. ANR Decrypt

The CARAMBA team coordinates this ANR Project (started in January 2019) with the 5 following partners: LORIA, LIRIS (Lyon), LIMOS (Clermont-Ferrand), IRISA (Rennes), TASC (Nantes). This project aims to propose a declarative language dedicated to cryptanalytic problems in symmetric key cryptography using constraint programming (CP) to simplify the representation of attacks, to improve existing attacks and to build new cryptographic primitives that withstand these attacks. We also want to compare the different tools that can be used to solve these problems: SAT and MILP where the constraints are homogeneous and CP where the heterogeneous constraints can allow a more complex treatment.

One of the challenges of this project will be to define global constraints dedicated to the case of symmetric cryptography.

Concerning constraint programming, this project will define new dedicated global constraints, will improve the underlying filtering and solution search algorithms, and will propose dedicated explanations generated automatically. This 4-year project started in January 2019. See web site for more information.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Diego Aranha from Aarhus University visited the team one week in May and presented his work on the Brazilian voting machines at the SSL seminar, and his work on fast pairing implementation at the team's seminar. As a result, some of the new secure pairing-friendly curves of [21], [22] are implemented in the C++ library RELIC [0] (free software).
- Santanu Sarkar from IIT Madras, Chennai, India is visiting the team from December 2019 to the end of February 2020.

9.3.1.1. Internships

- Hamid Boukerrou (Université Paris 8, from March 2019 until September 2019). Subject: cryptanalysis of LBlock.
- Félix Breton (ÉNS Paris, from June 2019 until July 2019). Félix Breton has formally proven in Coq the GNU MPFR subtraction routine in the case where all three operands (the two inputs and the result) have the same precision p, and $1 \leq p < w$, where w is the machine bit-size. This extends previous work done by Jianyang Pan in 2018 on the addition and multiplication routines.
- Émilien Failly (CPP Nancy, from April 2019 until June 2019). Émilien Failly studied the Multiple Polynomial General Number Field Sieve (MNFS). He compared the use of 2, 3, and 4 polynomials on three test numbers: a 60-digit number, a 70-digit number, and a 96-digit number. In each case, the sieving time was estimated, because Cado-NFS cannot currently fully deal with MNFS polynomials.
- Liwei Liu (Peking University, from June 2019 until September 2019). In the context of the computation of discrete logarithms in finite field extensions of small degree, using the Number Field Sieve, Liwei Liu worked on the individual logarithm step, in order to make it faster and more robust.
- Rémi Piau (ÉNS Rennes, from May 2019 until July 2019). Rémi Piau worked on the implementation in Python of our attack against ECDSA using wNAF representation. He was able to improve it by making it cleaner, and using small tricks to make it faster too.

[0] https://github.com/relic-toolkit/relic

CASCADE Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives with Industry

7.1.1. ANBLIC: Analysis in Blind Clouds

Program: FUI

Duration: January 2018 – December 2020

Coordinator: Wallix

Partners: UPEC, CEA, Atos, SOGETI, CoeSSI

Local coordinator: David Pointcheval

The main goal is to industrialize for the first time several privacy enhancing technologies that are on the edge of theory and practice.

Fully Homomorphic Encryption let cloud providers compute arbitrary functions on their client's encrypted data, ensuring at the same time full privacy and functionality. Functional Encryption is a refinement of classical encryption, which allows data owners to delegate fine-grained access to their data. Thus it is possible to enable the computation of aggregated statistics over your personal data, while cryptographically ensuring its confidentiality.

However both these technologies still suffer from prohibitive inefficiencies for business applications. ANBLIC's academic partners will create new cryptographic schemes and performance models, tailored for industrial use cases, and create the first real-life scenario of encrypted queries on encrypted data and on open data.

7.1.2. RISQ: Regroupement de l'Industrie française pour la Sécurité Post-Quantique

Program: GDN

Duration: February 2017 – September 2020

Coordinator: Secure-IC

Partners: ANSSI, AIRBUS, C-S, CEA LIST, CryptoExperts, Inria/ENS/CASCADE, GEMALTO, Inria POLSYS, Inria AriC, IRISA, Orange Labs, THALES, UVSQ, PCQC

Local coordinator: Michel Abdalla and Phong Nguyen since September 2019

The main goal of RISQ is to help the French Industry and Academia become a significant international player in the transition to post-quantum cryptography.

7.2. National Collaborations with Academics

7.2.1. EnBiD: Encryption for Big Data

Program: ANR JCJC

Duration: October 2014 – September 2019

PI: Hoeteck Wee

Partners: Université Paris 2, Université Limoges

The main objective of this project is to study techniques for efficient and expressive functional encryption schemes. Functional encryption is a novel paradigm for public-key encryption that enables both fine-grained access control and selective computation on encrypted data, as is necessary to protect big, complex data in the cloud.

7.2.2. EfTrEC: Efficient Transferable E-Cash

Program: ANR JCJC

Duration: October 2016 – December 2019

PI: Georg Fuchsbauer

Partners: Université Paris 2

This project deals with e-cash systems which let users transfer electronic coins between them offline. The main objectives of this project are:

- establish a clean formal model for the primitive;
- construct schemes which are practically efficient;
- develop schemes that are resistant to attacks on quantum computers.

7.2.3. SaFED: Safe and Functional Encrypted Databases

Program: ANR JCJC

Duration: October 2019 – Septembre 2023

PI: Brice Minaud

Partners: ENS, DGA

This project addresses the security of encrypted databases, with the proposal of new searchable encryption techniques and deeper security analysis.

7.2.4. ALAMBIC: AppLicAtions of MalleaBIlity in Cryptography

Program: ANR PRC

Duration: October 2016 – September 2020

PI: Damien Vergnaud

Partners: ENS Lyon, Université Limoges

The main objectives of the proposal are the following:

- Define theoretical models for “malleable” cryptographic primitives that capture strong practical attacks (in particular, in the settings of secure computation outsourcing, server-aided cryptography, cloud computing and cryptographic proof systems);
- Analyze the security and efficiency of primitives and constructions that rely on malleability;
- Conceive novel cryptographic primitives and constructions (for secure computation outsourcing, server-aided cryptography, multi-party computation, homomorphic encryption and their applications);
- Implement these new constructions in order to validate their efficiency and effective security.

7.3. European Initiatives

7.3.1. CryptoCloud: Cryptography for the Cloud

Program: FP7 ERC Advanced Grant

Duration: June 2014 – May 2020

PI: David Pointcheval

The goal of the CryptoCloud project is to develop new interactive tools to provide privacy in the Cloud.

7.3.2. SAFEcrypto: Secure Architectures of Future Emerging Cryptography

Program: H2020

Duration: January 2015 – January 2019

Coordinator: The Queen's University of Belfast

Partners: Inria/ENS (France), Emc Information Systems International (Ireland), Hw Communications (United Kingdom), The Queen's University of Belfast (United Kingdom), Ruhr-Universitaet Bochum (Germany), Thales Uk (United Kingdom), Universita della Svizzera italiana (Switzerland), IBM Research Zurich (Switzerland)

Local coordinator: Michel Abdalla

SAFEcrypto will provide a new generation of practical, robust and physically secure post quantum cryptographic solutions that ensure long-term security for future ICT systems, services and applications. Novel public-key cryptographic schemes (digital signatures, authentication, public-key encryption, identity-based encryption) will be developed using lattice problems as the source of computational hardness. The project will involve algorithmic and design optimisations, and implementations of the lattice-based cryptographic schemes addressing the cost, energy consumption, performance and physical robustness needs of resource-constrained applications, such as mobile, battery-operated devices, and of real-time applications such as network security, satellite communications and cloud. Currently a significant threat to cryptographic applications is that the devices on which they are implemented leak information, which can be used to mount attacks to recover secret information. In SAFEcrypto the first analysis and development of physical-attack resistant methodologies for lattice-based cryptographic implementations will be undertaken. Effective models for the management, storage and distribution of the keys utilised in the proposed schemes (key sizes may be in the order of kilobytes or megabytes) will also be provided. This project will deliver proof-of-concept demonstrators of the novel lattice-based public-key cryptographic schemes for three practical real-word case studies with real-time performance and low power consumption requirements. In comparison to current state-of-the-art implementations of conventional public-key cryptosystems (RSA and Elliptic Curve Cryptography (ECC)), SAFEcrypto's objective is to achieve a range of lattice-based architectures that provide comparable area costs, a 10-fold speed-up in throughput for real-time application scenarios, and a 5-fold reduction in energy consumption for low-power and embedded and mobile applications.

7.3.3. ECRYPT-NET: Advanced Cryptographic Technologies for the Internet of Things and the Cloud

Program: H2020 ITN

Duration: March 2015 – February 2019

Coordinator: KU Leuven (Belgium)

Partners: KU Leuven (Belgium), Inria/ENS (France), Ruhr-Universität Bochum (Germany), Royal Holloway, University of London (UK), University of Bristol (UK), CryptoExperts (France), NXP Semiconductors (Belgium), Technische Universiteit Eindhoven (the Netherlands)

Local coordinator: Michel Abdalla

ECRYPT-NET is a research network of six universities and two companies, as well as 7 associated companies, that intends to develop advanced cryptographic techniques for the Internet of Things and the Cloud and to create efficient and secure implementations of those techniques on a broad range of platforms.

7.3.4. aSCEND: Secure Computation on Encrypted Data

Program: H2020 ERC Starting Grant

Duration: June 2015 – May 2021

PI: Hoeteck Wee

The goals of the aSCEND project are (i) to design pairing- and lattice-based functional encryption that are more efficient and ultimately viable in practice; and (ii) to obtain a richer understanding of expressive functional encryption schemes and to push the boundaries from encrypting data to encrypting software.

7.3.5. FENTEC: Functional Encryption Technologies

Program: H2020

Duration: January 2018 – December 2020

Coordinator: ATOS Spain SA

Scientific coordinator: Michel Abdalla

Partners: Inria/ENS (France), Flensburg University (Germany), KU Leuven (Belgium), University of Helsinki (Finland), Nagra (Switzerland), XLAB (Switzerland), University of Edinburgh (United Kingdom), WALLIX (France)

Local coordinator: Michel Abdalla

Functional encryption (FE) has recently been introduced as a new paradigm of encryption systems to overcome all-or-nothing limitations of classical encryption. In an FE system the decryptor deciphers a function over the message plaintext: such functional decryptability makes it feasible to process encrypted data (e.g. on the Internet) and obtain a partial view of the message plaintext. This extra flexibility over classical encryption is a powerful enabler for many emerging security technologies (i.e. controlled access, searching and computing on encrypted data, program obfuscation...). FENTEC's mission is to make the functional encryption paradigm ready for wide-range applications, integrating it in ICT technologies as naturally as classical encryption. The primary objective is the efficient and application-oriented development of functional encryption systems. FENTEC's team of cryptographers, software and hardware experts and information technology industry partners will document functional encryption needs of specific applications and subsequently design, develop, implement and demonstrate applied use of functional cryptography. Ultimately, a functional encryption library for both SW and HW-oriented application will be documented and made public so that it may be used by European ICT entities. With it, the FENTEC team will build emerging security technologies that increase the trustworthiness of the European ICT services and products. Concretely, the FENTEC team will showcase the expressiveness and versatility of the functional encryption paradigm in 3 use cases:

- Privacy-preserving digital currency, enforcing flexible auditing models
- Anonymous data analytics enabling computation of statistics over encrypted data, protecting European Fundamental Rights of Data Protection and Privacy
- Key and content distribution with improved performance & efficiency as foundational technology for establishing secure communication among a vast number of IOT devices.

7.4. International Initiatives with Industry

7.4.1. CryptBloC: Cryptography for the Blockchain

Partners: MSR Redmond (USA), MSR Cambridge (UK), Inria

Duration: October 2017 – October 2021

PI: Georg Fuchsbauer

The goal of this Microsoft-Inria joint project on privacy and decentralization is to use cryptography to improve privacy on the blockchain and decentralized systems more generally. We will investigate means of privacy-preserving authentication, such as electronic currencies, and other applications of blockchain and distributed transparency mechanisms.

7.5. International Research Visitors

7.5.1. Professors

- Sep 1 - Oct 31, 2019: Manuel Barbosa (University of Porto)
- Jun 20 - 21, 2019: Jean Paul Degabriele (TU Darmstadt)
- Jun 20 - 30, 2019: Joël Alwen (Wickr)
- Jul 4-5, 2019: David Wu (University of Virginia)

7.5.2. PhD students

- Jun 18 - 25, 2019: Ward Beullens (KU Leuven)
- Jun 15 - Jul 1, 2019: Rotem Tsabary (Weizmann)
- June 1 - 30, 2019: Hendrik Waldner (Edinburgh)
- Jun 23 - Jul 3, 2019: Naty Peter (Ben-Gurion University)

7.6. Internships

- Apr-Sep 2019: Hugo Marival (Ecole Polytechnique) - Michel Abdalla and David Pointcheval
- Apr-Sep 2019: Thibaut Bagory (ENS Paris-Saclay - UVSQ) - Brice Minaud
- Oct-Dec 2019: Marie Euler (X - DGA) - Brice Minaud

CASH Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- Laure Gonnord's "Jeune Chercheur" ANR, CODAS, has started in January 2018 (42 months).

8.1.2. Scientific Advising

- Christophe Alias is scientific advisor (concours scientifique, 20%) for the XTREMLOGIC start-up.

8.2. International Initiatives

8.2.1. Informal International Partners

- Laure Gonnord has regular collaborations with Fernando Pereira from UFMG, Brasil (5 publications in total, last in 2017). End of 2019 they have restarted discussions with Gabriel Radanne about proving termination properties of linux kernel BPF programs. These programs must be always terminating, and we hope to be able to prove these properties in a scalable way with the termite analyser.
- In 2018 Laure Gonnord has began a collaboration with Tobias Grösser, from ETH Zurich, and in end of 2019 this collaboration has been extended to involved more people of Verimag (David Monniaux) and CASH, in the contexte of a europeean project proposal around certified polyhedral optimisation.
- In 2019, Laure Gonnord has pursued her collaboration with Sebastien Mosser, who moved from univ Nice to UQAM (Quebec, Canada). This collaboration has led to shared interns and a "inria associate team" proposal late in october 2019, which got accepted in January 2019.
- Ludovic Henrio has regular collaborations with: University of Oslo and University of Bergen in Norway (Cristal C. Din, Einar B. Johnsen, and Silvia Lizeth. Tapia Tarifa, Violet K.I. Pun); Reiner Hähnle (TU Darmstadt), Wolfgang Ahrendt (Chalmers); Kiko Fernandez-Reyes, Dave Clarke, and Tobiaas Wrigstad (Univ Uppsala); Christoph Kessler and Ahmed Rezine (Univ of Linköping).

8.3. International Research Visitors

8.3.1. Visits of International Scientists

8.3.1.1. Internships

- Amaury Maillé, M2: from Dec 2018 to Aug 2019 (6 months in total), "Dataflow explicit futures: Formalisation and/or experimentation".
- Julien Rudeau, INSA 4A, from to Apr 2019 to Aug 2019, "Ordonnancement sous contrainte de pipeline", supervised by Christophe Alias.
- Julien Philippon, EPITECH 1A, from to Jul 2019 to Dec 2019, "Compiling dataflow models to circuits", supervised by Christophe Alias and Matthieu Moy.
- Mohamed Hadjoudj, ENS Paris-Saclay 1A, from Jun 2019 to Jul 2019, "Parallélisation sous contrainte de ressources", supervised by Christophe Alias.
- Julian Bruyat, Lyon 1 M1, part-time from January 2019 to May 2019, "Outillage pour l'étude de l'impact de l'ordre des passes de LLVM", supervised by Laure Gonnord and Matthieu Moy.
- Sebastien Michelland, ENS de Lyon M1, abroad co-supervision by Laure Gonnord and Matthieu Moy with main supervision Sebastien Mosser at UQAM (Canada), from May 2019 to July 2019 "Exploration et cartographie des passes de LLVM".

CELTIQUE Project-Team

5. Partnerships and Cooperations

5.1. National Initiatives

5.1.1. The ANR Scrypt project

Participants: Frédéric Besson, Sandrine Blazy, Thomas Jensen, David Pichardie, Alexandre Dang, Remi Hutin.

Security, Secure compilation

The Scrypt project (ANR-18-CE25-0014) aims at providing secure implementations of crypto-graphic primitives using formal methods and secure compilation techniques. One specific goal is to design secure compilers which preserve the security of the source code against side-channel attacks.

This is a joint project with the Inria team MARELLE, École Polytechnique and AMOSSYS.

5.1.2. The ANR MALTHY project

Participant: David Cachera.

The MALTHY project, funded by ANR in the program INS 2013, aims at advancing the state-of-the-art in real-time and hybrid model checking by applying advanced methods and tools from linear algebra and algebraic geometry. MALTHY is coordinated by VERIMAG, involving CEA-LIST, Inria Rennes (Tamis and Celtique), Inria Saclay (MAXPLUS) and VISEO/Object Direct.

5.1.3. The ANR AJACS project

Participants: Thomas Jensen, Alan Schmitt.

The goal of the AJACS project is to provide strong security and privacy guarantees on the client side for web application scripts. To this end, we propose to define a mechanized semantics of the full JavaScript language, the most widely used language for the Web. We then propose to develop and prove correct analyses for JavaScript programs, in particular information flow analyses that guarantee no secret information is leaked to malicious parties. The definition of sub-languages of JavaScript, with certified compilation techniques targeting them, will allow us to derive more precise analyses. Finally, we propose to design and certify security and privacy enforcement mechanisms for web applications, including the APIs used to program real-world applications.

The project partners include the following Inria teams: Celtique, Indes, Prosecco, and Toccata; it also involves researchers from Imperial College as external collaborators. The project runs from December 2014 to March 2019.

5.1.4. The ANR DISCOVER project

Participants: Sandrine Blazy, David Cachera, Delphine Demange, Thomas Jensen, David Pichardie, Yon Fernandez de Retana, Thomas Rubiano, Yannick Zakowski.

The DISCOVER project project (2014–09/2019) aims at leveraging recent foundational work on formal verification and proof assistants to design, implement and verify compilation techniques used for high-level concurrent and managed programming languages. The ultimate goal of DISCOVER is to devise new formalisms and proof techniques able to scale to the mechanized correctness proof of a compiler involving a rich class of optimizations, leading to efficient and scalable applications, written in higher-level languages than those currently handled by cutting-edge verified compilers.

In the light of recent work in optimizations techniques used in production compilers of high-level languages, control-flow-graph based intermediate representations seems too rigid. Indeed, the analyses and optimizations in these compilers work on more abstract representations, where programs are represented with data and control dependencies. The most representative representation is the sea-of-nodes form, used in the Java Hotspot Server Compiler, and which is the rationale behind the highly relaxed definition of the Java memory model. DISCOVER proposes to tackle the problem of verified compilation for shared-memory concurrency with a resolute language-based approach, and to investigate the formalization of adequate program intermediate representations and associated correctness proof techniques.

The project started in October 2014 and ended on September 2019.

5.1.5. The ANR CISC project

Participants: Frédéric Besson, Thomas Jensen, Alan Schmitt.

The goal of the CISC project is to investigate multitier languages and compilers to build secure IoT applications with private communication. In particular, we aim at extending multitier platforms by a new orchestration language that we call Hiphop.js to synchronize internal and external activities of IoT applications as a whole. Our goal is to define language, semantics, attacker models, and policies for the IoT and investigate automatic implementation of privacy and security policies by multitier compilation of IoT applications. To guarantee such applications are correct, and in particular that the required security and privacy properties are achieved, we propose to certify them using the Coq proof assistant. We plan to implement the CISC results as extensions of the multitier language Hop.js (developed at Inria), based on the JavaScript language to maximize its impact. Using the new platform, we will carry out experimental studies on IoT security.

The project partners include the following Inria teams: Celtique, Collège de France, Indes, and Privatics. The project runs from April 2018 to March 2022.

5.2. European Initiatives

5.2.1. FP7 & H2020 Projects

5.2.1.1. The ERC VESTA project

Participants: David Pichardie, Sandrine Blazy, Nicolas Barré, Stefania Dumbrava, Jean-Christophe Léchenet, Rémi Hutin, Aurèle Barrière, Solène Mirliaz.

The VESTA project aims at proposing guidance and tool-support to the designers of static analysis, in order to build advanced but reliable static analysis tools. We focus on analyzing low-level softwares written in C, leveraging on the CompCert verified compiler. Verasco is a verified static analyser that analyses C programs and follows many of the advanced abstract interpretation techniques developped for Astrée. The outcome of the VESTA project will be a platform that help designing other verified advanced abstract interpreters like Verasco, without starting from a white page. We will apply this technique to develop security analyses for C programs. The platform will be open-source and will help the adoption of abstract interpretation techniques.

This a consolidator ERC awarded to David Pichardie for 5 years. The project started in September 2018.

5.2.1.2. The SPARTA cybersecurity competence network

Participants: Thomas Jensen, Frédéric Besson.

SPARTA is a novel Cybersecurity Competence Network, supported by the EU's H2020 program, with the objective to develop and implement top-tier research and innovation collaborative actions. Guided by concrete challenges forming an ambitious Cybersecurity Research & Innovation Roadmap, SPARTA will set up unique collaboration means, leading the way in building transformative capabilities and forming a world-leading Cybersecurity Competence Network across the EU. The SPARTA consortium assembles 44 actors from 14 EU Member States at the intersection of scientific excellence, technological innovation, and societal sciences in cybersecurity.

Celtique is coordinating the Inria participation in the SPARTA network. The team contributes to the programme on intelligent infrastructures with techniques for building security-enhanced systems code that respects strong information flow constraints. The team is also leading the elaboration of the SPARTA scientific roadmap, in collaboration with TU Munich.

5.2.2. Collaborations in European Programs, Except FP7 & H2020

Program:CA COST Action CA15123

Project acronym: EUTYPES

Project title: European research network on types for programming and verification

Duration: 03/2016 to 03/2020

Coordinator: Herman Geuvers (Radboud University Nijmegen, The Netherlands)

Other partners: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Macedonia, Germany, Hungary, Israel, Italy, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Sweden, United Kingdom

Abstract: Types are pervasive in programming and information technology. A type defines a formal interface between software components, allowing the automatic verification of their connections, and greatly enhancing the robustness and reliability of computations and communications. In rich dependent type theories, the full functional specification of a program can be expressed as a type. Type systems have rapidly evolved over the past years, becoming more sophisticated, capturing new aspects of the behaviour of programs and the dynamics of their execution.

This COST Action will give a strong impetus to research on type theory and its many applications in computer science, by promoting (1) the synergy between theoretical computer scientists, logicians and mathematicians to develop new foundations for type theory, for example as based on the recent development of "homotopy type theory", (2) the joint development of type theoretic tools as proof assistants and integrated programming environments, (3) the study of dependent types for programming and its deployment in software development, (4) the study of dependent types for verification and its deployment in software analysis and verification. The action will also tie together these different areas and promote cross-fertilisation.

Sandrine Blazy is Substitute Member of the Managment Committee for France.

5.3. International Initiatives

5.3.1. WEBCERT

Title: Verified Trustworthy web Applications

International Partner (Institution - Laboratory - Researcher):

Imperial College London - Department of Computing - Philippa Gardner

Duration: 2015 - 2019

Start year: 2015

See also: JSCert web page

The WebCert partnership focuses on applying formal methods to the JavaScript language: mechanized specification, development of an executable formal specification, design of a program logic, development of verification tools, and study of secure sub-languages.

CIDRE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- **Labex COMINLABS contract (2016-2019): "BigClin" - https://bigclin.cominlabs.u-bretagneloire.fr/fr**

  Health Big Data (HBD) is more than just a very large amount of data or a large number of data sources. The data collected or produced during the clinical care process can be exploited at different levels and across different domains, especially concerning questions related to clinical and translational research. To leverage these big, heterogeneous, sensitive and multi-domain clinical data, new infrastructures are arising in most of the academic hospitals, which are intended to integrate, reuse and share data for research.

  Yet, a well-known challenge for secondary use of HBD is that much of detailed patient information is embedded in narrative text, mostly stored as unstructured data. The lack of efficient Natural Language Processing (NLP) resources dedicated to clinical narratives, especially for French, leads to the development of ad-hoc NLP tools with limited targeted purposes. Moreover, the scalability and real-time issues are rarely taken into account for these possibly costly NLP tools, which make them inappropriate in real-world scenarios. Some other today's challenges when reusing Health data are still not resolved: data quality assessment for research purposes, scalability issues when integrating heterogeneous HBD or patient data privacy and data protection. These barriers are completely interwoven with unstructured data reuse and thus constitute an overall issue which must be addressed globally.

  In this project, we plan to develop distributed methods to ensure both the scalability and the online processing of these NLP/IR and data mining techniques; In a second step, we will evaluate the added value of these methods in several real clinical data and on real use-cases, including epidemilology and pharmaco-vigilance, clinical practice assessment and health care quality research, clinical trials.

8.2. National Initiatives

- **ANR Project: PAMELA (2016-2020) - https://project.inria.fr/pamela/**

  PAMELA is a collaborative ANR project involving Rennes 1 university (ASAP and CIDRE teams in Rennes), Inria Lille (MAGNET team), LIP6 (MLIA team) and two start-ups, Mediego and Snips. It aims at developing machine learning theories and algorithms in order to learn local and personalized models from data distributed over networked infrastructures. The project seeks to provide first answers to modern information systems built by interconnecting many personal devices holding private user data in the search of personalized suggestions and recommendations. More precisely, we will focus on learning in a collaborative way with the help of neighbors in a network. We aim to lay the first blocks of a scientific foundation for these new types of systems, in effect moving from graphs of data to graphs of data and learned models. CIDRE's contribution in this project involves the design of adversary models and privacy metrics suitable to the privacy-related issues of this distributed learning paradigm.

8.3. International Research Visitors

8.3.1. Research Stays Abroad

Emmanuelle Anceaume has been invited by the University of La Sapienza (Italy) from the 1st to the 30th of September 2019. During this stay, she collaborated with Profs Leonardo Querzony and Giuseppe A. Di Luna. Their collaboration gave rise to an implementation of the Replicated State Machine, which is resilient to Byzantine behaviors in asynchronous environments [18] (will appear at IPDPS in 2020).

8.4. European Initiatives

8.4.1. H2020 Projects

- **SPARTA (2019-2022) - https://www.sparta.eu/**

  SPARTA is a Cybersecurity Competence Network supported by the EU's H2020 program (Grant agreement ID: 830892) and led by CEA. This 3 years project started in February 2019. It aims to coordinate and develop the implementation of high-level research and innovation in digital security, in order to strengthen the strategic autonomy of the European Union.The CIDRE team is involved both in the workpackage 2 (SPARTA Roadmap) that aims to develop an ambitious Cybersecurity Research and Innovation Roadmap and the workpackage 6 (SPARTA Program HAII-T) that will develop a foundation for secure-by-design Intelligent infrastructures. More precisely, in the context of a task dedicated to resilience-by-design, we design an intrusion detection mechanism that combines both signature-based and anomaly-based approaches.

COMETE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. LOST2DNN

Program: DATAIA Call for Research Projects

Project title: Leakage of Sensitive Training Data from Deep Neural Networks

Duration: October 2019 - September 2022

Coordinators: Catuscia Palamidessi, Inria Saclay, EPI Comète and Pablo Piantanida, Centrale Supèlec

Other PI's and partner institutions: Georg Pichler, TU Wien, Austria

Abstract: The overall project goal is to develop a fundamental understanding with experimental validation of the information-leakage of training data from deep learning systems. More specifically, we aim at:

- Developing a compelling case study based on state-of-the-art algorithms to perform model inversion attacks, showcasing the feasibility of uncovering specified sensitive information from a trained software (model) on real data.
- Quantifying information leakage. Based on the uncovered attacks, the amount of sensitive information present in trained software will be measured or quantified. The resulting measure of leakage will serve as a basis for the analysis of attacks and for the development of robust mitigation techniques.
- Mitigating information leakage. Strategies will be explored to avoid the uncovered attacks and minimize the potential information leakage of a trained model.

8.2. National Initiatives

8.2.1. REPAS

Program: ANR Blanc

Project title: Reliable and Privacy-Aware Software Systems via Bisimulation Metrics

Duration: October 2016 - September 2021

Coordinator: Catuscia Palamidessi, Inria Saclay, EPI Comète

Other PI's and partner institutions: Ugo del Lago, Inria Sophia Antipolis (EPI Focus) and University of Bologna (Italy) Vincent Danos, ENS Paris. Filippo Bonchi, ENS Lyon

Abstract: In this project we investigate quantitative notions and tools for proving program correctness and protecting privacy. In particular, we focus on bisimulation metrics, which are the natural extension of bisimulation on quantitative systems. As a key application, we will develop a mechanism to protect the privacy of users when their location traces are collected

8.3. European Initiatives: FP7 & H2020 Projects

8.3.1. HYPATIA

Program: European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme.

Project acronym: HYPATIA

Project title: Privacy and Utility Allied

Duration: October 2019 – September 2024

Principal Investigator: Catuscia Palamidessi

Abstract: With the ever-increasing use of internet-connected devices, such as computers, smart grids, IoT appliances and GPS-enabled equipments, personal data are collected in larger and larger amounts, and then stored and manipulated for the most diverse purposes. Undeniably, the big-data technology provides enormous benefits to industry, individuals and society, ranging from improving business strategies and boosting quality of service to enhancing scientific progress. On the other hand, however, the collection and manipulation of personal data raises alarming privacy issues. Not only the experts, but also the population at large are becoming increasingly aware of the risks, due to the repeated cases of violations and leaks that keep hitting the headlines.

The objective of this project is to develop the theoretical foundations, methods and tools to protect the privacy of the individuals while letting their data to be collected and used for statistical purposes. We aim in particular at developing mechanisms that can be applied and controlled directly by the user thus avoiding the need of a trusted party, are robust with respect to combination of information from different sources, and provide an optimal trade-off between privacy and utility.

8.4. International Initiatives

8.4.1. Inria Associate Teams Not Involved in an Inria International Labs

8.4.1.1. LOGIS

Title: Logical and Formal Methods for Information Security

Inria principal investigator: Konstantinos Chatzikokolakis

International Partners:

Mitsuhiro Okada, Keio University (Japan)

Yusuke Kawamoto, AIST (Japan)

Tachio Terauchi, JAIST (Japan)

Masami Hagiya, University of Tokyo (Japan)

Start year: January 2019 - December 2021.

URL: http://www.lix.polytechnique.fr/~kostas/projects/logis/

Abstract: The project aims at integrating the logical / formal approaches to verify security protocols with (A) complexity theory and (B) information theory. The first direction aims at establishing the foundations of logical verification for security in the computational sense, with the ultimate goal of automatically finding attacks that probabilistic polynomial-time adversaries can carry out on protocols. The second direction aims at developing frameworks and techniques for evaluating and reducing information leakage caused by adaptive attackers.

8.4.2. Inria International Partners

Geoffrey Smith, Florida International University, USA

Carroll Morgan, NICTA , Australia

Annabelle McIver, Maquarie University, Australia

Mario Ferreira Alvim Junior, Assistant Professor, Federal University of Minas Gerais, Brazil

Camilo Rueda, Professor, Universidad Javeriana de Cali, Colombia

Carlos Olarte, Universidade Federal do Rio Grande do Norte, Brazil

Camilo Rocha, Associate Professor, Universidad Javeriana de Cali, Colombia

8.4.3. Participation in Other International Programs

8.4.3.1. CLASSIC

Program: Colciencias - Conv. 712.

Project acronym: CLASSIC.

Project title: Concurrency, Logic and Algebra for Social and Spatial Interactive Computation.

Duration: Oct 2016 - Oct 2019.

URL: http://goo.gl/Gv6Lij

Coordinator: Camilo Rueda, Universidad Javeriana de Cali, Colombia.

Other PI's and partner institutions: Carlos Olarte, Universidade Federal do Rio Grande do Norte, Brazil and Frank Valencia, CNRS-LIX and Inria Saclay.

Abstract: This project will advance the state of the art of domains such as mathematical logic, order theory and concurrency for reasoning about spatial and epistemic behaviour in multi-agent systems..

8.4.3.2. FACTS

Program: ECOS NORD.

Project acronym: FACTS.

Project title: Foundational Approach to Cognition in Today?s Society.

Duration: Jan 1 2019 - Dec 31, 2021.

URL: https://goo.gl/zVhg32

Coordinator: Frank Valencia, Ecole Polytechnique.

Other PI's and partner institutions: Jean-Gabriel Ganascia LIP6, Sorbonne University and Camilo Rueda, Universidad Javeriana de Cali, Colombia.

Abstract: This projects aims at studying the phenomenon of "Group Polarization"; the tendency for a group to learn or acquire beliefs or to make decisions that are more extreme than the initial inclinations of its members.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Yusuke Kawamoto, Researcher, AIST, Japan, AIST, March 2019 and Nov-Dec 2019

Takao Murakami, Researcher, AIST, Japan, AIST, March 2019

Sophia Knight, Assistant Professor, University of Minnesota, USA, May 2019

Carlos Olarte, Assistant Professor, Universidade Federal do Rio Grande do Norte, Brazil. Nov 2019

Camilo Rueda, Professor, Universidad Javeriana de Cali, Colombia. May-July 2019

Mario Ferreira Alvim Junior, Assistant Professor, Federal University of Minas Gerais, Brazil. Nov 2019

Sergio Ramirez, PhD student, Universidad Javeriana de Cali, Colombia. Oct-Dec 2019

Carlos Pinzon, Master student, Universidad Javeriana de Cali, Colombia. Nov 2019

8.5.2. Internships

Sayan Biswas, Master student, Univ. of Bath, UK. From Jun 2019 until Sep 2019

Noemie Fong, Master student, ENS Paris. Jan-Feb 2019

Federica Granese, Univ. Od Rome "La Sapienza", Italy. From Mar 2019 until Jun 2019

Boammani Lompo, ENS Rennes. From May 2019 until Jul 2019

CONVECS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. ARC6 Programme

Participants: Lina Marsso, Radu Mateescu [correspondent], Wendelin Serwe.

ARC6 is an academic research community funded by the Auvergne Rhône-Alpes region, whose objective is to foster the scientific collaborations between different academic institutions of the region working in the domain of information and communication technologies. ARC6 organizes various scientific animations (conferences, working groups, summer schools, etc.) and issues a yearly call for PhD and post-doctorate research project proposals.

Lina Marsso is supported by an ARC6 grant (from October 2016 to October 2019) on formal methods for testing networks of programmable logic controllers, under the supervision of Radu Mateescu and Wendelin Serwe (CONVECS), and Ioannis Parissis (LCIS, Valence).

9.2. National Initiatives

9.2.1. PIA (Programme d'Investissements d'Avenir)

9.2.1.1. CAPHCA

Participants: Frédéric Lang, Radu Mateescu [correspondent], Wendelin Serwe.

CAPHCA (*Critical Applications on Predictable High-Performance Computing Architectures*) is a project funded by the PIA. The project, led by IRT Saint-Exupéry (Toulouse), involves a dozen of industrial partners (among which Airbus, CS Systèmes d'Information, Synopsis, and Thalès Avionics), the University Paul Sabatier (Toulouse), and Inria Grenoble – Rhône-Alpes (CONVECS and SPADES project-teams). CAPHCA addresses the dual problem of achieving performance and determinism when using new, high performance, multicore System-on-Chip (SoC) platforms for the deployment of real-time, safety-critical applications. The methodology adopted by CAPHCA consists in building a pragmatic combination of methods, tools, design constraints and patterns deployable at a short-term horizon in the industrial domains targeted in the project.

CAPHCA started in December 2017 for four years. The main contributions of CONVECS to CAPHCA are the detection of concurrency errors in parallel applications by means of formal methods and verification techniques.

9.2.2. Competitivity Clusters

9.2.2.1. SECURIOT-2

Participants: Hubert Garavel [correspondent], Armen Inants, Radu Mateescu, Wendelin Serwe.

SECURIOT-2 is a project funded by the FUI (*Fonds Unique Interministériel*) within the *Pôle de Compétitivité* Minalogic. The project, led by Tiempo Secure (Grenoble), involves the SMEs (*Small and Medium Enterprises*) Alpwise, Archos, Sensing Labs, and Trusted Objects, the Institut Fourier and the VERIMAG laboratories of Université Grenoble Alpes, and CONVECS. SECURIOT-2 aims at developing a secure micro-controller unit (SMCU) that will bring to the IoT a high level of security, based on the techniques used for smart cards or electronic passports. The SMCU will also include an original power management scheme adequate with the low power consumption constraints of the IoT.

SECURIOT-2 started in September 2017 for three years. The main contributions of CONVECS to SECURIOT-2 are the formal modeling and verification of the asynchronous hardware implementing the secure elements developed by the project partners.

9.2.3. Other National Collaborations

We had sustained scientific relations with the following researchers:

- Xavier Etchevers (Orange Labs, Meylan),
- Fabrice Kordon and Lom Messan Hillah (LIP6, Paris),
- Eric Jenn and Viet Anh Nguyen (IRT Saint-Exupéry, Toulouse),
- Michel Le Pallec (Nokia Bell Labs, Nozay),
- Chu-Min Li (University of Picardie Jules Verne),
- Ioannis Parissis and Oum-El-Kheir Aktouf (LCIS, Valence),
- Pascal Poizat (LIP6, Paris).

9.3. European Initiatives

9.3.1. Collaborations with Major European Organizations

The CONVECS project-team is member of the FMICS (*Formal Methods for Industrial Critical Systems*) working group of ERCIM [0]. H. Garavel and R. Mateescu are members of the FMICS board, H. Garavel being in charge of dissemination actions.

9.4. International Initiatives

H. Garavel is a member of IFIP (*International Federation for Information Processing*) Technical Committee 1 (*Foundations of Computer Science*) Working Group 1.8 on Concurrency Theory chaired successively by Luca Aceto and Jos Baeten.

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

Saarland University (Germany): we collaborate on a regular basis with the DEPEND (*Dependable Systems and Software*) research group headed by Holger Hermanns, who received an ERC Advanced Grant (“POWVER”) in 2016.

9.4.2. Other International Collaborations

In 2019, we had scientific relations with several universities and institutes abroad, including:

- University of Málaga, Spain (Francisco Durán),
- University of Cali, Colombia (Camilo Rocha),
- University of Zaragoza, Spain (José Ignacio Requeno),
- ISTI/CNR, Pisa, Italy (Franco Mazzanti),
- FBK, Trento, Italy (Enrico Magnano),
- Aalto University, Finland and Northeastern University, Boston, Massachusetts (Stavros Tripakis),
- Saarland University, Germany (Holger Hermanns),
- Eindhoven University of Technology, The Netherlands (Anton Wijs and Sander de Putter),
- University of Zielona Gora, Poland (Remigiusz Wisniewski).

[0] http://fmics.inria.fr

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- H. Garavel is an invited professor at Saarland University (Germany) as a holder of the Gay-Lussac Humboldt Prize.
- Hernan Ponce de Leon (Fortiss, Munich, Germany) visited us on June 25–26, 2019. He gave a lecture entitled "*BMC with Weak Memory Models*".
- Hugues Evrard (Google, London, UK) visited us on October 21, 2019. He gave a lecture entitled "*GPU Schedulers: How Fair is Fair Enough?*".
- Karoliina Lehtinen (University of Liverpool, UK) visited us on October 23, 2019. She gave a lecture entitled "*Quasi-Polynomial Techniques for Parity Games and Other Problems*".
- Peter Csaba Ölveczky (University of Oslo, Norway) visited us on November 25, 2019. He gave a lecture entitled "*Formal Specification and Analysis of Real-Time Systems in Real-Time Maude*".

The annual CONVECS seminar was held in Villard-de-Lans (France) on July 1-3, 2019. The following invited scientists attended the seminar:

- Loïc Letondeur (Orange Labs) gave on July 2, 2019 a talk entitled "*Artificial Intelligence and Edge Computing*".
- Eric Jenn (IRT Saint-Exupéry / Thales Avionics) gave on July 3, 2019 a talk entitled "*Recent Achievements of the CAPHCA Project*".
- Viet Anh Nguyen (IRT Saint-Exupéry) gave on July 3, 2019 a talk entitled "*Using Model Checking to Identify Timing Interferences on Multicore Processors*".

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. HEAVEN Persyval Project

- Title: HEterogenous Architectures: Versatile Exploitation and programmiNg
- HEAVEN leaders: François Broquedis, Olivier Muller [TIMA lab]
- CORSE participants: François Broquedis, Frédéric Desprez, Georgios Christodoulis, Manuel Selva
- Duration: September 2015 - December 2019
- Abstract: The main objective of this project was to improve the accessibility of heterogeneous architectures comprising FPGA accelerators with portability and real experimentation in mind. The portability criterion allows application programmers to benefit from FPGA devices with only small modifications to their applications. It was achieved by extending a standard parallel programming environment already targeting heterogeneous architectures comprising CPUs and GPUs. During the project, we developed an operational prototype targeting Xilinx FPGAs. Experiments have been conducted using both matrix multiplication and Cholesky decomposition kernels. These experiments have shown the usability of the framework and its very low overhead. This framework opens the path for challenging questions regarding the scheduling of heterogeneous applications targeting FPGAs.

8.2. National Initiatives

8.2.1. IPL ZEP

- Title: Zero-Power computing systems
- Coordinator: Kevin Marquet (INRIA Socrate)
- CORSE participants: Fabrice Rastello
- Other INRIA Partners: Cairn, Pacap
- Duration: from Apr. 2017 to Sept. 2019
- Abstract: The ZEP project addresses the issue of designing tiny computing objects with no battery by combining non-volatile memory (NVRAM), energy harvesting, micro-architecture innovations, compiler optimizations, and static analysis. The main application target is Internet of Things (IoT) where small communicating objects will be composed of this computing part associated to a low-power wake-up radio system. The ZEP project gathers four Inria teams that have a scientific background in architecture, compilation, operating system and low power together with the CEA Lialp and Lisan laboratories of CEA LETI & LIST. The major outcomes of the project will be a prototype harvesting board including NVRAM and the design of a new microprocessor associated with its optimizing compiler and operating system.

8.3. International Initiatives

8.3.1. Inria Associate Teams Not Involved in an Inria International Labs

8.3.1.1. IOComplexity

Title: Automatic characterization of data movement complexity

International Partner (Institution - Laboratory - Researcher):

Ohio State University (United States). P. Sadayappan

Colorado State University (United States). Louis-Noël Pouchet

Start year: 2018

See also: https://team.inria.fr/corse/iocomplexity/

The goal of this project is to extend techniques for automatic characterization of data movement of an application to the design of performance estimation.

The EA as three main objectives: 1. broader applicability of IO complexity analysis; 2. Hardware characterization; 3. Performance model.

8.4. International Research Visitors

8.4.1. Visits to International Teams

8.4.1.1. Research Stays Abroad

- Fabrice Rastello visited the University of Utah to work with P. Sadayappan during the month of November. He worked on abstract simulation, and optimization of pattern specific programs.
- Nicolas Derumigny visited the University of Utah to work with P. Sadayappan during the month of November. He worked on abstract simulation.
- Nicolas Tollenaere visited the University of Utah to work with P. Sadayappan during the month of November. He worked on abstract simulation, and optimization of convolutions
- Theo Barollet visited the Colorado State University to work with Steve Kommrusch during the month of October. He worked on graph neural networks.
- Nicolas Tollenaere visited the university of Utah to work with P. Sadayappan during the month of August. He worked on optimizing packing and transposition of tensors.

7. Partnerships and Cooperations

7.1. Regional Initiatives

Mini course on “Sheaf Theory and Topological Data Analysis” taught by Rodrigo Cordoniu (Nice University) at Inria Sophia Antipolis — 8 weeks, 2h per week, Feb 2019 to Apr 2019.

7.2. National Initiatives

7.2.1. ANR

7.2.1.1. ANR ASPAG

Participant: Marc Glisse.

- Acronym : ASPAG.

- Type : ANR blanc.

- Title : Analysis and Probabilistic Simulations of Geometric Algorithms.

- Coordinator : Olivier Devillers (équipe Inria Gamble).

- Duration : 4 years from January 2018 to December 2021.

- Others Partners: Inria Gamble, LPSM, LABRI, Université de Rouen, IECL, Université du Littoral Côte d’Opale, Telecom ParisTech, Université Paris X (Modal’X), LAMA, Université de Poitiers, Université de Bourgogne.

- Abstract:

The analysis and processing of geometric data has become routine in a variety of human activities ranging from computer-aided design in manufacturing to the tracking of animal trajectories in ecology or geographic information systems in GPS navigation devices. Geometric algorithms and probabilistic geometric models are crucial to the treatment of all this geometric data, yet the current available knowledge is in various ways much too limited: many models are far from matching real data, and the analyses are not always relevant in practical contexts. One of the reasons for this state of affairs is that the breadth of expertise required is spread among different scientific communities (computational geometry, analysis of algorithms and stochastic geometry) that historically had very little interaction. The Aspag project brings together experts of these communities to address the problem of geometric data. We will more specifically work on the following three interdependent directions.

(1) Dependent point sets: One of the main issues of most models is the core assumption that the data points are independent and follow the same underlying distribution. Although this may be relevant in some contexts, the independence assumption is too strong for many applications.

(2) Simulation of geometric structures: The phenomena studied in (1) involve intricate random geometric structures subject to new models or constraints. A natural first step would be to build up our understanding and identify plausible conjectures through simulation. Perhaps surprisingly, the tools for an effective simulation of such complex geometric systems still need to be developed.

(3) Understanding geometric algorithms: the analysis of algorithm is an essential step in assessing the strengths and weaknesses of algorithmic principles, and is crucial to guide the choices made when designing a complex data processing pipeline. Any analysis must strike a balance between realism and tractability; the current analyses of many geometric algorithms are notoriously unrealistic. Aside from the purely scientific objectives, one of the main goals of Aspag is to bring the communities closer in the long term. As a consequence, the funding of the project is crucial to ensure that the members of the consortium will be able to interact on a very regular basis, a necessary condition for significant progress on the above challenges.

- See also: https://members.loria.fr/Olivier.Devillers/aspag/

7.3. International Research Visitors

7.3.1. Visits of International Scientists

- Arijit Ghosh, Indian Statistical Institute, Kolkata, India (September 2019)
- Ramsay Dyer Berkeley Publishing (September 2019)
- Mathijs Wintraecken, IST Austria (September and October 2019)

7.3.1.1. Internships

- Alex Delalande, Centrale-Supelec, (May-October 2019).

7.3.1.2. Research Stays Abroad

- Martin Royer, Fujitsu Laboratories, Tokyo, 2 months.

DATASPHERE Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

The team is hosted by IXXI, the Complex System Institute, at ENS Lyon, and strongly involved in the inter-disciplinary cooperation promoted by IXXI. Stéphane Grumbach is vice-director of IXXI. Kavé Salamatian is in the Executive committee of the Data Institute of Grenoble Alps Institute, and of the Cyber@Alps Institute of cybersecurity.

8.2. National Initiatives

- Chaire Castex, Ecole Militaire, Paris.
- AMNECYS (Alpine Multidisciplinary NEtwork on CYber-security Studies), University of Grenoble-Alpes.
- GEODE Research team on Geopolitics.
- Kavé Salamatian in co-leading the chair "AI and society" of the MIAI institute of University of Grenoble Alps.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

- RIHN, Research Institute on Humanity and Nature, Kyoto.
- Information School, UC Berkeley.
- ICT, Institute of Computing Technologies, Chinese Academy of Sciences, Beijing.
- CSIRO, Sydney.
- Center for CyberSecurity, University Macquarie, Sydney.
- Center for Internet Human Rights (CIHR), Berlin.
- Nippon Institute of Computing Technology, Tokyo, Japan
- Cyber Civilisation Research Center at Keio University, Tokyo, Japan

8.4. International Research Visitors

8.4.1. Visits to International Teams

8.4.1.1. Research Stays Abroad

Stéphane Grumbach has been visiting scientist at the Research Institute on Humanity and Nature, RIHN, in Kyoto for a semester in 2018/2019.

DEDUCTEAM Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Valentin Blot obtained funding for hiring Étienne Miquey as a post-doctoral researcher from Île-de-France region's DIM-RFSI (Domaine d'Intérêt Majeur - Réseau Francilien en Sciences Informatiques).

8.2. National Initiatives

The ANR PROGRAMme is an ANR for junior researcher Liesbeth Demol (CNRS, UMR 8163 STL, University Lille 3) to which G. Dowek participates. The subject is: "What is a program? Historical and Philosophical perspectives". This project aims at developing the first coherent analysis and pluralistic understanding of "program" and its implications to theory and practice.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

Frédéric Blanqui cooperates with various researchers in Japan: Makato Hamana (Gunma University), Yoji Akama (Tohoku University) and Kentaro Kikuchi (Tohoku University).

8.4. International Research Visitors

8.4.1. Visits to International Teams

8.4.1.1. Research Stays Abroad

Gilles Dowek has spent two weeks at the Institute of Software in Beijing where he has worked with Ying Jiang, Wu Peng, and Wenhui Zhang.

Gilles Dowek has spent two weeks at the University of Buenos Aires where he has worked with Alejandro Díaz-Caro.

Frédéric Blanqui has been invited for two weeks in Japan by Yoji Akama (Tohoku University) and Makato Hamana (Gunma University).

As a "Short Term Scientific Mission" financed by COST Action EUTypes, Guillaume Genestier spent five weeks in Chalmers University, Gothenburg, Sweden, to cooperate with Jesper Cockx and Andreas Abel on the translation between the proof assistant Agda and Dedukti.

GALLINETTE Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

Vercoma (Atlanstic 2020/Attractivity grant)

Goal: Verified computer mathematics.

Coordinator: A. Mahboubi.

Duration: 08/2018 - 08/2021.

7.2. National Initiatives

7.2.1. ANR

FastRelax (ANR-14-CE25-0018).

Goal: Develop computer-aided proofs of numerical values, with certified and reasonably tight error bounds, without sacrificing efficiency.

Coordinator: Bruno Salvy (Inria, ENS Lyon).

Participant: A. Mahboubi.

Duration: 2014-2019.

Website: http://fastrelax.gforge.inria.fr/.

Note: This project started when A. Mahboubi was still in the Specfun project at the Saclay Île-de-France CRI. The budget is still managed there, within the Toccata project, but remains available to A. Mahboubi.

7.3. European Initiatives

7.3.1. FP7 & H2020 Projects

7.3.1.1. CoqHoTT

Title: Coq for Homotopy Type Theory

Programm: H2020

Type: ERC

Duration: June 2015 - May 2020

Coordinator: Inria

Inria contact: Nicolas TABAREAU

Every year, software bugs cost hundreds of millions of euros to companies and administrations. Hence, software quality is a prevalent notion and interactive theorem provers based on type theory have shown their efficiency to prove correctness of important pieces of software like the C compiler of the CompCert project. One main interest of such theorem provers is the ability to extract directly the code from the proof. Unfortunately, their democratization suffers from a major drawback, the mismatch between equality in mathematics and in type theory. Thus, significant Coq developments have only been done by virtuosos playing with advanced concepts of computer science and mathematics. Recently, an extension of type theory with homotopical concepts such as univalence is gaining traction because it allows for the first time to marry together expected principles of equality. But the univalence principle has been treated so far as a new axiom which breaks one fundamental property of mechanized proofs: the ability to compute with programs that make use of this axiom. The main goal of the CoqHoTT project is to provide a new generation of proof assistants with a computational version of univalence and use them as a base to implement effective logical model transformation so that the power of the internal logic of the proof assistant needed to prove the correctness of a program can be decided and changed at compile time—according to a trade-off between efficiency and logical expressivity. Our approach is based on a radically new compilation phase technique into a core type theory to modularize the difficulty of finding a decidable type checking algorithm for homotopy type theory. The impact of the CoqHoTT project will be very strong. Even if Coq is already a success, this project will promote it as a major proof assistant, for both computer scientists and mathematicians. CoqHoTT will become an essential tool for program certification and formalization of mathematics.

Program: COST

Project acronym: EUTYPES

Project title: The European research network on types for programming and verification

Duration: 21/03/2016 - 20/03/2020.

Coordinator: Herman Geuvers (Radboud Univerity, Nijmegen, The Netherlands)

Abstract: Types are pervasive in programming and information technology. A type defines a formal interface between software components, allowing the automatic verification of their connections, and greatly enhancing the robustness and reliability of computations and communications. In rich dependent type theories, the full functional specification of a program can be expressed as a type. Type systems have rapidly evolved over the past years, becoming more sophisticated, capturing new aspects of the behaviour of programs and the dynamics of their execution.

This COST Action will give a strong impetus to research on type theory and its many applications in computer science, by promoting (1) the synergy between theoretical computer scientists, logicians and mathematicians to develop new foundations for type theory, for example as based on the recent development of "homotopy type theory", (2) the joint development of type theoretic tools as proof assistants and integrated programming environments, (3) the study of dependent types for programming and its deployment in software development, (4) the study of dependent types for verification and its deployment in software analysis and verification. The action will also tie together these different areas and promote cross-fertilisation.

Europe has a strong type theory community, ranging from foundational research to applications in programming languages, verification and theorem proving, which is in urgent need of better networking. A COST Action that crosses the borders will support the collaboration between groups and complementary expertise, and mobilise a critical mass of existing type theory research.

7.4. International Initiatives

7.4.1. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

7.4.1.1. GECO

Title: Gradual verification and robust proof Engineering for COq

International Partner (Institution - Laboratory - Researcher):

Universidad de Chile (Chile) - Centrum Wiskunde & Informatica - Éric Tanter

Start year: 2018

See also: http://geco.gforge.inria.fr

The development of tools to construct software systems that respect a given specification is a major challenge of current and future research in computer science. Interactive theorem provers based on type theory, such as Coq, have shown their effectiveness to prove correctness of important pieces of software like the C compiler of the CompCert project. Certified programming with dependent types is attracting a lot of attention recently, and Coq is the de facto standard for such endeavors, with an increasing amount of users, pedagogical material, and large-scale projects. Nevertheless, significant work remains to be done to make Coq more usable from a software engineering point of view.

This collaboration project gathers the expertise of researchers from Chile (Inria Chile, Universidad de Chile, Universidad Católica de Valparaíso) and France (Inria Nantes, Inria Paris), in different areas that are crucial to develop the vision of certified software engineering. The focus of this project is both theoretical and practical, covering novel foundations and methods, design of concrete languages and tools, and validation through specific case studies.

The end result will be a number of enhancements to the Coq proof assistant (frameworks, tactic language) together with guidelines and demonstrations of their applicability in realistic scenarios.

7.4.2. Inria International Partners

7.4.2.1. Informal International Partners

- A. Mahboubi holds a part-time endowed professor position in the Department of Mathematics at the Vrije Universiteit Amsterdam (the Netherlands).

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- Matias Toro (U. Chile) visited 1 week in January to work with G. Munch-Maccagnoni.

7.5.2. Visits to International Teams

7.5.2.1. Research Stays Abroad

+ G. Munch-Maccagnoni visited E. Tanter and M. Toro (U. Chile) in March.

GAMBLE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR SoS

Project title: Structures on Surfaces
Duration: 4 years
Starting Date: April 1st, 2018
Coordinator: Monique Teillaud
Participants:

- Gamble project-team, Inria.
- LIGM (Laboratoire d'Informatique Gaspard Monge), Université Paris-Est Marne-la-Vallée. Local Coordinator: Éric Colin de Verdière.
- RMATH (Mathematics Research Unit), University of Luxembourg. National Coordinator: Hugo Parlier

SoS is co-funded by ANR (ANR-17-CE40-0033) and FNR (INTER/ANR/16/11554412/SoS) as a PRCI (Projet de Recherche Collaborative Internationale).

The central theme of this project is the study of geometric and combinatorial structures related to surfaces and their moduli. Even though they work on common themes, there is a real gap between communities working in geometric topology and computational geometry and SoS aims to create a long-lasting bridge between them. Beyond a common interest, techniques from both ends are relevant and the potential gain in perspective from long-term collaborations is truly thrilling.

In particular, SoS aims to extend the scope of computational geometry, a field at the interface between mathematics and computer science that develops algorithms for geometric problems, to a variety of unexplored contexts. During the last two decades, research in computational geometry has gained wide impact through CGAL, the Computational Geometry Algorithms Library. In parallel, the needs for non-Euclidean geometries are arising, e.g., in geometric modeling, neuromathematics, or physics. Our goal is to develop computational geometry for some of these non-Euclidean spaces and make these developments readily available for users in academy and industry.

To reach this aim, SoS will follow an interdisciplinary approach, gathering researchers whose expertise cover a large range of mathematics, algorithms and software. A mathematical study of the objects considered will be performed, together with the design of algorithms when applicable. Algorithms will be analyzed both in theory and in practice after prototype implementations, which will be improved whenever it makes sense to target longer-term integration into CGAL.

Our main objects of study will be Delaunay triangulations and circle patterns on surfaces, polyhedral geometry, and systems of disjoint curves and graphs on surfaces.

Project website: https://members.loria.fr/Monique.Teillaud/collab/SoS/.

9.1.2. ANR Aspag

Project title: Analyse et Simulation Probabilistes d'Algorithmes Géométriques
Duration: 4 years
Starting date: January 1st, 2018
Coordinator: Olivier Devillers

Participants:

- Gamble project-team, Inria.
- Labri (Laboratoire Bordelais de Recherche en Informatique), Université de Bordeaux. Local Coordinator: Philippe Duchon.
- Laboratoire de Mathématiques Raphaël Salem, Université de Rouen. Local Coordinator: Pierre Calka.
- LAMA (Laboratoire d'Analyse et de Mathématiques Appliquées), Université Paris-Est Marne-la-Vallée. Local Coordinator: Matthieu Fradelizi

Abstract: The ASPAG projet is funded by ANR under number ANR-17-CE40-0017 .

The analysis and processing of geometric data has become routine in a variety of human activities ranging from computer-aided design in manufacturing to the tracking of animal trajectories in ecology or geographic information systems in GPS navigation devices. Geometric algorithms and probabilistic geometric models are crucial to the treatment of all this geometric data, yet the current available knowledge is in various ways much too limited: many models are far from matching real data, and the analyses are not always relevant in practical contexts. One of the reasons for this state of affairs is that the breadth of expertise required is spread among different scientific communities (computational geometry, analysis of algorithms and stochastic geometry) that historically had very little interaction. The Aspag project brings together experts of these communities to address the problem of geometric data. We will more specifically work on the following three interdependent directions.

(1) Dependent point sets: One of the main issues of most models is the core assumption that the data points are independent and follow the same underlying distribution. Although this may be relevant in some contexts, the independence assumption is too strong for many applications.

(2) Simulation of geometric structures: The phenomena studied in (1) involve intricate random geometric structures subject to new models or constraints. A natural first step would be to build up our understanding and identify plausible conjectures through simulation. Perhaps surprisingly, the tools for an effective simulation of such complex geometric systems still need to be developed.

(3) Understanding geometric algorithms: the analysis of algorithms is an essential step in assessing the strengths and weaknesses of algorithmic principles, and is crucial to guide the choices made when designing a complex data processing pipeline. Any analysis must strike a balance between realism and tractability; the current analyses of many geometric algorithms are notoriously unrealistic. Aside from the purely scientific objectives, one of the main goals of Aspag is to bring the communities closer in the long term. As a consequence, the funding of the project is crucial to ensure that the members of the consortium will be able to interact on a very regular basis, a necessary condition for significant progress on the above challenges.

Project website: https://members.loria.fr/Olivier.Devillers/aspag/.

9.1.3. ANR MinMax

Project title: MIN-MAX
Duration: 4 years
Starting date: 2019
Coordinator: Stéphane Sabourau (Université Paris-Est Créteil)
Participants:

- Université Paris Est Créteil, Laboratoire d'Analyse et de Mathématiques Appliquées (LAMA). Local coordinator: Stéphane Sabourau
- Université de Tours, Institut Denis Poisson. Local coordinator: Laurent Mazet. This node includes two participants from Nancy, Benoît Daniel (IECL) and Xavier Goaoc (Loria, GAMBLE).

Abstract: The MinMax projet is funded by ANR under number ANR-19-CE40-0014

This collaborative research project aims to bring together researchers from various areas – namely, geometry and topology, minimal surface theory and geometric analysis, and computational geometry and algorithms – to work on a precise theme around min-max constructions and waist estimates.

9.1.4. Institut Universitaire de France

Xavier Goaoc was appointed *junior member* of the Institut Universitaire de France, a grant supporting a reduction in teaching duties and funding.

Starting Date: October 1st, 2014.
Duration: 5 years.

9.2. International Initiatives

9.2.1. Inria Associate Teams Not Involved in an Inria International Labs

9.2.1.1. TRIP

Title: Triangulation and Random Incremental Paths

International Partner (Institution - Laboratory - Researcher):

Carleton University (Canada) - CGLab - Prosenjit Bose

Start year: 2018

See also: https://members.loria.fr/Olivier.Devillers/trip/

The two teams are specialists of Delaunay triangulation with a focus on computation algorithms on the French side and routing on the Canadian side. We plan to attack several problems where the two teams are complementary:

- Stretch factor of the Delaunay triangulation in 3D.
- Probabilistic analysis of Theta-graphs and Yao-graphs.
- Smoothed analysis of a walk in Delaunay triangulation.
- Walking in/on surfaces.
- Routing un non-Euclidean spaces.

9.2.1.2. Astonishing

Title: ASsociate Team On Non-ISH euclIdeaN Geometry

International Partner (Institution - Laboratory - Researcher):

University of Groningen (Netherlands) - Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence - Gert Vegter

Start year: 2017

See also: https://members.loria.fr/Monique.Teillaud/collab/Astonishing/

Some research directions in computational geometry have hardly been explored. The spaces in which most algorithms have been designed are the Euclidean spaces $\mathbb{R}^d$. To extend further the scope of applicability of computational geometry, other spaces must be considered, as shown by the concrete needs expressed by our contacts in various fields as well as in the literature. Delaunay triangulations in non-Euclidean spaces are required, e.g., in geometric modeling, neuromathematics, or physics. Topological problems for curves and graphs on surfaces arise in various applications in computer graphics and road map design. Providing robust implementations of these results is a key towards their reusability in more applied fields. We aim at studying various structures and algorithms in other spaces than $\mathbb{R}^d$, from a computational geometry viewpoint. Proposing algorithms operating in such spaces requires a prior deep study of the mathematical properties of the objects considered, which raises new fundamental and difficult questions that we want to tackle.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

Gert Vegter (University of Groningen, NL) spent two weeks in GAMBLE in the context of the Astonishing associate team.

Matthijs Ebbens (University of Groningen, NL) spent one week in GAMBLE in the context of the Astonishing associate team.

Hugo Parlier (University of Luxembourg) spent two days in GAMBLE in the context of the ANR project SoS.

Erin Wolf Chambers (Saint Louis University, USA) spent two days in GAMBLE

Vanessa Robins (Australian National University) spent two days in GAMBLE

Andreas Holmsen (KAIST, South Korea) and Zuzanna Patáková (IST Austria, Vienna) spent a week in GAMBLE

9.3.2. Visits to International Teams

Olivier Devillers and Monique Teilaud spent one week in June at the Computational Geometry Lab of Carleton University http://cglab.ca/ in the context of the TRIP associate team.

Vincent Despré spent a total of three week during 2019 at the Mathematical Research Unit of the University of Luxembourg in the context of the ANR SoS project.

Sylvain Lazard spent two weeks in September at the Computational Geometry Lab of Carleton University http://cglab.ca/ in the context of the TRIP associate team.

Monique Teillaud spent two weeks at Bernoulli Institute for Mathematics, Computer Science and Artificial Intelligence of the University of Groningen in the context of the Astonishing associate team.

Monique Teillaud spent two days at University of Luxembourg in the context of the ANR SoS project

Xavier Goaoc spent one week at UNAM Queretaro, in Mexico.

GRACE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Participants: Daniel Augot, Matthieu Rambaud.

Daniel Augot and Matthieu Rambaud (Institut Mines-Telecom) received a Digicosme Grant, to fund a new PhD student, A. Saadeh, starting November 2019, on the topic of Secure Multiparty Computation.

8.2. National Initiatives

8.2.1. ANR MANTA

Participants: Daniel Augot, Alain Couvreur, Françoise Levy-Dit-Vehel, Philippe Lebacque, Matthieu Rambaud, Isabella Panaccione, Luca de Feo.

MANTA (accepted July 2015, starting March 2016, Ended September 2019): "Curves, surfaces, codes and cryptography". This project deals with applications of coding theory error correcting codes to in cryptography, multi-party computation, and complexity theory, using advanced topics in algebraic geometry and number theory.

We have four annual national retreats, the last one in January 2019, and we organized a closing international workshop in August 2019, with more than 40 participants, half French, half international.

See http://anr-manta.inria.fr/.

8.2.2. ANR CIAO

Participants: Benjamin Smith, Luca de Feo, Antonin Leroux, Mathilde de La Morinerie.

ANR **CIAO** (Cryptography, Isogenies, and Abelian varieties Overwhelming) is a JCJC 2019 project, led by Damien Robert (Inria EP LFANT). This project, which started in October 2019, will examine applications of higher-dimensional abelian varieties in isogeny-based cryptography.

8.2.3. ANR CBCRYPT

Participant: Alain Couvreur.

ANR **CBCRYPT** (Code–based Cryptography) This is a project from (*Appel à projets générique, Défi 9, Liberté et sécurité de l'Europe, de ses citoyens et de ses résidents, Axe 4 ; Cybersécurité*). This project, starting in october 2017 led by Jean-Pierre Tillich (Inria, EP Cosmiq) focusses on the design and the security analysis of code–based primitives, in the context of the current NIST competition.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

Participant: Benjamin Smith.

- SPARTA https://www.sparta.eu/ is a cybersecurity competence network, with the objective to collaboratively develop and implement top-tier research and innovation actions

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Alessandro Neri visited us from September 2019 to December 2019, as post-doctoral visitor, to work on rank-metric codes.
- Vincent Neiger (Mcf, Univ. Limoges) visited our team twice. One week in march and one meek in november, to work on the decoding of Reed–Solomon codes.

HYCOMES Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Participants: Benoît Caillaud, Aurélien Lamercerie.

The Hycomes has been participating to the SUNSET project (2016–2019) of the CominLabs excellence laboratory [0]. This project focuses on the computation of surgical procedural knowledge models from recordings of individual procedures, and their execution [28]. The objective is to develop an enabling technology for procedural knowledge based computer assistance of surgery. In this project, we demonstrate its potential added value in nurse and surgeon training. The main contribution of the Hycomes team to this project has been the development of Demodocos, a process model synthesis tool, capable of generating models of a surgical procedure, from a few recordings of actual procedures. Demodocos has been interfaced to the `#SEVEN` virtual reality scenario modeling language and engine, developed in the Hybrid team at Inria Rennes. In 2019, the team has contributed to two publications presenting experimental results of the SUNSET project [9][6].

8.2. National Initiatives

8.2.1. Inria Project Lab (IPL): ModeliScale, Languages and Compilation for Cyber-Physical System Design

The project gathers researchers from three Inria teams, and from three other research labs in Grenoble and Paris area.

Name	*Team*	*Inria Center or Laboratory*
Vincent Acary Bernard Brogliato Alexandre Rocca	Tripop	Inria Grenoble Rhône Alpes
Albert Benveniste Benoît Caillaud Khalil Ghorbal Christelle Kozaily Mathias Malandain Benoît Vernay	Hycomes	Inria Rennes Bretagne Atlantique
Marc Pouzet Tim Bourke Imsail Lakhim-Bennani	Parkas	ENS & Inria Paris
Goran Frehse	SSH	ENSTA Paris-Tech.
Antoine Girard		L2S-CNRS, Saclay
Eric Goubault Sylvie Putot	Cosynus	LIX, École Polytechnique, Saclay

The main objective of ModeliScale is to advance modeling technologies (languages, compile-time analyses, simulation techniques) for CPS combining physical interactions, communication layers and software components. We believe that mastering CPS comprising thousands to millions of components requires radical changes of paradigms. For instance, modeling techniques must be revised, especially when physics is involved. Modeling languages must be enhanced to cope with larger models. This can only be done by combining new compilation techniques (to master the structural complexity of models) with new mathematical tools (new numerical methods, in particular).

[0] http://www.s3pm.cominlabs.ueb.eu/

MiodeliScale gathers a broad scope of experts in programming language design and compilation (reactive synchronous programming), numerical solvers (nonsmooth dynamical systems) and hybrid systems modeling and analysis (guaranteed simulation, verification). The research program is carried out in close cooperation with the Modelica community as well as industrial partners, namely, Dassault Systèmes as a Modelica/FMI tool vendor, and EDF and Engie as end users.

In 2019, three general meetings have been organized, with presentations of the partners on new results related to hybrid systems modeling and verification.

Two PhDs are funded by the ModeliScale IPL. Both started in October 2018:

- Christelle Kozaily has started a PhD, under the supervision of Vincent Acary (TRIPOP team at Inria Grenoble), Benoît Caillaud, Khalil Ghorbal on the structural and numerical analysis of non-smooth DAE systems. She is located in the Hycomes team at Inria Rennes.
- Ismail Lahkim-Bennani has started a PhD under the supervision of Goran Frehse (ENSTA Paris-Tech.) and Marc Pouzet (PARKAS team, Inria/ENS Paris). His PhD topic is on random testing of hybrid systems, using techniques inspired by QuickCheck [36].

8.2.2. FUI ModeliScale: Scalable Modeling and Simulation of Large Cyber-Physical Systems

Participants: Albert Benveniste, Benoît Caillaud, Khalil Ghorbal, Mathias Malandain.

FUI ModeliScale is a French national collaborative project coordinated by Dassault Systèmes. The partners of this project are: EDF and Engie as main industrial users; DPS, Eurobios and PhiMeca are SME providing mathematical modeling expertise; CEA INES (Chambéry) and Inria are the academic partners. The project started January 2018, for a maximal duration of 42 months. Three Inria teams are contributing to the project : Hycomes, Parkas (Inria Paris / ENS) and Tripop (Inria Grenoble / LJK).

The focus of the project is on the scalable analysis, compilation and simulation of large Modelica models. One of the main contributions expected from Inria are:

- A novel structural analysis algorithms for multimode DAE systems, capable of handling large systems of guarded equations, that do not depend on the enumeration of a possibly exponential number of modes.
- The partitioning and high-performance distributed co-simulation of large Modelica models, based on the results of the structural analysis.

In 2019, the effort has been put on the first objective, and two important milestones have been reached:

- The design of a novel algorithm for the structural analysis of multimode DAE systems. This algorithm is a generalization of the Pryce structural analysis method to the multimode case. The key feature of our method is that it works on implicit representations of the set of modes, and of the varying structure of the multimode DAE. In other words, it does not imply the enumeration of the system's modes. Performing the structural analysis at compile-time brings two decisive advantages: 1/ it allows to deliver to the user precise diagnostics about the model, and can be compared type-checking in programming languages; 2/ it is instrumental for the generation of efficient simulation code. Our algorithm is the first method enabling the compile-time analysis of systems with extremely large combinatorics of modes.
- Our multimode DAE structural analysis algorithm has been implemented in IsamDAE, a software comprizing an algorithmic library, to be used in modeling language compilers (Modelica tools) and a standalone tool, to be used independently of a complex Modelica toolset. IsamDAE has allowed to benchmark the method against several families of models, inspired by case-studies developed by industrial partners of the FUI ModeliScale project. Despite the tool is still under development, we have already been able to deal with models with up to 10^{23} modes.

On top of these two main results, the Hycomes team has started investigating the use of Quantized Space Systems (QSS), for the simulation of large DAE systems. QSSs simulation (QSS) was introduced in the early 2000's by F. Cellier and E. Kofman as an alternative to time-based simulation, which is the dominant approach to ODE/DAE systems simulation. Rather than linking QSS to Discrete Event Simulation, we propose to relate it to Synchronous Programming and its continuous time extension Zelus. In the deliverable [20], we expose our understanding of QSS and its variants, then we propose ideas toward a QSS-based cosimulation, by building on top of our knowledge on distributed executions of synchronous programs.

The plan for 2020 is to extend our structural analysis to cover impulsive mode changes and the consistent initialization problem, in the multimode case. A coupling of IsamDAE with Dymola (Dassault Système's commercial implementation of the Modelica language) is under development.

Another future development is to turn our structural analysis method to a compositional method, where large models could be considered by parts. This is a key problem in the Modelica language, as the compilation of a Modelica model is not modular.

Work on QSS methods will continue, and we envision to prototype a QSS-based distributed simulation method for hybrid ODE systems, based on the Zélus language.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

We have a long standing informal collaboration with Martin Otter (DLR, Munich, Germany) and Hilding Helmqvist (Mogram AB, Lund, Sweden). In 2019, this fruitful collaboration has resulted in one publication [7]. The publication draws links between two radically different, but equivalent approaches to the same problem: the impulsive behavior of some multimode DAE, when it is switching from one mode to another. The first approach relies on a transformation of the multimode DAE system to a special index one form, for which state-jumps are proved to be solution of a system of algebraic equations relating right limits to left limits. The second approach builds on the use of nonstandard analysis, combined with the heritage of synchronous programming languages, particularly on the concept of constructive semantics. This gives a formulation of the state-jumps, as a system of difference equations, with an infinitesimal time-step. The latter approach is more general than the former, in the sense that impulsive behavior can be characterized for a larger class of multimode DAE systems. Yet, both approaches coincide on a restricted class of multimode DAEs.

Kairos Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Université Côte d'Azur Academy 1 and EUR DS4H

In the context of the local UCA-Jedi IDEX program and its RISE Academy, we were afforded a three years funding, including a postdoctoral position, for the "Smart IoT for Mobility" project. This project, lead by the LEAT UMR and Kairos, aims at building a formal language for the design of smart contracts in the context of a mobility project, in collaboration with Renault Software Labs and Symag, a subsidiary of BNP Paribas. This agreement was operational in preparing the larger ANR project SIM, that was accepted this year, while an even larger European project is under proposal.

9.1.2. PSPC-Region project ADAVEC

This project was recently accepted, and not yet started in practice. It associates Renault Software Labs with UCA (represented by our team), together with Avisto Telecom and EPICnPOC companies. The focus is on requirements and specification for Automated Driving Assistance, and more specially the transitions that need to be properly handled when control needs to be held back to the human driver.

9.2. National Initiatives

9.2.1. ANR Project SIM

The ANR SIM (Smart IoT for Mobility) is a PRCE project co-funded by ANR (AAPG 2019) and DGA for 42 months. The national coordinator is the LEAT (UMR CNRS) and the other partners are Renault Software Labs and Symag. The goal is to provide a formal meta-language to describe smart contracts that can be used in the context of an autonomous vehicles to provide services to the users. The services are related to the combined use of multi-model transportation systems by having a single smart contracts that can enforce all the intermediate transactions with all the actors involved (car manufacturing, parking lease, highway toll companies, insurances, bike rental companies).

9.2.2. Competitivity Clusters

The Kairos team is involved in the actions of the cluster SCS (Systèmes Communicants Sécurisés) and Frédéric MALLET is elected in the steering committee of SCS. One of the more prominent action is to build, in partnership with University Aix-Marseille, a Digital Innovation Hub, to open the access (with actions of transfer and valorization) to Digital Innovations for companies that would benefit from it, like public institutions (hospitals, human resources, employment institutions) or private companies that could use IoT for agriculture, tourism, smart infrastructures (harbours, buildings, cities).

9.2.3. CNRS GDRs

We are registered members of three GDR funded by CNRS : **SoC**^{2}, on topics of Hardware-software codesign and Non-Functional Property modeling for co-simulation; **LTP**, on verification and language design for reactive CPS systems; **GPL**, on software engineering and Domain-Specific Languages.

9.2.4. Inria Project Lab SPAI

This collaborative action, targeting *Security by Program Analysis for the IoT (SPAI)*, is headed by the Indes Project, and associated the Antique, Privatics and Celtique EPIs. See 7.15 for our contribution.

9.2.5. PAI ES3CAP

ES3CAP (Embedded Smart Safe Secure Computing Autonomous Platform) is a PIA (Programme d'Investissements d'Avenir) project. Its budget is of 22.2MEuros, over 36 months. The national coordinator is Kalray, and other partners include Safran, Renault, and MBDA. The objectives of the project are to:

- Build a hardware and software industry-grade solution for the development of computation-intensive critical application. The solution should cover the needs of industrial end users, and target multi/many-core hardware platforms. The solution will come with 3 to 6 usage profiles specific to various industries (automotive, aerospace, defence)
- Improve the technology readiness level of the proposed development flow from TRL4-5 (technology development) to TRL6-7, thus approaching as much as possible commercialization.
- Build an alternate, perennial ecosystem for critical real-time OSs and development tools for computer vision, data fusion and neural networks. The tools and components must be available on a prototyping and demonstration platform that is safe and secure.
- Capitalize on the convergence between the automotive and aerospace markets on subjects such as security, safety, decision making, and big data.

Our technical contributions to this project are described in 7.16 . This project partially finances Hugo Pompugnac's PhD and Jad Khatib's post-doc.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. IIP TuMuLT

Title: Trustworthy Modeling using Logical Time

International Partner (Institution - Laboratory - Researcher):

E.C.N.U. (Shanghai, China) - Departement of Software Engineering and Computer Science - Zhang Min

Duration: 2018 - 2022

See also: https://team.inria.fr/tumult/

- Modeling the Uncertain Environments of Cyber-Physical Systems: Logical Time is one of the main scientific foundation of the KAIROS Team. From the background in theory of concurrency, we are used to consider mainly discrete control systems that can guarantee a functional determinism independently of any implementation-specific timing variation. Addressing Cyber-Physical Systems and the Internet of Things means widening those assumptions to consider the external environment, typically involving uncertainty, as part of the design. This task explores the definition of sound extensions to logical time to capture both the physical continuous behavior and make an abstract characterization as a statistical approximation.
- SMT For Logical Time: While synchronous systems usually focus on finite state-based control systems, our abstraction of logical time relies on both Boolean algebra (for synchronous operations) and integer arithmetic (for synchronizing mechanisms), In that context, SMT is a promising solution to solve systems that combine several theories. We had first results on this aspect [SCP'17] but we still need to increase the subset of constraints that can be addressed efficiently as well as the performances of the solving tools.
- Spatio-Temporal Specification for Trustworthy Intelligent Transportation Systems: Focusing on Intelligent Transportation Systems as a subset of Cyber-Physical Systems, we encounter specific problems. This task would focus on extensions of our framework for a spatio-temporal logics based on logical time. This means a description of the location of infrastructures as well as the ability to build constraints that depend both on time (logic or physical) and locations (logical or physical).

- Symbolic approaches for models and analysis of Open systems: Methods for analyzing and guaranteeing the properties of critical and complex systems, including their data and time depend aspects, have strongly evolved with the emergence of efficient SAT and SMT engines. We are working on novel methods combining classical verification paradigms with SMT approaches to create symbolic and compositional verification methods and tool platforms [22], [27].

  Collaboration will come in the form of scientific short or middle term visits, student exchanges (master and PhD), and organization of events (workshops and conferences).

9.3.1.2. Informal International Partners

- Luigi Liquori has a steady collaboration with researchers from University of Udine and Turin, Italy.
- We keep close informal relations with the Universities of Kiel and Bamberg Germany, in the context of the Synchronous Reactive academic community. We all attended the yearly Synchron seminar, held this year in Aussois (together with researchers from Verimag and the Parkas and Spades Inria teams).
- Frédéric Mallet has a collaboration with Peter Olvecsky from University of Oslo. He was funded in 2019 by a program of the French Embassy in Norway called Asgard.

9.3.2. Participation in Other International Programs

- PHC Cai Yuan Pei: The partnership is a joint funding from Campus France and Chinese Scholarship Council (CSC) to fund short exchanges of permanent staffs and long exchanges of PhD students. A 2-week visit was carried out by Frédéric Mallet in 2019, while Xiaohong Chen is visiting France during 3 months starting in mid-November. The program is funded for three years and a PhD student (Zhang Juan) will visit our team during 16 months in 2020.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Xiaohong Chen, Assistant Professor at East China Normal University (Shanghai), from Nov 2019 to Feb 2020.
- Grygoriy Zholtkevych, Professor at V.N. Karazin Kharkiv National University (Ukraine), from Oct 2019 until Nov 2019.
- Peter Olvescky, Professor at University of Oslo, from November 24th to November 29th, 2019.
- Matteo Sereno, Professor, University of Turin, Italy, in May 2019.
- Thomas Ehrhard, University of Paris, in September 2019.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

- E. Madelaine spent 4 weeks visiting the Software Engineering an Computer Science department at ECNU Shanghai (2 weeks in May, 2 weeks in September), founded by the foreign expert program of ECNU; and 1 week visiting the Institute of Software of the Chinese Academy of Science (ISCAS, Beijing), funded by ISCAS.
- Marie-Agnès Peraldi Frati spent 10 days at Danang University in May 2019 in the context of the joined UCA/UD international DNIIT laboratory for student supervision and scientific meetings. The visit was funded by Mobility Contract Erasmus Mundus.
- Frédéric Mallet stayed three weeks in Shanghai in August 2019. He stayed one week in Hangzhou in September as part of a Chinese competition for oversea professors. He also stayed two weeks in Shanghai in November 2019 through the PHC Cai Yuan Pei program.

KOPERNIC Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. FUI

8.1.1.1. CEOS

This project was started on May 2017. Partners of the project are: ADCIS, ALERION, Aeroport de Caen, EDF, ENEDIS, RTaW, EDF, Thales Communications and Security, ESIEE engineering school and Lorraine University. The CEOS project delivers a reliable and secure system of inspections of pieces of works using professional mini-drone for Operators of Vital Importance coupled with their Geographical Information System. These inspections are carried out automatically at a lower cost than current solutions employing helicopters or off-road vehicles. Several software applications proposed by the industrial partners, are developed and integrated in the drone, within an innovative mixed-criticality approach using multi-core platforms.

8.2. European Initiatives

8.2.1. Collaborations with Major European Organizations

University of York: Real-Time System Group (UK)

Uncertainties in real-time systems: the utilization of extreme value theory has received increased efforts from our community and more rigorous principles are needed for its full understanding. Our two research teams have gathered these principles in a joint publication.

8.3. International Research Visitors

8.3.1. Visits of International Scientists

- Prof. Christopher Gill, Washington University in St. Louis (May 2019).
- Robert Davis, University of York (July 2019).

8.3.1.1. Internships

- Kartikeya Singh (India).

LFANT Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR Alambic – AppLicAtions of MalleaBIlity in Cryptography

Participant: Guilhem Castagnos.

https://crypto.di.ens.fr/projects:alambic:main

The ALAMBIC project is a research project formed by members of the Inria Project-Team CASCADE of ENS Paris, members of the AriC Inria project-team of ENS Lyon, and members of the CRYPTIS of the university of Limoges. G. Castagnos is an external member of the team of Lyon for this project.

Non-malleability is a security notion for public key cryptographic encryption schemes that ensures that it is infeasible for an adversary to modify ciphertexts into other ciphertexts of messages which are related to the decryption of the first ones. On the other hand, it has been realized that, in specific settings, malleability in cryptographic protocols can actually be a very useful feature. For example, the notion of homomorphic encryption allows specific types of computations to be carried out on ciphertexts and generate an encrypted result which, when decrypted, matches the result of operations performed on the plaintexts. The homomorphic property can be used to create secure voting systems, collision-resistant hash functions, private information retrieval schemes, and for fully homomorphic encryption enables widespread use of cloud computing by ensuring the confidentiality of processed data.

The aim of the ALAMBIC project to investigate further theoretical and practical applications of malleability in cryptography. More precisely, this project focuses on three different aspects: secure computation outsourcing and server-aided cryptography, homomorphic encryption and applications and << paradoxical >> applications of malleability.

7.1.2. ANR CLap–CLap – The p-adic Langlands correspondence: a constructive and algorithmical approach

Participants: Xavier Caruso, Jean-Marc Couveignes.

The p-adic Langlands correspondence has become nowadays one of the deepest and the most stimulating research programs in number theory. It was initiated in France in the early 2000's by Breuil and aims at understanding the relationships between the p-adic representations of p-adic absolute Galois groups on the one hand and the p-adic representations of p-adic reductive groups on the other hand. Beyond the case of $\mathrm{GL}_2(\mathbb{Q}_p)$ which is now well established, the p-adic Langlands correspondence remains quite obscure and mysterious new phenomena enter the scene; for instance, on the $\mathrm{GL}_n(F)$-side one encounters a vast zoology of representations which seems extremely difficult to organize.

The CLap–CLap ANR project aims at accelerating the expansion of the p-adic Langlands program beyond the well-established case of $\mathrm{GL}_2(\mathbb{Q}_p)$. Its main originality consists in its very constructive approach mostly based on algorithmics and calculations with computers at all stages of the research process. We shall pursue three different objectives closely related to our general aim:

1. draw a conjectural picture of the (still hypothetical) p-adic Langlands correspondence in the case of GL_n,
2. compute many deformation spaces of Galois representations and make the bridge with deformation spaces of representations of reductive groups,
3. design new algorithms for computations with Hilbert and Siegel modular forms and their associated Galois representations.

This project will also be the opportunity to contribute to the development of the mathematical software SAGEMATH and to the expansion of computational methodologies.

7.1.3. ANR Ciao – Cryptography, Isogenies and Abelian varieties Overwhelming

Participants: Jean-Marc Couveignes, Jean Kieffer, Aurel Page, Damien Robert.

The CIAO ANR project is a young researcher ANR project led by Damien Robert October 2019.

The aim of the CIAO project is to study the security and improve the efficiency of the SIDH (supersingular isogenies Diffie Helmann) protocol, which is one of the post-quantum cryptographic project submitted to NIST, which passed the first round selection.

The project include all aspects of SIDH, from theoretical ones (computing the endomorphism ring of supersingular elliptic curves, generalisation of SIDH to abelian surfaces) to more practical aspects like arithmetic efficiency and fast implementations, and also extending SIDH to more protocols than just key exchange.

Applications of this project is to improve the security of communications in a context where the currently used cryptosystems are vulnerable to quantum computers. Beyond post-quantum cryptography, isogeny based cryptosystems also allow to construct new interesting cryptographic tools, like Verifiable Delay Functions, used in block chains.

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

Title: OpenDreamKit

Program: H2020

Duration: January 2016 - December 2019

Coordinator: Nicolas Thiéry

Inria contact: Karim Belabas

Description http://cordis.europa.eu/project/rcn/198334_en.html, http://opendreamkit.org

OpenDreamKit was a Horizon 2020 European Research Infrastructure project (#676541) that ran for four years, starting from September 2015. It provided substantial funding to the open source computational mathematics ecosystem, and in particular popular tools such as LinBox, MPIR, SageMath, GAP, Pari/GP, LMFDB, Singular, MathHub, and the IPython/Jupyter interactive computing environment.

7.3. International Initiatives

7.3.1. Inria International Labs

International Laboratory for Research in Computer Science and Applied Mathematics
Associate Team involved in the International Lab:

7.3.1.1. FAST

Title: (Harder Better) FAster STronger cryptography

International Partner (Institution - Laboratory - Researcher): and the PRMAIS project

Université des Sciences et Techniques de Masuku (Gabon) - Tony Ezome

Start year: 2017

See also: http://fast.gforge.inria.fr/

The project aims to develop better algorithms for elliptic curve cryptography with prospect of the two challenges ahead: - securing the internet of things - preparing towards quantum computers.

Elliptic curves are currently the fastest public-key cryptosystem (with a key size that can fit on embeded devices) while still through a different mode of operation beeing (possibly) able to resist quantum based computers.

This was the last year of the Fast projet, which was represented at the Journees du Lirimia in Yaounde by Emmanuel Fouotsa.

In total the project funded one EMA and two CIMPA schools, had 14 publications in journals and conferences (with three upcoming preprints), two PhD defense with two upcoming.

7.3.2. Inria International Partners

7.3.2.1. Informal International Partners

The team is used to collaborating with Leiden University through the ALGANT programme for joint PhD supervision.

Eduardo Friedman (U. of Chile), long term collaborator of K. Belabas's and H. Cohen's, is a regular visitor in Bordeaux (about 1 month every year).

7.4. International Research Visitors

7.4.1. Visits of International Scientists

Researchers visiting the team to give a talk to the team seminar include David Lubicz (DGA Rennes), Hartmut Monien (Bethe Center for Theoretical Physics, Bonn), Francesco Battestoni (University of Milan), David Roe (MIT, Boston), Maria Dostert (EPFL, Lausanne), and Alice Pellet-Mary (KU Leuven).

Abdoulaye Maiga visited the team for one month in December 2019, and Tony Ezome visited for two weeks in November 2019.

MEXICO Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- MATTHIAS FUEGGER is co-leading the Digicosme working group *HicDiesMeus* on *Highly Constrained Discrete Agents for Modeling Natural Systems*.
- STEFAN HAAR is co-leading the Digicosme working group *TheoBioR* on *Computational methods for modelling and analysing biological networks*.

8.2. National Initiatives

- Thomas Chatain, Stefan Haar, Serge Haddad and Stefan Schwoon are participating in the ANR Project ALGORECELL.
- Matthias Függer participates in the ANR project FREDDA on verification and synthesis of distributed algorithms.

8.3. International Research Visitors

8.3.1. Visits of International Scientists

- Susanna DONATELLI was invited professor of ENS Paris-Saclay during one month in January, working with Serge Haddad on the expressiveness and conciseness of temporal logic for Markov chains. This work was also coninued durin a visit of Serge Haddad at the university of Torino in March. Their joint work has led to a publication to appear in the international conference LATA 2020 at Milano.
- Sven DZIADEK, Sep-Nov 2019 (PhD student, Univ. Leipzig)

8.3.1.1. Research Stays Abroad

- JURAJ KOLCˇÁK visited the SDM group of Hasuo Ichiro at NII Tokyo from August 2018 to February 2019, working in particular on differential logics.

MOCQUA Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- Project acronym: ANR PRCE SoftQPro (ANR-17-CE25-0009)
  Project title: Solutions logicielles pour l'optimisation des programmes et ressources quantiques.
  Duration: Dec. 2017 - Dec. 2022
  Coordinator: Simon Perdrix
  Other partners: Atos-Bull, LRI, CEA-Saclay.
  Participants: Simon Perdrix, Emmanuel Jeandel, Emmanuel Hainry, and Romain Péchoux
  Abstract: Quantum computers can theoretically solve problems out of reach of classical computers. We aim at easing the crucial back and forth interactions between the theoretical approach to quantum computing and the technological efforts made to implement the quantum computer. Our software-based quantum program and resource optimisation (SoftQPRO) project consists in developing high level techniques based on static analysis, certification, transformations of quantum graphical languages, and optimisation techniques to obtain a compilation suite for quantum programming languages. We will target various computational model back-ends (e.g. QRAM, measurement-based quantum computations) as well as classical simulation. Classical simulation is central in the development of the quantum computer, on both ends: as a way to test quantum programs but also as a way to test quantum computer prototypes. For this reason we aim at designing sophisticated simulation techniques on classical high-performance computers (HPC).
- Project acronym: ANR PRCI VanQuTe (ANR-17-CE24-0035)
  Project title: Validation of near-future quantum technologies.
  Duration: Fev. 2018 - Jan. 2022
  Coordinator: Damian Markham (Laboratoire d'informatique de Paris 6)
  Other partners: NTU (Nanyang Technological University), SUTD (Singapore University of Technology and Design), NUS (Nationl University of Singapore), LIP6 (Laboratoire d'informatique de Paris 6)
  Participants: Simon Perdrix, Emmanuel Jeandel
  Abstract: In the last few years we have seen unprecedented advances in quantum information technologies. Already quantum key distribution systems are available commercially. In the near future we will see waves of new quantum devices, offering unparalleled benefits for security, communication, computation and sensing. A key question to the success of this technology is their verification and validation.

  Quantum technologies encounter an acute verification and validation problem: On one hand, since classical computations cannot scale-up to the computational power of quantum mechanics, verifying the correctness of a quantum-mediated computation is challenging. On the other hand, the underlying quantum structure resists classical certification analysis. Members of our consortium have shown, as a proof-of-principle, that one can bootstrap a small quantum device to test a larger one. The aim of VanQuTe is to adapt our generic techniques to the specific applications and constraints of photonic systems being developed within our consortium. Our ultimate goal is to develop techniques to unambiguously verify the presence of a quantum advantage in near future quantum technologies.

8.1.2. Other initiatives

- Quantex. Project acronym: PIA-GDN/Quantex. (initially an ITEA3 project finally funded by the *Grands défis du Numérique / Programme d'investissements d'avenir*).
  Project title: Simulation/Emulation of Quantum Computation.
  Duration: Feb. 2018 - Jan 2021.
  Coordinator: Huy-Nam Nguyen (Atos Bull).
  Other partners: Atos-Bull, LRI, CEA Grenoble.
  Participants: Simon Perdrix (WP leader), Emmanuel Jeandel
  Abstract: The lack of quantum computers leads to the development of a variety of software-based simulators to assist in the research and development of quantum algorithms. This proposal focuses on the development of a combined software-based and hardware-accelerated toolbox for quantum computation. A quantum computing stack including specification language, libraries and optimisation/execution tools will be built upon a well-defined mathematical framework mixing classical and quantum computation. Such an environment will be dedicated to support the expression of quantum algorithms for the purpose of investigation and verification.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

Mathieu Hoyrup participates in the Marie-Curie RISE project Computing with Infinite Data coordinated by Dieter Spreen (Univ. Siegen) that has started in April 2017.

8.3. International Initiatives

8.3.1. Participation in Other International Programs

ECOS-Sud A17C03 QuCa - 01/2018 - 12/2020. **Quantum Calculi**. Funded by MinCyT and ECOS France.
Argentine Director: A. Díaz-Caro (UNQ/CONICET), French Director: G. Dowek (Inria, LSV, ENS Paris-Saclay)
Permanent members: P. Arrighi (Aix-Marseille) - J.-Y. Marion (LORIA) - P. E. Martínez López (UNQ) - S. Perdrix - B. Valiron (CentraleSupélec).

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Alonso Herrera: Universidad Andrés Bello, Chile.
- Takayuki Kihara : Nagoya University, Japan.
- Damiano Mazza, CNRS, LIPN.
- Victor Selivanov: Ershov Institute of Informatics Systems, Novosibirsk, Russia.

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

Simon Perdrix visited Universita Buenos Aires, Universita de Quilmes and Conicet for two weeks in November 2019. The visit was part of the QuCa Ecos Sud project and was partially funded by LIA SINFIN.

OURAGAN Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

- FMJH Program, PGMO grant

  ALMA (Algebraic methods in games and optimization).

  Duration: 2018 – 2020. (2 years project)

  Coordinator: Elias Tsigaridas, with Stéphane Gaubert and Xavier Allamigeon (CMAP, École Polytechnique)

9.1.1. ANR

- ANR JCJC GALOP (Games through the lens of ALgebra and OPptimization)

  Coordinator: Elias Tsigaridas

  Duration: 2018 – 2022

  GALOP is a Young Researchers (JCJC) project with the purpose of extending the limits of the state-of-the-art algebraic tools in computer science, especially in stochastic games. It brings original and innovative algebraic tools, based on symbolic-numeric computing, that exploit the geometry and the structure and complement the state-of-the-art. We support our theoretical tools with a highly efficient open-source software for solving polynomials. Using our algebraic tools we study the geometry of the central curve of (semi-definite) optimization problems. The algebraic tools and our results from the geometry of optimization pave the way to introduce algorithms and precise bounds for stochastic games.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

Program: H2020-EU.1.1. - EXCELLENT SCIENCE - European Research Council (ERC)

Project acronym: Almacrypt

Project title: Algorithmic and Mathematical Cryptology

Duration: 01/2016 - 12/2010

Coordinator: Antoine Joux

Abstract: Cryptology is a foundation of information security in the digital world. Today's internet is protected by a form of cryptography based on complexity theoretic hardness assumptions. Ideally, they should be strong to ensure security and versatile to offer a wide range of functionalities and allow efficient implementations. However, these assumptions are largely untested and internet security could be built on sand. The main ambition of Almacrypt is to remedy this issue by challenging the assumptions through an advanced algorithmic analysis. In particular, this proposal questions the two pillars of public-key encryption: factoring and discrete logarithms. Recently, the PI contributed to show that in some cases, the discrete logarithm problem is considerably weaker than previously assumed. A main objective is to ponder the security of other cases of the discrete logarithm problem, including elliptic curves, and of factoring. We will study the generalization of the recent techniques and search for new algorithmic options with comparable or better efficiency. We will also study hardness assumptions based on codes and subset-sum, two candidates for post-quantum cryptography. We will consider the applicability of recent algorithmic and mathematical techniques to the resolution of the corresponding putative hard problems, refine the analysis of the algorithms and design new algorithm tools. Cryptology is not limited to the above assumptions: other hard problems have been proposed to aim at post-quantum security and/or to offer extra functionalities. Should the security of these other assumptions become critical, they would be added to Almacrypt's scope. They could also serve to demonstrate other applications of our algorithmic progress. In addition to its scientific goal, Almacrypt also aims at seeding a strengthened research community dedicated to algorithmic and mathematical cryptology.

9.3. International Initiatives

- Partenariat Hubert Curien franco-turc (PHC Bosphore) with Gebze Technical University, Turkey.

  Title: "Gröbner bases, ResultAnts and Polyhedral gEometry" (GRAPE)

  Duration: 2019 – 2020 (2 years project)

  Coordinator: Elias Tsigaridas

9.3.1. Inria Associate Teams Not Involved in an Inria International Labs

9.3.1.1. MACAO

Title: Mathematics and Algorithms for Cryptographic Advanced Objects

International Partner (Institution - Laboratory - Researcher):

University of Wollongong (Australia) - Thomas Plantard

Start year: 2019

See also: https://ssl.informatics.uow.edu.au/MACAO/

Since quantum computers have the ability to break the two main problems on which current public cryptography relies, i.e., the factoring and discrete logarithm problem, every step towards the practical realization of these computers raises fears about potential attacks on cryptographic systems. By scrutinizing the techniques proposed to build post-quantum cryptography, we can identify a few candidate hard problems which underly the proposals. One objective of this international project is to precisely assess the security of these cryptographic algorithms. First, by analyzing in a systematic manner the existing resolution algorithms and by assessing their complexity as a function of security parameters. Then, we will consider new algorithmic techniques to solve these candidate hard Post-Quantum problems, both on classical computers and quantum machines aiming at the discovery of new and better algorithms to solve them.

9.3.2. Inria International Partners

9.3.2.1. Declared Inria International Partners

- University of Wollongong (Australia)

9.3.2.2. Informal International Partners

- CQT Singapour (UMI CNRS Majulab)
- UFPA - Para -Brésil (José Miguel Veloso)
- Institut Joseph Fourier - Université Grenoble Alpes (Martin Deraux, V. Vitse et Pierre Will)
- Max-Planck-Institut für Informatik - Saarbrücken - Germany (Alex. Kobel)
- Holon Institute of Technology, Israel (Jeremy Kaminsky)
- Department of Informatics, National Kapodistrian University of Athens, Greece (Ioannis Emiris)

PACAP Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

The Brittany Region is partially funding the PhD fellowship for Niloofar Charmchi on the topic “Hardware prefetching and related issues” and Nicolas Bellec on the topic “Security in real-time embedded systems”.

9.2. National Initiatives

9.2.1. Zero Power Computing Systems (ZEP): Inria Project Lab (2017–2020)

Participants: Erven Rohou, Bahram Yarahmadi.

This proposal addresses the issue of designing tiny wireless, batteryless, computing objects, harvesting energy in the environment. The energy level harvested being very low, very frequent energy shortages are expected. In order for the new system to maintain a consistent state, it will be based on a new architecture embedding non-volatile RAM (NVRAM). In order to benefit from the hardware innovations related to energy harvesting and NVRAM, software mechanisms will be designed. On the one hand, a compilation pass will compute a worst-case energy consumption. On the other hand, dedicated runtime mechanisms will allow:

1. to manage efficiently and correctly the NVRAM-based hardware architecture;
2. to use energy intelligently, by computing the worst-case energy consumption.

The ZEP project gathers four Inria teams that have a scientific background in architecture, compilation, operating systems together with the CEA Lialp and Lisan laboratories of CEA LETI & LIST [39]. The main application target is Internet of Things (IoT).

9.2.2. NOPE

Participants: Piéric Giraud, Erven Rohou, Bahram Yarahmadi.

NOPE is a one-year exploratory action funded by the Labex Cominlabs. This project aimed at being a first step, and served to elaborate more ambitious future works. Through this project, the consortium was able to grow its knowledge on a topical research theme and lay the foundations of an innovative hardware-software approach. The short term goals were:

- building and sharing across the consortium a strong expertise in state-of-the art results and tools on transient computing, and identifying challenges that should be focused on;
- initiating collaborations between the participants in order to identify opportunities at the hardware-software interface;
- building the foundations of a shared experimental platform for transient computing.

An intern, Piéric Giraud, was hired thanks to NOPE. He ported our WCET infrastructure Heptane to the MSP430 instruction set.

The NOPE project gathers teams PACAP, IETR Syscom and LS2N STR.

9.2.3. Hybrid SIMD architectures (2018–2019)

Participants: Caroline Collange, Alexandre Kouyoumdjian, Erven Rohou.

The project objective is to define new parallel computer architectures that offer high parallel performance on high-regularity workloads while keeping the flexibility to run more irregular parallel workloads. inspired by both GPU and SIMD or vector architectures.

This project is funded by the French Ministry of Armed Forces (*Ministère des Armées*).

9.2.4. DGA/PEC ARMOUR (2018–2021)

Participants: Kévin Le Bon, Erven Rohou.

ARMOUR (dynAmic binaRy optiMizatiOn cyber-secURity) aims at improving the security of computing systems at the software level. Our contribution will be twofold: (1) identify vulnerabilities in existing software, and (2) develop adaptive countermeasure mechanisms against attacks. We will rely on dynamic binary rewriting (DBR) which consists in observing a program and modifying its binary representation in memory while it runs. DBR does not require the source code of the programs it manipulates, making it convenient for commercial and legacy applications. We will study the feasibility of an adaptive security agent that monitors target applications and deploys (or removes) countermeasures based on dynamic conditions. Lightweight monitoring is appropriate when the threat condition is low, heavy countermeasures will be dynamically woven into the code when an attack is detected. Vulnerability analysis will be based on advanced fuzzing. DBR makes it possible to monitor and modify deeply embedded variables, inaccessible to traditional monitoring systems, and also to detect unexpected/suspicious values taken by variables and act before the application crashes.

ARMOUR is funded by DGA (*Direction Générale de l'Armement*) and PEC (*Pôle d'Excellence Cyber*).

9.2.5. ANR DYVE (31/03/2020 – 30/09/2023)

Participants: Arthur Blanleuil, Caroline Collange, Pierre-Yves Peneau.

Most of today's computer systems have CPU cores and GPU cores on the same chip. Though both are general-purpose, CPUs and GPUs still have fundamentally different software stacks and programming models, starting from the instruction set architecture. Indeed, GPUs rely on static vectorization of parallel applications, which demands vector instruction sets instead of CPU scalar instruction sets. In the DYVE project, we advocate a disruptive change in both CPU and GPU architecture by introducing Dynamic Vectorization at the hardware level.

Dynamic Vectorization will combine the efficiency of GPUs with the programmability and compatibility of CPUs by bringing them together into heterogeneous general-purpose multicores. It will enable processor architectures of the next decades to provide (1) high performance on sequential program sections thanks to latency-optimized cores, (2) energy-efficiency on parallel sections thanks to throughput-optimized cores, (3) programmability, binary compatibility and portability.

DYVE is funded by the ANR through the JCJC funding instrument.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. ARGO

Participants: Damien Hardy, Isabelle Puaut, Stefanos Skalistis.

Title: Argo: WCET-Aware Parallelization of Model-Based Applications for Heterogeneous Parallel Systems

Program: H2020

Type: RIA

Duration: Jan 2016 – Mar 2019

Coordinator: Karlsruhe Institut für Technologie (Germany)

Université de Rennes 1 contact: Steven Derrien

Partners:

Karlsruher Institut für Technologie (Germany)

SCILAB enterprises SAS (France)

Université de Rennes 1 (France)

Technologiko Ekpaideftiko Idryma (TEI) Dytikis Elladas (Greece)

Absint GmbH (Germany)

Deutsches Zentrum für Luft- und Raumfahrt EV (Germany)

Fraunhofer (Germany)

Increasing performance and reducing costs, while maintaining safety levels and programmability are the key demands for embedded and cyber-physical systems in European domains, e.g. aerospace, automation, and automotive. For many applications, the necessary performance with low energy consumption can only be provided by customized computing platforms based on heterogeneous many-core architectures. However, their parallel programming with time-critical embedded applications suffers from a complex toolchain and programming process. Argo (WCET-Aware PaRallelization of Model-Based Applications for HeteroGeneOus Parallel Systems) will address this challenge with a holistic approach for programming heterogeneous multi- and many-core architectures using automatic parallelization of model-based real-time applications. Argo will enhance WCET-aware automatic parallelization by a crosslayer programming approach combining automatic tool-based and user-guided parallelization to reduce the need for expertise in programming parallel heterogeneous architectures. The Argo approach will be assessed and demonstrated by prototyping comprehensive time-critical applications from both aerospace and industrial automation domains on customized heterogeneous many-core platforms.

Argo also involves Steven Derrien and Angeliki Kritikakou from the CAIRN team.

9.3.1.2. HiPEAC4 NoE

Participants: Pierre Michaud, Erven Rohou, André Seznec, Isabelle Puaut.

P. Michaud, A. Seznec and E. Rohou are members of the European Network of Excellence HiPEAC4.

HiPEAC4 addresses the design and implementation of high-performance commodity computing devices in the 10+ year horizon, covering both the processor design, the optimizing compiler infrastructure, and the evaluation of upcoming applications made possible by the increased computing power of future devices.

9.3.1.3. Eurolab-4-HPC

Participant: Erven Rohou.

Title: EuroLab-4-HPC: Foundations of a European Research Center of Excellence in High Performance Computing Systems

Program: H2020

Duration: September 2018 – September 2020

Coordinator: Chalmers Tekniska Hoegskola AB (Sweden)

Partners:

Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)

Chalmers Tekniska Hoegskola (Sweden)

Foundation for Research and Technology Hellas (Greece)

Universität Stuttgart (Germany)

The University of Manchester (United Kingdom)

Inria (France)

Universität Augsburg (Germany)

ETH Zürich (Switzerland)

École Polytechnique Federale de Lausanne (Switzerland)

Technion - Israel Institute of Technology (Israel)

The University of Edinburgh (United Kingdom)

Rheinisch-Westfaelische Technische Hochschule Aachen (Germany)

Universiteit Gent (Belgium)

Inria contact: Albert Cohen (Inria Paris)

Europe has built momentum in becoming a leader in large parts of the HPC ecosystem. It has brought together technical and business stakeholders from application developers via system software to exascale systems. Despite such gains, excellence in high performance computing systems is often fragmented and opportunities for synergy missed. To compete internationally, Europe must bring together the best research groups to tackle the long-term challenges for HPC. These typically cut across layers, e.g., performance, energy efficiency and dependability, so excellence in research must target all the layers in the system stack. The EuroLab-4-HPC project's bold overall goal is to build connected and sustainable leadership in high-performance computing systems by bringing together the different and leading performance oriented communities in Europe, working across all layers of the system stack and, at the same time, fueling new industries in HPC.

9.4. International Initiatives

9.4.1. ANR CHIST-ERA SECODE 2016–2019

Participants: Damien Hardy, Erven Rohou.

Title: SECODE – Secure Codes to Thwart Cyber-Physical Attacks

CHIST-ERA - RTCPS

Duration: January 2016 – December 2019 (one year extension)

Coordinator: Télécom Paris Tech (France)

Partners:

Télécom Paris Tech (France)

Inria (France)

Université Paris 8 (France)

Sabancı Üniversitesi (Turkey)

Université Catholique de Louvain (Belgium)

Inria contact: Erven Rohou

In this project, we specify and design error correction codes suitable for an efficient protection of sensitive information in the context of Internet of Things (IoT) and connected objects. Such codes mitigate passive attacks, like memory disclosure, and active attacks, like stack smashing. The innovation of this project is to leverage these codes for protecting against both cyber and physical attacks. The main advantage is a full coverage of attacks of the connected embedded systems, which is considered as a smart connected device and also a physical device. The outcome of the project is first a method to generate and execute cyber-resilient software, and second to protect data and its manipulation from physical threats like side-channel attacks.

9.4.2. Informal International Partners

Caroline Collange has collaborated with Marcos Yukio Siraichi, Vinicius Fernandes dos Santos and Fernando Magno Quintão Pereira from UFMG, Brazil [31].

Isabelle Puaut has collaborated with Renato Mancuso (University of Boston, USA) and Heechul Yun (University of Kansas, USA) on predictable memory hierarchies [26]. She has collaborated with Martin Schoeberl (Technical University of Denmark) on predictable branch predictors [29].

Erven Rohou has been collaborating with Prof. Ahmed El-Mahdy (Egypt-Japan University of Science and Technology, Alexandria, Egypt) and his group [21], [22].

Erven Rohou and Loïc Besnard have been collaborating with Prof. João Cardoso (University of Porto, Porto, Portugal) and his group [16].

PARKAS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

The ANR JCJC project “FidelR” was awarded to Timothy Bourke this year and will begin in 2020.

8.1.1.1. ANR/CHIST-ERA DIVIDEND project, 2013-2019.

This project continues.

8.1.2. FUI: Fonds unique interministériel

8.1.2.1. Modeliscale contract (AAP-24)

Using Modelica at scale to model and simulate very large Cyber-Physical Systems. Principal industrial partner: Dassault-Systèmes. Inria contacts are Benoit Caillaud (HYCOMES, Rennes) and Marc Pouzet (PARKAS, Paris).

8.1.3. Programme d’Investissements d’Avenir (PIA)

8.1.3.1. ES3CAP collaborative project (Bpifrance)

Develop a software and hardware platform for tomorrow’s intelligent systems. PARKAS collaborates with the industrial participants ANSYS/Esterel Technologies, Kalray, and Safran Electronics & Defense. Inria contacts are Marc Pouzet (PARKAS, Paris) and Fabrice Rastello (CORSE, Grenoble).

8.1.4. Others

8.1.4.1. Inria Project Lab (IPL) Modeliscale

This project treats the modelling and analysis of Cyber-Physical Systems at large scale. The PARKAS team contributes their expertise in programming language design for reactive and hybrid systems to this multi-team effort.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

- MNEMOSENE is a project with funding from the European Union’s Horizon 2020 Research and Innovation Programme. Its objectives include the improvement of the energy-delay product, the computational efficiency and performance density by several orders of magnitude compared to state-of-the-art architectures. A cornerstone of the proposed solution is the memristor-based Compute-in-Memory (CIM) architecture, which eliminates long-distance, high-latency data transfers between memory and computing units required in conventional Von Neumann-based architectures by carrying out computations for performance-critical operations directly in memory.
- TETRAMAX, *Technology Transfer via Multinational Application Experiments*, is funded by the H2020 “Smart Anything Everywhere (SAE)” initiative. The overall ambition is to build and leverage a European Competence Center Network in customized low-energy computing, providing easy access for SMEs and mid-caps to novel CLEC technologies via local contact points. This is a bidirectional interaction: SMEs can demand CLEC technologies and solutions via the network, and vice versa academic research institutions can actively and effectively offer their new technologies to European industries. Furthermore, TETRAMAX wants to support 50+ industry clients and 3rd parties with innovative technologies, using different kinds of Technology Transfer Experiments (TTX) to accelerate innovation within European industries and to create a competitive advantage in the global economy.

8.3. International Initiatives

8.3.1. Participation in Other International Programs

- VerticA (Francesco Zappa Nardelli), 2017-2020, joint project with Northeastern University, USA, financed by the ONR (Office of Naval Research), $1.5M (subcontract for $150k).

PARSIFAL Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. DIM-RFSI

Gabriel Scherer obtained funding from the Région Île-de-France to hire a post-doc, Luc Pellissier, to work on canonical representation of programs (linking proof theory and category-theory approaches), in collaboration with Adrien Guatto in IRIF (Université Paris 7).

9.2. National Initiatives

9.2.1. ANR

COCA HOLA: Cost Models for Complexity Analyses of Higher-Order Languages, coordinated by B. Accattoli, 2016–2019.

FISP: The Fine Structure of Formal Proof Systems and their Computational Interpretations, coordinated by Lutz Straßburger in collaboration with Université Paris 7, Universität Innsbruck and TU Wien, 2016–2019.

9.2.2. Competitivity Clusters

UPScale: Universality of Proofs in SaCLay, a Working Group of LabEx DigiCosme, organized by Chantal Keller (LRI) with regular participation from Parsifal members and a post-doc co-supervision.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

Claudio Sacerdoti Coen (Universita di Bologna, Italy) spent a month visiting Beniamino Accattoli thanks to funding for short-term international visits.

PESTO Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- ANR SEQUOIA *Security properties, process equivalences and automated verification*, duration: 4 years, since October 2014, leader: Steve Kremer, other partners: ENS Cachan, Univ Luxembourg. Most protocol analysis tools are restricted to analyzing reachability properties while many security properties need to be expressed in terms of some process equivalences. The increasing use of observational equivalence as a modeling tool shows the need for new tools and techniques that are able to analyze such equivalence properties. The aims of this project are *(i)* to investigate which process equivalences — among the plethora of existing ones — are appropriate for a given security property, system assumptions and attacker capabilities; *(ii)* to advance the state of the art of automated verification for process equivalences, allowing for instance support for more cryptographic primitives, relevant for case studies; *(iii)* to study protocols that use low-entropy secrets expressed using process equivalences; *(iv)* to apply these results to case studies from electronic voting.
- ANR TECAP *Protocol Analysis — Combining Existing Tools*, duration: 4 years, starting in 2018, leader: Vincent Cheval, other partners: ENS Cachan, Inria Paris, Inria Sophia Antipolis, IRISA, LIX. Despite the large number of automated verification tools, several cryptographic protocols (e.g. stateful protocols) still represent a real challenge for these tools and reveal their limitations. To cope with these limits, each tool focuses on different classes of protocols depending on the primitives, the security properties, etc. Moreover, the tools cannot interact with each other as they evolve in their own model with specific assumptions. The aim of this project is to get the best of all these tools, that is, to improve the theory and implementations of each individual tool towards the strengths of the others and to build bridges that allow the cooperations of the methods/tools. We will focus in this project on CryptoVerif, EasyCrypt, Scary, ProVerif, *TAMARIN*, *Akiss* and APTE. In order to validate the results obtained in this project, we will apply our results to several case studies such as the Authentication and Key Agreement protocol from the telecommunication networks, the Scytl and Helios voting protocols, and the low entropy 3D-Secure authentication protocol. These protocols have been chosen to cover many challenges that the current tools are facing.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

- SPOOC (2015–2020) [0]— ERC Consolidator Grant on Automated Security Proofs of Cryptographic Protocols: Privacy, Untrusted Platforms and Applications to E-voting Protocols.

  The goals of the Spooc project are to develop solid foundations and practical tools to analyze and formally prove security properties that ensure the privacy of users as well as techniques for executing protocols on untrusted platforms. We will

  - develop foundations and practical tools for specifying and formally verifying new security properties, in particular privacy properties;
  - develop techniques for the design and automated analysis of protocols that have to be executed on untrusted platforms;
  - apply these methods in particular to novel e-voting protocols, which aim at guaranteeing strong security guarantees without the need to trust the voter client software.

[0] https://members.loria.fr/SKremer/files/spooc/index.html

Steve Kremer is the leader of the project.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

- Collaboration with David Basin, Ralf Sasse and Lara Schmid (ETH Zurich), Cas Cremers (Helmholtz Center for Information Security (CISPA)), and Sasa Radomirovic (Univ Dundee) on the improvement of the *TAMARIN* prover
- Collaboration with David Basin and Lara Schmid (ETH Zurich) on the study of the security impact of the bulletin board in e-voting protocols
- Collaboration with Guillaume Girol (CEA), David Basin, Ralf Sasse (ETH Zurich), Dennis Jackson (Univ Oxford), and Cas Cremers (Helmholtz Center for Information Security (CISPA)) on a new security analysis framework for the Noise language
- Collaboration with Ravishankar Borgaonkar (Sintef), Shinjo Park, and Altaf Shaik (TU Berlin) on the study of practical privacy attacks in mobile communication
- Collaboration with Matteo Maffei (Univ Wien) on type systems for e-voting systems
- Collaboration with Bogdan Warinschi (Univ Bristol) on defining game-based privacy for e-voting protocols
- Collaboration with Robert Künnemann (CISPA, Germany) on the development of the SAPIC tool
- Collaboration with Gilles Barthe (MPI for Security and Privacy, Germany) on the automation of computer-aided cryptographic proofs
- Collaboration with Paliath Narendran's group (SUNY Albany) on automated deduction
- Collaboration with Serdar Erbatur (LMU, Germany) and Andrew Marshall (Univ Mary Washington, USA) on decision procedures for combined equational theories
- Collaboration with Hanifa Boucheneb's group (Polytechnique Montreal) on model-checking of collaborative systems
- Collaboration with John Mullins's group (Polytechnique Montreal) on information hiding

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Bogdan Warinschi (Univ Bristol), November 2018 and April 2019.
- Ralf Sasse (ETH Zurich), November 2019.

PI.R2 Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

Pierre-Louis Curien, Emilio J. Gallego Arias, Yves Guiraud, Hugo Herbelin, and Alexis Saurin are members of the GDR Informatique Mathématique, in the LHC (Logique, Homotopie, Catégories) and Scalp (Structures formelles pour le calcul et les preuves) working groups. Alexis Saurin is coordinator of the Scalp working group.

Pierre-Louis Curien, Yves Guiraud (local coordinator until Sept. 2019) and Matthieu Sozeau are members of the GDR Topologie Algébrique, federating French researchers working on classical topics of algebraic topology and homological algebra, such as homotopy theory, group homology, K-theory, deformation theory, and on more recent interactions of topology with other themes, such as higher categories and theoretical computer science.

Yves Guiraud is member of the GDR Tresses, federating French researchers working on algebraic, algorithmic and topological aspects of braid groups, low-dimensional topology, and connected subjects.

Yves Guiraud will coordinate the four-year Action Exploratoire Inria Réal (Réécriture Algébrique), starting in January 2020. Its aim is to continue the unification of rewriting-like methods in abtract and higher algebra, with a view toward applications in homological and higher algebra, and group and representation theory. This investigation is pursued in immersion at IMJ-PRG, the fundamental maths common laboratory of Sorbonne Université and Université Paris Diderot.

Emilio J. Gallego Arias is a member of the GDR Génie de la Programation et du Logiciel, in the LTP (Langages, Types et Preuves) group.

Yann Régis-Gianas collaborates with Mitsubishi Rennes on the topic of differential semantics. This collaboration led to the CIFRE grant for the PhD of Thibaut Girka.

Yann Régis-Gianas collaborates with ANSSI on the topic of certified ful programming in Coq.

Yann Régis-Gianas collaborates with Nomadic Labs on the topic of certified smart contract compilation.

Yann Régis-Gianas is a member of the ANR COLIS dedicated to the verification of Linux Distribution installation scripts. This project is joint with members of VALS (Univ Paris Sud) and LIFL (Univ Lille).

Yann Régis-Gianas and Alexis Saurin (coordinator) are members of the four-year RAPIDO ANR project, started in January 2015 and ended in September 2019. RAPIDO aims at investigating the use of proof-theoretical methods to reason and program on infinite data objects. The goal of the project is to develop logical systems capturing infinite proofs (proof systems with least and greatest fixpoints as well as infinitary proof systems), to design and to study programming languages for manipulating infinite data such as streams both from a syntactical and semantical point of view. Moreover, the ambition of the project is to apply the fundamental results obtained from the proof-theoretical investigations (i) to the development of software tools dedicated to the reasoning about programs computing on infinite data, *e.g.* stream programs (more generally coinductive programs), and (ii) to the study of properties of automata on infinite words and trees from a proof-theoretical perspective with an eye towards model-checking problems. Other permanent members of the project are Christine Tasson from IRIF (PPS team), David Baelde from LSV, ENS-Cachan, and Pierre Clairambault, Damien Pous and Colin Riba from LIP, ENS-Lyon.

Matthieu Sozeau is a member of the CoqHoTT project led by Nicolas Tabareau (Gallinette team, Inria Nantes & École des Mines de Nantes), funded by an ERC Starting Grant, ending in 2020. The PhD grant of Antoine Allioux is funded by the CoqHoTT ERC.

8.2. European Initiatives

8.2.1. Collaborations in European Programs, Except FP7 & H2020

- Program: COST
- Project acronym: EUTypes
- Project title: The European research network on types for programming and verification
- Duration: March 2016 - March 2020
- Coordinator: Herman Geuvers
- Other partners: 29 countries
- Abstract: This COST promotes (1) the synergy between theoretical computer scientists, logicians and mathematicians to develop new foundations for type theory (2) the joint development of type theoretic tools as proof assistants and integrated programming environments, (3) the study of dependent types for programming and its deployment in software development, (4) the study of dependent types for verification and its deployment in software analysis and verification.

8.3. International Initiatives

8.3.1. Inria Associate Teams Not Involved in an Inria International Labs

Pierre-Louis Curien and Claudia Faggian are members of the CRECOGI associate team, coordinated on one side by Ugo dal Lago (research-team FoCUS, Inria Sophia and Bologna), and on the other side by Ichiro Hasuo (NII, Tokyo). The full name of the project is Concurrent, Resourceful and full Computation, by Geometry of Interaction. This project was renewed in 2019 for a duration of two years.

Presentation of CRECOGI: Game semantics and geometry of interaction (GoI) are two closely related frameworks whose strengh is to have the characters of both a denotational and an operational semantics. They offer a high-level, mathematical (denotational) interpretation, but are interactive in nature. The formalisation in terms of movements of tokens through which programs communicate with each other can actually be seen as a low-level program. The current limit of GoI is that the vast majority of the literature and of the software tools designed around it have a pure, sequential functional language as their source language. This project aims at investigating the application of GoI to concurrent, resourceful, and effectful computation, thus paving the way to the deployment of GoI-based correct-by-construction compilers in real-world software developments in fields like (massively parallel) high-performance computing, embedded and cyberphysical systems, and big data. The presence of both the Japanese GoI community (whose skills are centered around effects and coalgebras) and the French GoI community (more focused on linear logic and complexity analysis) bring essential, complementary, ingredients.

8.3.2. Inria International Partners

8.3.2.1. Participation in International Programs

Pierre-Louis Curien and Alexis Saurin are members of CNRS GDRI-LL a french-italian network on linear logic community in France and Italy.

8.3.2.2. International Initiatives

Pierre-Louis Curien is principal investigator on the French side for a joint project Inria - Chinese Academy of Sciences. The project's title is "Verification, Interaction, and Proofs" (December 2017 – December 2020). The principal investigator on the Chinese side is Ying Jiang, from the Institute of Software (ISCAS) in Beijing. The participants of the project on the French side are Pierre-Louis Curien and Jean-Jacques Lévy, as well as other members of IRIF (Thomas Ehrhard, Jean Krivine, Giovanni Bernardi, Ahmed Bouajjani, Mihaela Sighireanu, Constantin Enea, Gustavo Petri), and Gilles Dowek (Deducteam team of Inria Saclay). On the Chinese side, the participants are Ying Jiang, as well as other members of the ISCAS (Angsheng Li, Xinxin Liu, Yi Lü, Peng Wu, Yan Rongjie, Zhilin Wu, and Wenhui Zhang), and Yuxi Fu (from Shanghai Jiaotong University).

8.4. International Research Visitors

8.4.1. Research Stays Abroad

Matthieu Sozeau visited the Programming Languages group of Benjamin Pierce at the University of Pennsylvania in June and July 2019, along with visits at MIT and Princeton to other members of the NSF DeepSpec project.

Pierre-Louis Curien visited East China Normal University (ECNU), Shanghai, for a month from early October to early December 2019 as invited professor.

8. Partnerships and Cooperations

8.1. Regional Initiatives

- **Grant CAMiSAdo** (funded by PGMO).

  COMPUTER ALGEBRA METHODS FOR SEMI-ALGEBRAIC PROGRAMMING

  `Participants:` J. Berthomieu [contact], M. Safey El Din.

  Semi-Algebraic Programming is the art of optimizing some quantity subject to semi-algebraic constraints. The very basic and natural instance of semi-algebraic programming is the problem of optimizating a polynomial function subject to polynomial inequalities and is known as the polynomial optimization problem (POP). More general instances of semi-algebraic programming are as follows: given a system of polynomial equations/inequalities depending on parameters, what are the parameters' values which maximize the dimension of the semi-algebraic set defined by the instantiated system? And when the number of solutions is finite, what is this maximum number of solutions? Hence Semi-Algebraic Programming encompasses a wide range of computational issues related to semi-algebraic sets. It finds applications in many engineering sciences. Let us mention the few ones that we target in CAMiSAdo: Path-planning optimization in robotics, Mobility properties of manipulators in mechanism design, Stability analysis for sensor-based controllers.

8.2. National Initiatives

- **ANR SESAME (Singularités Et Stabilité des AsservisseMEnts référencés capteurs)**

  `Duration:` 2018–2022

  `Participants:` J.-C. Faugère, M. Safey El Din [contact].

  The demand for flexible, adaptable robots capable of interacting with their environment (e.g. navigation, handling, cooperation) is growing. This is why the sensor-based controllers, which make it possible to include external sensory feedback in robot control, have been widely developed in recent years, both for industrial, medical, air, space and marine robotics and in the context of autonomous vehicles (ground mobile robotics).

  The first research on sensor-based control techniques took place at the end of the 1980s, with the use of proximal and force and vision sensors, and much work has been done to improve the performance of this type of controllers, in particular by modelling various sensor primitives.

  Despite the fact that, empirically, sensor-based controllers have shown that they have interesting performances, these performances are by no means guaranteed, which is a major obstacle to the widespread use of their large-scale use. This is related to the fact that, despite three decades of research on the subject, two broad classes of problems have been little explored:

  - The study of the singularities of sensor-based controllers
  - The study of their stability.

  The objectives of the project SESAME are take advantage on recent mathematical advances in order to:

  - study singularities and stability of certain classes of sensor-based controllers
  - synthesize globally asymptotically stable sensor-based controllers, whose performance (i.e. convergence properties towards the desired configuration, abseance of local singularities and minima) are guaranteed in all object/sensor related configurations.

Many of the computational tools SESAME relies on involve computer algebra and polynomial system solving.

- **ANR Jeunes Chercheurs GALOP (Games through the lens of ALgebra and OPptimization)**

  `Duration:` 2018–2022

  `Participants:` E. Tsigaridas [contact], F. Johansson, H. Gimbert, J.-C. Faugère, M. Safey El Din.

  GALOP [0] is a Young Researchers (JCJC) project with the purpose of extending the limits of the state-of-the-art algebraic tools in computer science, especially in stochastic games. It brings original and innovative algebraic tools, based on symbolic-numeric computing, that exploit the geometry and the structure and complement the state-of-the-art. We support our theoretical tools with a highly efficient open-source software for solving polynomials. Using our algebraic tools we study the geometry of the central curve of (semi-definite) optimization problems. The algebraic tools and our results from the geometry of optimization pave the way to introduce algorithms and precise bounds for stochastic games.

- **ANR ECARP (Efficient Certified Algorithms for Robot Motion Planning)**

  `Duration:` 2020–2024

  `Participants:` J. Berthomieu, J.-C. Faugère, M. Safey El Din [contact].

  ECARP is an international project, jointly funded by ANR and FWF (the funding agency of Austria). It targets the design and implementation of high-performance computer algebra algorithms for semi-algebraic sets in order to answer connectivity queries over those sets. This is applied to motion planning issues in robotics, e.g. for analyzing kinematic singularities ; parallel and serial manipulators will be investigated. The consortium gathers experts in geometry and robotics from J. Kepler Univ. (Austria) and LS2N (Nantes).

- **ANR DRN (DeRerumNatura)**

  `Duration:` 2020–2024

  `Participants:` J. Berthomieu [contact], M. Safey El Din.

  Classifying objects, determining their nature is more often than not the endgame of a theory. Yet, even the most established theory can be impractible on a concrete instance, either because of a lack of efficiency or because of a computational wall. In both cases, an algorithm is lacking: we need to systematize efficiently and automatically. This is what DRN proposes to do to solve classification problems related to numbers, analytic functions and combinactorics generating series. The consortium gathers experts in computer algebra (Inria Saclay, Limoges, Lyon, POLSYS), Combinactorics (Inria Saclay, Lyon) and Galois Theory (Toulouse, Strasbourg, Versailles).

8.2.1. Programme d'investissements d'avenir (PIA)

- **PIA grant RISQ: Regroupement of the Security Industry for Quantum-Safe security (2017-2020).** The goal of the RISQ project is to prepare the security industry to the upcoming shift of classical cryptography to quantum-safe cryptography. (J.-C. Faugère [contact], and L. Perret).

  The RISQ [0] project is certainly the biggest industrial project ever organized in quantum-safe cryptography. RISQ is one of few projects accepted in the call Grands Défis du Numérique which is managed by BPI France, and will be funded thanks to the so-called Plan d'Investissements d'Avenir.

  The RISQ project is a natural continuation of POLSYS commitment to the industrial transfert of quantum-safe cryptography. RISQ is a large scale version of the HFEBoost project; which demonstrated the potential of quantum-safe cryptography.

[0] https://project.inria.fr/galop/
[0] http://risq.fr/

POLSYS actively participated to shape the RISQ project. POLSYS is now a member of the strategic board of RISQ, and is leading the task of designing and analyzing quantum-safe algorithms. In particular, a first milestone of this task was to prepare submissions to NIST's quantum-safe standardisation process.

8.3. European Initiatives

- Innovative Training Network POEMA (Polynomial Optimization, Efficiency through Moments and Algebra) - ITN Marie Curie H2020 program.

  `Duration:` 2019–2023

  `Participants:` J. Berthomieu, J.-C. Faugère, M. Safey El Din [contact].

  POEMA is part of the Marie Sklodowska-Curie Actions — Innovative Training Networks (ITN) funding scheme.

  POEMA aims to train scientists at the interplay of algebra, geometry and computer science for polynomial optimization problems and to foster scientific and technological advances, stimulating interdisciplinary and intersectoriality knowledge exchange between algebraists, geometers, computer scientists and industrial actors facing real-life optimization problems.

PRIVATICS Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. AMNECYS

- Title: AMNECYS
- Duration: 2015 - .
- Coordinator: CESICE, UPMF.
- Others partners: Inria/Privatics and LIG/Moais, Gipsa-lab, LJK, Institut Fourier, TIMA, Vérimag, LISTIC (Pole MSTIC) .
- Abstract: Privatics participates to the creation of an Alpine Multidisciplinary NEtwork on CYbersecurity Studies (AMNECYS). The academic teams and laboratories participating in this project have already developed great expertise on encryption technologies, vulnerabilities analysis, software engineering, protection of privacy and personal data, international & European aspects of cybersecurity. The first project proposal (ALPEPIC ALPs-Embedded security: Protecting Iot & Critical infrastructure) focuses on the protection of the Internet of Things (IoT) and Critical Infrastructure (CI).

7.1.2. Data Institute

- Title: Data Institute UGA
- Duration: 2017 - .
- Coordinator: TIMC-IMAG.
- Others partners: AGEIS, BIG, CESICE, GIN, GIPSA-lab, IAB, IGE, IPAG, LAPP, LARHRA, LIDILEM, LIG, LISTIC, LITT&ArTS, LJK, LUHCIE, LECA, OSUG, PACTE, TIMC-IMAG
- Abstract: Privatics is leading the WP5 (Data Governance, Data Protection and Privacy). This action (WP5) aims to analyze, in a multi-disciplinary perspective, why and how specific forms of data governance emerge as well as the consequences on the interaction between the state, the market and society. The focus will be on the challenges raised by the collection and use of data for privacy, on the data subjects' rights and on the obligations of data controllers and processors. A Privacy Impact/Risk assessments methodology and software will be proposed. A case study will focus on medical and health data and make recommendations on how they should be collected and processed.

7.1.3. CyberAlps

- Title: CyberAlps
- Duration: 2018 - .
- Coordinator: IF.
- Others partners: CEA LETI, CERAG, CESICE, CREg, G2E lab, GIPSA-lab, GSCOP, IF, LCIS, LIG, LISTIC, LJK, PACTE, TIMC-IMAG, VERIMAG.
- Abstract: The Grenoble Alpes Cybersecurity Institute aims at undertaking ground-breaking interdisciplinary research in order to address cybersecurity and privacy challenges. Our main technical focus is on low-cost secure elements, critical infrastructures, vulnerability analysis and validation of large systems, including practical resilience across the industry and the society. Our approach to cybersecurity is holistic, encompassing technical, legal, law-enforcement, economic, social, diplomatic, military and intelligence-related aspects with strong partnerships with the private sector and robust national and international cooperation with leading institutions in France and abroad.

7.1.4. Antidot

- Title: Antidot
- Type: Fédération Informatique de Lyon (inter laboratories project)
- Duration: September 2018 - 2020.
- Coordinator: Inria.
- Others partners: LIRIS.
- Abstract: The ANTIDOT project is interested in the privacy issues raised by the increasingly ubiquitous collection of mobility data and their exploitation by third-party applications. The objective of this project is to propose solutions and tools to increase the user awareness about the risks of violation of their privacy in the context of the mobile Internet. In order to achieve this objective, ANTIDOT will jointly address the study of information gathering mechanisms, the study of mobility data vulnerabilities and the protection of this personal data.

7.1.5. DARC

- Title: DARC - the Data Anonymization and Re-identification Competition
- Type: Innovation Pédagogique - IDEX LYON
- Duration: September 2019 - 2020.
- Coordinator: INSA.
- Abstract: In order to increase awareness and empower future digital engineers in a fun way on privacy issues, the DARC project offers learning through play through a challenge carried out jointly by three different training courses of INSA students in Bourges and in Lyon. This challenge consists first of all in anonymizing a dataset from an online sales site, then secondly in trying to re-identify the anonymized data of the other groups.

7.2. National Initiatives

7.2.1. ADT PRESERVE

- Title: PRESERVE: Plate-foRme wEb de SEnsibilisation aux pRoblèmes de Vie privéE
- Duration: 2019 - 2020
- Coordinator: INSA.
- Abstract: The goal of this project is to develop a web platform to increase the user awareness on privacy issues. This platform will gather multiple works investigated in the team and will be used to conduct demonstration and stimulate new collaborations and dissemination actions to end users and media.

7.2.2. ANR

7.2.2.1. CISC

Title: Certification of IoT Secure Compilation.

Type: ANR.

Duration: April 2018 - March 2022.

Coordinator: Inria INDES project-team (France)

Others partners: Inria CELTIC project-team (France), College de France (France) (France).

See also: http://cisc.gforge.inria.fr.

Abstract: The objective of the ANR CISC project is to investigate multitier languages and compilers to build secure IoT applications with private communication. A first goal is to extend multitier platforms by a new orchestration language that we call Hiphop.js to synchronize internal and external activities of IoT applications as a whole. CISC will define the language, semantics, attacker models, and policies for the IoT and investigate automatic implementation of privacy and security policies by multitier compilation of IoT applications. To guarantee such applications are correct, and in particular that the required security and privacy properties are achieved, the project will certify them using the Coq proof assistant.

7.2.2.2. SIDES 3.0

Title: Application of privacy by design to biometric access control.

Type: ANR.

Duration: August 2017 - August 2020.

Coordinator: Uness (France).

Others partners: Inria, UGA, ENS, Theia, Viseo.

Abstract: Since 2013, faculties of medicine have used a shared national platform that enables them to carry out all of their validating exams on tablets with automatic correction. This web platform entitled SIDES allowed the preparation of the medical students to the Computerized National Classing Events (ECN) which were successfully launched in June 2016 (8000 candidates simultaneously throughout France). SIDES 3.0 proposes to upgrade the existing platform. Privatics goals in this project is to ensure that privacy is respected and correctly assessed .

7.2.2.3. DAPCODS/IOTics

Title: DAPCODS/IOTics.

Type: ANR 2016.

Duration: May 2017 - Dec. 2020.

Coordinator: Inria PRIVATICS.

Others partners: Inria DIANA, EURECOM, Univ. Paris Sud, CNIL.

Abstract:

Thanks to the exponential growth of Internet, citizens have become more and more exposed to personal information leakage in their digital lives. This trend began with web tracking when surfing the Internet with our computers. The advent of smartphones, our personal assistants always connected and equipped with many sensors, further reinforced this tendency. And today the craze for “quantified self” wearable devices, for smart home appliances or for other connected devices enable the collection of potentially highly sensitive personal information in domains that were so far out of reach. However, little is known about the actual practices in terms of security, confidentiality, or data exchanges. The enduser is therefore prisoner of a highly asymmetric system. This has important consequences in terms of regulation, sovereignty, and leads to the hegemony of the GAFAs (Google, Amazon, Facebook and Apple). Security, transparency and user control are three key properties that should be followed by all the stakeholders of the smartphone and connected devices ecosystem. Recent scandals show that the reality is sometimes at the opposite.

The DAPCODS project gathers four renowned research teams, experts in security, privacy and digital economy. They are seconded by CNIL, the French data protection agency. The project aims at contributing along several axes:

- by analyzing the inner working of a significant set of connected devices in terms of personal information leaks. This will be made possible by analyzing their data flows (and associated smartphone application if applicable) from outside (smartphone and/or Wifi network) or inside, through ondevice static and dynamic analyses. New analysis methods and tools will be needed, some of them leveraging on previous works when applicable;

- by studying the device manufacturers' privacy policies along several criteria (e.g., accessibility, precision, focus, privacy risks). In a second step, their claims will be compared to the actual device behavior, as observed during the test campaigns. This will enable an accurate and unique ranking of connected devices;
- by understanding the underlying ecosystem, from the economical viewpoint. Data collected will make it possible to define the blurred boundaries of personal information market, a key aspect to set up an efficient regulation;
- and finally, by proposing a public website that will rank those connected devices and will inform citizens. We will then test the impact of this information on the potential change of behavior of stakeholders.

By giving transparent information of hidden behaviors, by highlighting good and bad practices, this project will contribute to reduce the information asymmetry of the system, to give back some control to the endusers, and hopefully to encourage certain stakeholders to change practices.

7.2.3. Inria-CNIL collaboration

Privatics is in charged of the Cnil-Inria collaboration. This collaboration was at the origin of the Mobilitics project and it is now at the source of many discussions and collaborations on data anoymisation, risk analysis, consent or IoT Privacy. Privatics and Cnil are both actively involved on the IoTics project, that is the follow-up of the Mobilitics projects. The goal of the Mobilitics project was to study information leakage in mobile phones. The goal of IoTics is to extend this work to IoT and connected devices.

Privatics is also in charged of the organization of the Cnil-Inria prize that is awarded every year to an outstanding publication in the field of data privacy.

7.3. European Initiatives

7.3.1. Collaborations in European Programs, Except FP7 & H2020

7.3.1.1. UPRISE-IoT

Title: User-centric PRIvacy & Security in IoT

Programm: CHISTERA

Duration: December 2016 - December 2019

Coordinator: SUPSI (Suisse)

Inria contact: Claude Castelluccia

The call states that "Traditional protection techniques are insufficient to guarantee users' security and privacy within the future unlimited interconnection": UPRISE-IoT will firstly identify the threats and model the behaviours in IoT world, and further will build new privacy mechanisms centred around the user. Further, as identified by the call "all aspects of security and privacy of the user data must be under the control of their original owner by means of as simple and efficient technical solutions as possible", UPRISE-IoT will rise the awareness of data privacy to the users. Finally, it will deeply develop transparency mechanisms to "guarantee both technically and regulatory the neutrality of the future internet." as requested by the call. The U-HIDE solution developed inn UPRISE-IoT will "empower them to understand and make their own decisions regarding their data, which is essential in gaining informed consent and in ensuring the take-up of IoT technologies", using a methodology that includes "co-design with users to address the key, fundamental, but inter-related and interdisciplinary aspects of privacy, security and trust."

7.3.1.2. SPARTA

Title: Strategic Programs for Advanced Research and Technology in Europe (SPARTA)

Programm: H2020-SU-ICT-03-2018

Duration: February 2019 - January 2022

Coordinator: CEA

Inria contact: Thomas Jensen (Inria), Vincent Roca (for PRIVATICS)

SPARTA Cybersecurity European Competence Network. The consortium consists of 44 partners from 14 different countries, with the goal to demonstrate the setup and assessment of a European SPARTA Cybersecurity Competence Network.

7.4. International Initiatives

7.4.1. DATA

Title: Data and Algorithmic Transparency and Accountability

International Partner (Institution - Laboratory - Researcher):

Université du Québec à Montréal (UQAM) (Canada) - Département d'informatique - Sébastien Gambs

Start year: 2018

See also: http://planete.inrialpes.fr/data-associated-team/

The accelerated growth of the Internet has outpaced our abilities as individuals to maintain control of our personal data. The recent advent of personalized services has lead to the massive collection of personal data and the construction of detailed profiles about users. However, users have no information about the data which constitute its profile and how they are exploited by the different entities (Internet companies, telecom operators, ...). This lack of transparency gives rise to ethical issues such as discrimination or unfair processing.

In this associate team, we propose to strengthen the complementary nature and the current collaborations between the Inria Privatics group and UQAM to advance research and understanding on data and the algorithmic transparency and accountability.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- Jeremy Decouchant (University of Luxembourg) visited Privatics from 14/10/2019 to 25/10/2019 through the Erasmus Staff Mobility For Teaching program. During the visit, Jeremie Decouchant participated in network programming lectures and practical sessions at the INSA Lyon engineering school at the M1 level. In addition, the existing scientific collaborations with the team have been also extended around the usage of Intel Software Guard Extensions (SGX) to implement a privacy-preserving recommendation systems and genome studies.
- Gergely Acs, assistant professor at Budapest University (Hungary), visited our team in June. He worked together with Claude Castelluccia on the security and privacy of Federated machine learning.
- Rosin Claude Ngueveu (UQAM) visited the team in Lyon in July 2019 for two weeks to increase the DATA collaboration. During the visit, Rosin Claude Ngueveu presented joint work at APVP 2019 and advanced existing collaboration to include fairness in our work on protection of motion sensor data.

PROSECCO Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. AnaStaSec

Title: Static Analysis for Security Properties (ANR générique 2014.)

Other partners: Inria Paris/EPI Antique, Inria Rennes/EPI Celtique, Airbus Operations SAS, AMOSSYS, CEA-LIST, TrustInSoft

Duration: January 2015 - September 2019.

Coordinator: Jérôme Féret, EPI Antique, Inria Paris (France)

Participant: Bruno Blanchet

Abstract: The project aims at using automated static analysis techniques for verifying security and confidentiality properties of critical avionics software.

9.1.1.2. AJACS

Title: AJACS: Analyses of JavaScript Applications: Certification and Security

Other partners: Inria-Rennes/Celtique, Inria-Saclay/Toccata, Inria-Sophia Antipolis/INDES, Imperial College London

Duration: October 2014 - March 2019.

Coordinator: Alan Schmitt, Inria (France)

Participants: Karthikeyan Bhargavan, Bruno Blanchet, Nadim Kobeissi

Abstract: The goal of the AJACS project is to provide strong security and privacy guarantees for web application scripts. To this end, we propose to define a mechanized semantics of the full JavaScript language, the most widely used language for the Web, to develop and prove correct analyses for JavaScript programs, and to design and certify security and privacy enforcement mechanisms.

9.1.1.3. SafeTLS

Title: SafeTLS: La sécurisation de l'Internet du futur avec TLS 1.

Other partners: Université Rennes 1, IRMAR, Inria Sophia Antipolis, SGDSN/ANSSI

Duration: October 2016 - September 2020

Coordinator: Pierre-Alain Fouque, Université de Rennes 1 (France)

Participants: Karthikeyan Bhargavan

Abstract: Our project, SafeTLS, addresses the security of both TLS 1.3 and of TLS 1.2 as they are (expected to be) used, in three important ways: (1) A better understanding: We will provide a better understanding of how TLS 1.2 and 1.3 are used in real-world applications; (2) Empowering clients: By developing a tool that will show clients the quality of their TLS connection and inform them of potential security and privacy risks; (3) Analyzing implementations: We will analyze the soundness of current TLS 1.2 implementations and use automated verification to provide a backbone of a secure TLS 1.3 implementation.

9.1.1.4. TECAP

Title: TECAP: Protocol Analysis - Combining Existing Tools (ANR générique 2017.)

Other partners: Inria Nancy/EPI PESTO, Inria Sophia Antipolis/EPI MARELLE, IRISA, LIX, LSV - ENS Cachan.

Duration: January 2018 - December 2021

Coordinator: Vincent Cheval, EPI PESTO, Inria Nancy (France)

Participants: Bruno Blanchet, Benjamin Lipp

Abstract: A large variety of automated verification tools have been developed to prove or find attacks on security protocols. These tools differ in their scope, degree of automation, and attacker models. The aim of this project is to get the best of all these tools, meaning, on the one hand, to improve the theory and implementations of each individual tool towards the strengths of the others and, on the other hand, build bridges that allow the cooperations of the methods/tools. We will focus in this project on the tools CryptoVerif, EasyCrypt, Scary, ProVerif, Tamarin, AKiSs and APTE.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. ERC Consolidator Grant: CIRCUS

Title: CIRCUS: An end-to-end verification architecture for building Certified Implementations of Robust, Cryptographically Secure web applications

Duration: April 2016 - March 2021

Coordinator: Karthikeyan Bhargavan, Inria

The security of modern web applications depends on a variety of critical components including cryptographic libraries, Transport Layer Security (TLS), browser security mechanisms, and single sign-on protocols. Although these components are widely used, their security guarantees remain poorly understood, leading to subtle bugs and frequent attacks. Rather than fixing one attack at a time, we advocate the use of formal security verification to identify and eliminate entire classes of vulnerabilities in one go.

CIRCUS proposes to take on this challenge, by verifying the end-to-end security of web applications running in mainstream software. The key idea is to identify the core security components of web browsers and servers and replace them by rigorously verified components that offer the same functionality but with robust security guarantees.

9.2.1.2. ERC Starting Grant: SECOMP

Title: SECOMP: Efficient Formally Secure Compilers to a Tagged Architecture

Duration: Jan 2017 - December 2021

Coordinator: Catalin Hritcu, Inria

Abstract: The SECOMP project is aimed at leveraging emerging hardware capabilities for fine-grained protection to build the first, efficient secure compilation chains for realistic low-level programming languages (the C language, and Low* a safe subset of C embedded in F* for verification). These compilation chains will provide a secure semantics for all programs and will ensure that high-level abstractions cannot be violated even when interacting with untrusted low-level code. To achieve this level of security without sacrificing efficiency, our secure compilation chains target a tagged architecture, which associates a metadata tag to each word and efficiently propagates and checks tags according to software-defined rules. We will use property-based testing and formal verification to provide high confidence that our compilers are indeed secure.

9.2.1.3. NEXTLEAP (304)

Title: NEXTLEAP: NEXT generation Legal Encryption And Privacy

Programm: H2020

Duration: January 2016 - December 2018

Coordinator: Harry Halpin, Inria

Other partners: IMDEA, University College London, CNRS, IRI, and Merlinux

The objective of the NEXTLEAP project is to build the fundamental interdisciplinary internet science necessary to create decentralized, secure, and rights-preserving protocols for the next generation of collective awareness platforms. The long-term goal of NEXTLEAP is to have Europe take the "next leap ahead" of the rest of the world by solving the fundamental challenge of determining how both to scientifically build and how to help citizens and institutions adopt open-source decentralized and privacy-preserving digital social platforms in contrast to proprietary centralized cloud-based services and pervasive surveillance that function at the expense of rights and technological sovereignty.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

We have a range of long- and short-term collaborations with various universities and research labs. We summarize them by project:

- TLS analysis: Microsoft Research (Cambridge), Mozilla, University of Rennes
- F*: Microsoft Research (Redmond, Cambridge, Bangalore), MSR-Inria, CMU, MIT, University of Ljubljana, Nomadic Labs, Zen Protocol, Princeton University
- SECOMP: MPI-SWS, CISPA, Stanford University, CMU, University of Pennsylvania, Portland State University, University of Virginia, University of Iai
- Micro-Policies: University of Pennsylvania, Portland State University, MIT, Draper Labs, Dover Microsystems

9.3.2. Participation in Other International Programs

9.3.2.1. SSITH/HOPE

Title: Advanced New Hardware Optimized for Policy Enforcement, A New HOPE

Program: DARPA SSITH

Duration: December 2017 - February 2021

Coordinator: Charles Stark Draper Laboratory

Other Participants: Inria Paris, University of Pennsylvania, MIT, Portland State University, Dover Microsystems, DornerWorks

Participants from Inria Prosecco: Catalin Hritcu, Roberto Blanco, Jérémy Thibault

Abstract: A New HOPE builds on results from the Inherently Secure Processor (ISP) project that has been internally funded at Draper. Recent architectural improvements decouple the tagged architecture from the processor pipeline to improve performance and flexibility for new processors. HOPE securely maintains metadata for each word in application memory and checks every instruction against a set of installed security policies. The HOPE security architecture exposes tunable parameters that support Performance, Power, Area, Software compatibility and Security (PPASS) search space exploration. Flexible software-defined security policies cover all 7 SSITH CWE vulnerability classes, and policies can be tuned to meet PPASS requirements; for example, one can trade granularity of security checks against performance using different policy configurations. HOPE will design and formalize a new high-level domain-specific language (DSL) for defining security policies, based on previous research and on extensive experience with previous policy languages. HOPE will formally verify that installed security policies satisfy system-wide security requirements. A secure boot process enables policies to be securely updated on deployed HOPE systems. Security policies can adapt based on previously detected attacks. Over the multi-year, multi-million dollar Draper ISP project, the tagged security architecture approach has evolved from early prototypes based on results from the DARPA CRASH program towards easier integration with external designs, and is better able to scale from micro to server class implementations. A New HOPE team is led by Draper and includes faculty from University of Pennsylvania (Penn), Portland State University (PSU), Inria, and

MIT, as well as industry collaborators from DornerWorks and Dover Microsystems. In addition to Draper's in-house expertise in hardware design, cyber-security (defensive and offensive, hardware and software) and formal methods, the HOPE team includes experts from all domains relevant to SSITH, including (a) computer architecture: DeHon (Penn), Shrobe (MIT); (b) formal methods including programming languages and security: Pierce (Penn), Tolmach (PSU), Hritcu (Inria); and (c) operating system integration (DornerWorks). Dover Microsystems is a spin-out from Draper that will commercialize concepts from the Draper ISP project.

9.3.2.2. Everest Expedition

Program: Microsoft Expedition and MSR-Inria Collaborative Research Project

Expedition Participants: Microsoft Research (Cambridge, Redmond, Bangalore), Inria, MSR-Inria, CMU, University of Edinburgh

Duration of current MSR-Inria Project: October 2017 – October 2020

Participants from Inria Prosecco: Karthikeyan Bhargavan, Catalin Hritcu, Danel Ahman, Benjamin Beurdouche, Victor Dumitrescu, Nadim Kobeissi, Théo Laurent, Guido Martínez, Denis Merigoux, Marina Polubelova, Jean-Karim Zinzindohoué

Participants from other Inria teams: David Pichardie (Celtique), Jean-Pierre Talpin (TEA)

Abstract: The HTTPS ecosystem (HTTPS and TLS protocols, X.509 public key infrastructure, crypto algorithms) is the foundation on which Internet security is built. Unfortunately, this ecosystem is brittle, with headline-grabbing attacks such as FREAK and LogJam and emergency patches many times a year.

Project Everest addresses this problem by constructing a high-performance, standards-compliant, formally verified implementation of components in HTTPS ecosystem, including TLS, the main protocol at the heart of HTTPS, as well as the main underlying cryptographic algorithms such as AES, SHA2 or X25519.

At the TLS level, for instance, we are developing new implementations of existing and forthcoming protocol standards and formally proving, by reduction to cryptographic assumptions on their core algorithms, that our implementations provide a secure-channel abstraction between the communicating endpoints. Implementations of the core algorithms themselves are also verified, producing performant portable C code or highly optimized assembly language.

We aim for our verified components to be drop-in replacements suitable for use in mainstream web browsers, servers, and other popular tools and are actively working with the community at large to improve the ecosystem.

https://project-everest.github.io

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Éric Tanter (University of Chile) joined Inria as a Visiting Professor from Jul 2018 to March 2019 and from August to December 2019; he gave various seminars at Inria including one entitled "Gradual Parametricity, Revisited";
- Li-yao Xia (University of Pennsylvania) visited Prosecco on 7 January and gave a talk entitled "From C to Interaction Trees";
- Matías Toro (University of Chile) visited Prosecco on 9 January and gave a talk entitled "Type-Driven Gradual Security with References";
- Deepak Garg (MPI-SWS) visited Prosecco on 29 January and 20 November;
- Gilles Barthe (MPI-SP) visited Prosecco on various occasions: 29 January, 3–6 June, 9–13 Sept, and 7–9 October 2019;

- Jeremy Siek (Indiana University) visited Prosecco on 21 February and gave a seminar entitled “Toward Efficient Gradual Typing”;
- Andrew Tolmach (Portland State University) visted Prosecco on 8–12 April and gave a seminar on “Enforcing C-level security policies using machine-level tags”;
- Guido Martinez (CIFASIS-CONICET Rosario) visited Prosecco on various occasions: April 15–19, ICFP, 30 September to 12 October
- Nikos Vasilakis (University of Pennsylvania) visited Prosecco on 15–19 July and gave a seminar on “Retrofitting Security, Module by Module”;
- Clement Pit-Claudel (MPI) visited Prosecco on 14 August;
- Kevin Liao (MPI-SP) visited Prosecco on various occasions and gave a seminar on “ILC: A Calculus for Composable, Computational Cryptography”;
- Tahina Ramananandro (Microsoft Research) visited Prosecco on 30 September to 15 October and gave a seminar on “EverParse”;
- Nik Swamy (Microsoft Research) and Aymeric Fromherz (CMU) visited Prosecco from 7–11 October and gave a seminar on “Verifying a mixture of C and assembly code with Low* and Vale”;
- Jonathan Protzenko (Microsoft Research) visited Prosecco on 30 September to 15 October and gave a seminar on “The EverCrypt verified cryptographic provider”;
- Jakob von Raumer (University of Nottingham) visited Prosecco on 23 October and gave a seminar on “Indexed Inductive Types”;
- Bas Spitters (COBRA, Aarhus University) visited Prosecco on 25–29 November and gave a seminar on “ConCert: A Smart Contract Certification Framework in Coq”;
- Adrien Koutsos (MPI-SP) visited Prosecco on 5 November and gave a talk on “5G-AKA authentication protocol privacy”;
- Akram El-Korashy (MPI-SWS) visited Prosecco on 20 November;
- Shin-ya Katsumata (NII, Tokyo, Japan) visited Prosecco on 25–28 November;
- Ian Miers (Johns Hopkins University) visited Prosecco on 29 November and gave a seminar on “Zcash, Blockchains, and the possibilities for formal verification with zero-knowledge”;

9.4.1.1. Internships

- Antoine Van Muylder (Paris 7): from April to September 2019 – advised by Catalin Hritcu, Exequiel Rivas, and Kenji Maillard
- Guillaume Gette: from April to September 2019 – advised by Karthikeyan Bhargavan
- Mikhail Volkhov: from April to August 2019 – advised by Karthikeyan Bhargavan and Prasad Naldurg

9.4.2. Visits to International Teams

- Catalin Hritcu visited EPFL Lausanne on 25–27 September;
- Catalin Hritcu, Carmine Abate, Roberto Blanco, and Jeremy Thibault visited MPI-SWS in Saarbrücken on 18–22 October and 1–3 December;
- Catalin Hritcu visited Chalmers University in Gothenburg on 4–6 December;

SECRET Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- **ANR DEREC** ($10/16 \rightarrow 09/21$)
  Relativistic cryptography
  ANR Program: jeunes chercheurs
  244 kEuros
  The goal of project DEREC is to demonstrate the feasibility of guaranteeing the security of some cryptographic protocols using the relativistic paradigm, which states that information propagation is limited by the speed of light. We plan to study some two party primitives such as bit commitment and their security against classical and quantum adversaries in this model. We then plan to the integration of those primitives into larger cryptosystems. Finally, we plan on performing a demonstration of those systems in real life conditions.
- **ANR CBCRYPT** ($10/17 \rightarrow 09/21$)
  Code-based cryptography
  ANR Program: AAP Générique 2017
  Partners: Inria SECRET (coordinator), XLIM, Univ. Rouen, Univ. Bordeaux.
  197 kEuros
  The goal of CBCRYPT is to propose code-based candidates to the NIST call aiming at standardizing public-key primitives which resist to quantum attacks. These proposals are based either on code-based schemes relying on the usual Hamming metric or on the rank metric. The project does not deal solely with the NIST call. We also develop some other code-based solutions: these are either primitives that are not mature enough to be proposed in the first NIST call or whose functionalities are not covered by the NIST call, such as identity-based encryption, broadcast encryption, attribute based encryption or functional encryption. A third goal of this project is of a more fundamental nature: namely to lay firm foundations for code-based cryptography by developing thorough and rigorous security proofs together with a set of algorithmic tools for assessing the security of code-based cryptography.
- **ANR quBIC** ($10/17 \rightarrow 09/21$)
  Quantum Banknotes and Information-Theoretic Credit Cards
  ANR Program: AAP Générique 2017
  Partners: Univ. Paris-Diderot (coordinator), Inria SECRET, UPMC (LIP6), CNRS (Laboratoire Kastler Brossel)
  87 kEuros
  For a quantum-safe future, classical security systems as well as quantum protocols that guarantee security against all adversaries must be deployed. Here, we will study and implement one of the most promising quantum applications, namely unforgeable quantum money. A money scheme enables a secure transaction between a client, a vendor and a bank via the use of a credit card or via the use of banknotes, with maximal security guarantees. Our objectives are to perform a theoretical analysis of quantum money schemes, in realistic conditions and for encodings in both discrete and continuous variables, and to demonstrate experimentally these protocols using state-of-the-art quantum memories and integrated detection devices.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. QCALL

Title: Quantum Communications for ALL

Programm: H2020-MSCA-ITN-2015

Duration: December 2016 - November 2020

Coordinator: University of Leeds (UK)

Other partners: see http://www.qcall-itn.eu/

Inria contact: Anthony Leverrier

QCALL is a European Innovative Training Network that endeavors to take the next necessary steps to bring the developing quantum technologies closer to the doorsteps of end users. QCALL will empower a nucleus of 15 doctoral researchers in this area to provide secure communications in the European continent and, in the long run, to its connections worldwide.

8.2.1.2. ERC QUASYModo

Title: QUASYModo *Symmetric Cryptography in the Post-Quantum World*

Program: ERC starting grant

Duration: September 2017 - August 2022

PI: María Naya Plasencia

As years go by, the existence of quantum computers becomes more tangible and the scientific community is already anticipating the enormous consequences of the induced breakthrough in computational power. Cryptology is one of the affected disciplines. Indeed, the current state-of-the-art asymmetric cryptography would become insecure, and we are actively searching for alternatives. Symmetric cryptography, essential for enabling secure communications, seems much less affected at first sight: its biggest known threat is Grover's algorithm, which allows exhaustive key searches in the square root of the normal complexity. Thus, so far, it is believed that doubling key lengths suffices to maintain an equivalent security in the post- quantum world. The security of symmetric cryptography is completely based on cryptanalysis: we only gain confidence in the security of a symmetric primitive through extensive and continuous scrutiny. It is therefore not possible to determine whether a symmetric primitive might be secure or not in a post-quantum world without first understanding how a quantum adversary could attack it. Correctly evaluating the security of symmetric primitives in the post-quantum world cannot be done without a corresponding cryptanalysis toolbox, which neither exists nor has ever been studied. This is the big gap I have identified and that I plan to fill with this project. Next, doubling the key length is not a trivial task and needs to be carefully studied. My ultimate aim is to propose efficient solutions secure in the post-quantum world with the help of our previously obtained quantum symmetric cryptanalysis toolbox. This will help prevent the chaos that big quantum computers would generate: being ready in advance will definitely save a great amount of time and money, while protecting our current and future communications. The main challenge of QUASYModo is to redesign symmetric cryptography for the post-quantum world.

8.2.1.3. H2020 FET Flagship on Quantum Technologies - CiViQ

Title: CiViQ *Continuous Variable Quantum Communications*

Program: H2020 FET Flagship on Quantum Technologies

Duration: October 2018 - September 2021

PI: Anthony Leverrier

The goal of the CiViQ project is to open a radically novel avenue towards flexible and cost-effective integration of quantum communication technologies, and in particular Continuous-Variable QKD, into emerging optical telecom- munication networks. CiViQ aims at a broad technological impact based on a systematic analysis of telecom-defined user-requirements. To this end CiViQ unites for the first time a broad interdisciplinary community of 21 partners with unique breadth of experience, involving major telecoms, integrators and developers of QKD. The work targets advancing both the QKD technology itself and the emerging "software network" approach to lay the foundations of future seamless integration of both. CiViQ will culminate in a validation in true telecom network environment. Project-specific network integration and software development work will empower QKD to be used as a physical-layer-anchor securing critical infrastruc- tures, with demonstration in QKD-extended software-defined networks.

8.2.2. Collaborations in European Programs, Except FP7 & H2020

8.2.2.1. QCDA

Program: QuantERA ERA-NET Cofund in Quantum Technologies

Project acronym: QCDA

Project title: Quantum Code Design and Architecture

Duration: February 2018 - January 2021

Coordinator: Earl Campbell, University of Sheffield, UK

Other partners: University of Sheffield (UK), TU Delft (Netherlands), TU Munich (Germany), University College London (UK)

Inria contact: Anthony Leverrier

General purpose quantum computers must follow a fault-tolerant design to prevent ubiquitous decoherence processes from corrupting computations. All approaches to fault-tolerance demand extra physical hardware to perform a quantum computation. Kitaev's surface, or toric, code is a popular idea that has captured the hearts and minds of many hardware developers, and has given many people hope that fault-tolerant quantum computation is a realistic prospect. Major industrial hardware developers include Google, IBM, and Intel. They are all currently working toward a fault-tolerant architecture based on the surface code. Unfortunately, however, detailed resource analysis points towards substantial hardware requirements using this approach, possibly millions of qubits for commercial applications. Therefore, improvements to fault-tolerant designs are a pressing near-future issue. This is particularly crucial since sufficient time is required for hardware developers to react and adjust course accordingly.

This consortium will initiate a European co-ordinated approach to designing a new generation of codes and protocols for fault-tolerant quantum computation. The ultimate goal is the development of high-performance architectures for quantum computers that offer significant reductions in hardware requirements; hence accelerating the transition of quantum computing from academia to industry. Key directions developed to achieve these improvements include: the economies of scale offered by large blocks of logical qubits in high-rate codes; and the exploitation of continuous-variable degrees of freedom.

The project further aims to build a European community addressing these architectural issues, so that a productive feedback cycle between theory and experiment can continue beyond the lifetime of the project itself. Practical protocols and recipes resulting from this project are anticipated to become part of the standard arsenal for building scalable quantum information processors.

8.3. International Initiatives

8.3.1. Inria Associate Teams Not Involved in an Inria International Labs

8.3.1.1. CHOCOLAT

Title: Chosen-prefix Collision Attack on SHA-1 with ASICs Cluster

International Partner (Institution - Laboratory - Researcher):

NTU (Singapore) - SYLLAB - Peyrin Thomas

Start year: 2017

See also: https://team.inria.fr/chocolat/

The hash function SHA-1 is one of the most widely used hash functions in the industry, but it has been shown to not be collision-resistant by a team of Chinese researchers led by Prof. Wang in 2005. However, nobody has publicly produced a real pair of colliding messages so far, because the estimated attack complexity is around 2^{63} SHA-1 computations (this represents about 70000 years of computation on a normal PC).

While a collision of SHA-1 would clearly demonstrate the weakness of the algorithm, a much more powerful attack would be to find a collision such that the prefix of the colliding messages is chosen by some challenger beforehand. In particular, this would allow creating a rogue certificate authority certificate that would be accepted by browsers. Such an attack has already been deployed for certificates using the MD5 hash function, but MD5 is much weaker than SHA-1 and it has already been removed from most security applications. SHA-1 is still widely used and performing such an attack for certificates using SHA-1 would have a very big impact.

The objective of the project is to design a chosen-prefix collision attack against the SHA-1 hash function, and to implement the attack in practice. We estimate this will require 2^{70} computations, and we will use an ASIC cluster to perform such a computation.

8.3.2. Inria International Partners

8.3.2.1. Declared Inria International Partners

Title: Discrete Mathematics, Codes and Cryptography

International Partner (Institution - Laboratory - Researcher):

Indian Statistical Institute (India) - Cryptology Research Group - Bimal Roy

Duration: 2014 - 2019

Start year: 2014

Today's cryptology offers important challenges. Some are well-known: Can we understand existing cryptanalysis techniques well enough to devise criterion for the design of efficient and secure symmetric cryptographic primitives? Can we propose cryptographic protocols which offer provable security features under some reasonable algorithmic assumptions? Some are newer: How could we overcome the possible apparition of a quantum computer with its devastating consequences on public key cryptography as it is used today? Those challenges must be addressed, and some of the answers will involve tools borrowed to discrete mathematics, combinatorics, algebraic coding theory, algorithmic. The guideline of this proposal is to explore further and enrich the already well established connections between those scientific domains and their applications to cryptography and its challenges.

8.3.2.2. Informal International Partners

- Nanyang Technological University (Singapore): cryptanalysis of symmetric primitives.
- Ruhr-Universität Bochum (Germany): design and cryptanalysis of symmetric primitives.
- NTT Secure Platforms Laboratories (Japan): quantum cryptanalysis, symmetric cryptography.
- University of Sherbrooke (Canada): quantum codes.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Thomas Peyrin, NTU Singapore, January 2019 and July 2019
- Mustafa Mahmoud Mohammed Kairallah, NTU Singapore, July 2019
- Léo Ducas, CWI Amsterdam, NL, March 2019
- Akinori Hosoyamada, NTT Secure Platform Labaratories, Tokyo, Japan, March 2019 and November 2019
- Yu Sasaki, NTT Secure Platform Labaratories, Tokyo, Japan, November 2019
- Gregor Leander, Ruhr Université Bochum, Germany, November 2019

8.4.1.1. Internships

- Pierre Briaud, MPRI, March-Aug. 2019
- Lucien Grouès, Telecom ParisTech, March-Sept. 2019
- Antonio Florez Gutierrez, Université Paris Saclay, March-Aug. 2019
- Sohaïb Ouzineb, Telecom ParisTech, July-Aug. 2019
- Elodie Rohart-Barbey, INSA Rouen, June-Aug. 2019
- Augustin Bariant, Ecole Polytechnique, April-Aug. 2019

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

- Bar-Ilan Unversity, Israel, June 16-18, invitation by Nathan Keller (A. Canteaut and G. Leurent)
- Rostock University, Rostock, Germany, June 23-28, invitation to the Institut für Mathematik by Gohar Kyureghyan, (L. Perrin).
- NTT, Tokyo, Japan, August 27-September 27, invitation by Yu Sasaki (F. Sibleyras)

SPADES Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. CASERM (Persyval-Lab project)

Participants: Pascal Fradet, Alain Girault, Gregor Goessler, Xiaojie Guo, Maxime Lesourd, Xavier Nicollin, Stephan Plassart, Sophie Quinton, Jean-Bernard Stefani, Martin Vassor.

The CASERM project represents a significant effort towards a COQ-based design method for reconfigurable multi-view embedded systems, in order to formalize the structure and behavior of systems and to prove their main properties. The use of a proof assistant to support such a framework is motivated by the fact that the targeted systems are both extremely complex and critical. The challenges addressed are threefold:

1. to model software architectures for embedded systems taking into account their dynamicity and multiple constraints (functional as well as non functional);
2. to propose novel scheduling techniques for dynamically reconfiguring embedded systems; and
3. to advance the state of the art in automated proving for such systems.

The objectives of CASERM that address these challenges are organized in three tasks. They consist respectively in designing an architecture description framework based on a process calculus, in proposing online optimization methods for dynamic reconfiguration systems (this is the topic of Stephan Plassart's PhD), and in developing a formal framework for real-time analysis in the COQ proof assistant (this is the topic of Xiaojie Guo's and Maxime Lesourd's PhD).

The CASERM consortium gathers researchers from the LIG and VERIMAG laboratories who are reknowned specialists in these fields. The project started in November 2016 and was completed in November 2019.

8.1.2. SEC: Construction of Safe Explainable Cyber-physical systems

Participants: Gregor Goessler, Thomas Mari.

In cyber-physical systems (CPS), software interacts with physical processes so as achieve desired functionalities. CPS are usually subject to safety and reliability requirements. Depending on the application, their failure may have unacceptable consequences, it is therefore crucial to ensure their correctness at design time. In addition, explainability of increasingly autonomous CPS is becoming crucial in order for the CPS to be socially acceptable.

The goal of this project is twofold. First, we will investigate a contract-based design approach for safe CPS in which different aspects – such as functional requirements, real-time constraints, and continuous behaviors – are modeled and verified separately. Second, we will leverage the contracts in order to ensure explainability of the system behavior by construction. By explainability we understand, informally, that for any behavior of the system we can automatically construct, from a log generated by the execution, an excerpt that retains only the events that causally contributed to the outcome, and that is easy to understand by a human expert.

The SEC project is supported by the "Initiatives de Recherche Stratégiques (IRS)" program of the IDEX UGA. It funds the PhD thesis of Thomas Mari, who will be co-advised by Gregor Gössler and Thao Dang (VERIMAG).

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. RT-proofs

Participants: Pascal Fradet, Xiaojie Guo, Maxime Lesourd, Sophie Quinton.

RT-proofs is an ANR/DFG project between Inria, MPI-SWS, Onera, TU Braunschweig and Verimag, running from 2018 until 2022.

The overall objective of the RT-proofs project is to lay the foundations for computer-assisted formal verification of timing analysis results. More precisely, the goal is to provide:

1. a strong formal basis for schedulability, blocking, and response-time analysis supported by the Coq proof assistant, that is as generic, robust, and modular as possible;
2. correctness proofs for new and well-established generalized response-time analysis results, and a better, precise understanding of the role played by key assumptions and formal connections between competing analysis techniques;
3. an approach for the generation of proof certificates so that analysis results – in contrast to analysis tools – can be certified.

The results obtained in 2019 in connection with the RT-proofs project are described in Section 6.2.4 .

8.2.1.2. DCore

Participants: Gregor Goessler, Jean-Bernard Stefani.

DCORE is an ANR project between Inria project teams ANTIQUE, FOCUS and SPADES, and the IRIF lab, running from 2019 to 2023.

The overall objective of the project is to develop a semantically well-founded, novel form of concurrent debugging, which we call *causal debugging*, that aims to alleviate the deficiencies of current debugging techniques for large concurrent software systems. The causal debugging technology developed by DCORE will comprise and integrate two main novel engines:

1. *a reversible execution engine* that allows programmers to backtrack and replay a concurrent or distributed program execution, in a way that is both precise and efficient (only the exact threads involved by a return to a target anterior or posterior program state are impacted);
2. a *causal analysis engine* that allows programmers to analyze concurrent executions, by asking questions of the form “what caused the violation of this program property?”, and that allows for the precise and efficient investigation of past and potential program executions.

8.2.2. Institute of Technology (IRT)

8.2.2.1. CAPHCA

Participants: Alain Girault, Nicolas Hili.

CAPHCA is a project within the Antoine de Saint Exupéry IRT in Toulouse. The general objective of the project is to provide methods and tools to achieve both performance and determinism on modern, high-performance, multi-core and FPGA-enabled SOCs. Our specific contribution lies withing work packages dedicated to the design of novel PRET architectures and programming languages (see Section 6.2.1). This contract has yielded two publications so far [17], [16].

8.3. European Initiatives

8.3.1. Collaborations in European Programs, Except FP7 & H2020

Program: Celtic-Plus

Project acronym: SENDATE

Project title: Secure Networking for a Data center cloud in Europe

Duration: April 2016 - March 2019

Coordinator: Nokia France

Other partners: Nokia, Orange, IMT, Inria

Abstract: The SENDATE project aims to develop a clean-slate architecture for converged telecommunications networks and distributed data centers supporting 5G cellular networks and the needs from the Industrial Internet and the Internet of Things. It aims to provide scientific and technical solutions for intra and inter data centrers security, control, management and orchestration, placement and management of virtual network functions, as well as high-speed transport networks for data centers access and interconnection.

8.3.2. Collaborations with Major European Organizations

We have a strong collaboration with the Technische Universität Braunschweig in Germany and the MPI-SWS in Kaiserslautern (Germany) on formal proofs for the analysis real-time systems. This collaboration is formalized by the ANR-PRCI project called RT-proofs started in 2018, which involves MPI-SWS, TU Braunschweig, Inria, and Onera.

8.4. International Initiatives

8.4.1. Inria Associate Teams Not Involved in an Inria International Labs

8.4.1.1. Quasar

Title: Quantitative systems formal verification

International Partner (Institution - Laboratory - Researcher):

CAS (China) - Department of Informatics - Lijun Zhang

Start year: 2019

The general scientific objectives are to extend formal analysis and verification methods such as model checking, process algebra and interactive theorem proving (Coq) to quantitative systems, more specifically probabilistic and quantum computing systems. Application fields include compositional modeling for dynamic real-time probabilistic software architectures and risk analysis. The collaboration will involve active scientists on all these fields not only from Inria and Inst Soft. CAS, but also from CWI, Verimag Grenoble, ECNU Shanghai, and partners of CWI (VU Amsterdam and Twente).

SPECFUN Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

- *De rerum natura*. This project, set up by the team, was accepted this year and will be funded until 2023. It gathers over 20 experts from four fields: computer algebra; the Galois theories of linear functional equations; number theory; combinatorics and probability. Our goal is to obtain classification algorithms for number theory and combinatorics, particularly so for deciding irrationality and transcendence.

7.1.2. Research in Pairs

Alin Bostan together with Marc Mezzaroba (CNRS, Sorbonne Université) and Tanguy Rivoal (CNRS, Université Grenoble-Alpes) have done a "research in pairs" on the Fast Computation of Values of D-Finite Functions, from December 2 to 6, 2019, at CIRM (Luminy, France). The aim of the joint project was to investigate the implications of arithmetic properties of linear differential equations on the computational complexity of their numerical solutions. They focussed on E- and G-functions, which are power series solutions of differential equations that additionally satisfy strong arithmetic conditions and play a major role in Diophantine approximation. The main goal for this research session was to understand several remarks, given without proof by Chudnovsky and Chudnovsky in the late 1980s, and stating that number-theoretic properties could lead to slightly better complexity bounds for E- and G-functions than in the general case.

7.2. International Research Visitors

7.2.1. Visits of International Scientists

7.2.1.1. Internships

- Pierre Lairez supervised during two months Abhijit Balachandra, M1-level student from the Indian Institute of Science (Bangalore). They studied some new aspects of the numerical computation of the topology of complex algebraic surfaces.

STAMP Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

- FastRelax, "Fast and Reliable Approximations", started on October 1st, 2014, for 60 months (ending in September 2019), with a grant of 75 kEuros for Marelle. Other partners are Inria Grenoble (ARIC project-team), LAAS-CNRS (Toulouse), Inria Saclay (Toccata and Specfun project-teams), and LIP6-CNRS (Paris). The corresponding researcher for this contract is Laurence Rideau.
- TECAP "Analyse de protocoles, Unir les outils existants", starting on October 1st, 2017, for 60 months, with a grant of 89 kEuros. Other partners are Inria teams PESTO (Inria Nancy grand-est), Ecole Polytechnique, ENS Cachan, IRISA Rennes, and CNRS. The corresponding researcher for this contract is Benjamin Grégoire.
- SafeTLS "La sécurisation de l'Internet du futur avec TLS 1.3" started on October 1st, 2016, for 60 months, with a grant of 147kEuros. Other partners are Université de Rennes 1, and secrétariat Général de la Défense et de la Sécurité Nationale. The corresponding researcher for this contract is Benjamin Grégoire.
- BRUTUS "Chiffrements authentifiés et résistants aux attaques par canaux auxiliaires", started on October 1st, 2014, for 60 months, with a grant of 41 kEuros for STAMP. Other partners are Université de Rennes 1, CNRS, secrétariat Général de la défense et de la sécurité nationale, and Université des Sciences et Technologies de Lille 1. The corresponding researcher for this contract is Benjamin Grégoire.
- Scrypt "Compilation sécurisée de primitives cryptographiques" started on February 1st, 2019, for 48 months, with a grant of 100 kEuros. Other partners are Inria team Celtique (Inria Rennes Bretagne Atlantique), Ecole polytechnique, and AMOSSYS SAS. The corresponding researcher for this contract is Benjamin Grégoire.

7.1.2. FUI

The acronym *FUI* stands for "fonds unique interministériel" and is aimed at research and development projects in pre-industrial phase. The STAMP team is part of one such project.

- VERISICC (formal verification for masking techniques for security against side-channel attacks). This contract concerns 5 partners: CRYPTOEXPERTS a company from the Paris region (Île de France), ANSSI (Agence Nationale de Sécurité des Systèmes d'Information), Oberthur Technologies, University of Luxembourg, and STAMP. A sixth company (Ninjalabs) acts as a sub-contractant. The financial grant for STAMP is 391 kEuros, including 111kEuros that are reserved for the sub-contractant. This project started in October 2018 for a duration of 4 years. The corresponding researcher for this contract is Benjamin Grégoire.

7.2. European Initiatives

7.2.1. Collaborations in European Programs, Except FP7 & H2020

Program: COST

Project acronym: EUTypes

Project title: The European research network on types for programming and verification (EUTypes)

Coordinator: Prof. Herman Geuvers, Radboud University, The Netherlands

Abstract:This COST Action will give a strong impetus to research on type theory and its many applications in computer science, by promoting (1) the synergy between theoretical computer scientists, logicians and mathematicians to develop new foundations for type theory, for example as based on the recent development of "homotopy type theory", (2) the joint development of type theoretic tools as proof assistants and integrated programming environments, (3) the study of dependent types for programming and its deployment in software development, (4) the study of dependent types for verification and its deployment in software analysis and verification. The action will also tie together these different areas and promote cross-fertilisation.

7.2.2. Collaborations with Major European Organizations

Partner 1: MPI Bochum, Gilles Barthe, Germany

Formally verified cryptography

7.3. International Initiatives

7.3.1. Informal International Partners

We have strong collaborations with AIST in Japan. Reynald Affeldt, a researcher from AIST has been visiting our team since October 1st 2019. The topic of choice is formalization of a variety of topics using the Mathematical Components library, aiming mostly at formalizing robotics.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

We received the visit of Marc Gourjon (Technische Universität Hamburg) in April and from Manuel Barbosa (University of Porto) in June and July.

We received the visit of Reynald Affeldt (AIST, Japan) starting on October 1st.

We received the visit of Kazuhiko Sakaguchi (University of Tsukuba), from January 1st to October 31st.

SUMO Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Rennes Métropole: Allocation d'Installation Scientifique (AIS)

- Individual grant, led by Nicolas Markey

The objective of this project is to explore two research directions in the continuity of recent works: a truly quantitative theory of formal verification on the one hand, and the development of strategy-synthesis algorithms for modular systems on the other hand. It ended in June 2019.

9.2. National Initiatives

9.2.1. ANR TickTac: Efficient Techniques for Verification and Synthesis of Real-Time Systems (2019-2023)

- Link to website
- Led by Ocan Sankur (SUMO);
- SUMO participants: Emily Clément, Léo Henry, Thierry Jéron, Nicolas Markey, Victor Roussanaly, Ocan Sankur
- Partners: LSV (Cachan), ISIR (Paris), LaBRI (Bordeaux), LRDE (Paris), LIF (Marseille)

The aim of TickTac is to develop novel algorithms for the verification and synthesis of real-time systems using the timed automata formalism. One of the project's objectives is to develop an open-source and configurable model checker which will allow the community to compare algorithms. The algorithms and the tool will be used on a motion planning case study for robotics.

9.2.2. ANR HeadWork: Human-Centric Data-oriented WORKflows (2016-2020)

- Link to website
- Led by David Gross-Amblard (Université Rennes 1);
- Participants : Éric Badouel, Loïc Hélouët, Adrian Puerto Aubel, Rituraj Singh;
- Partners: Inria Project-Teams Valda (Paris), DRUID (Rennes), SUMO (Rennes), Links (Lille), MNHN, Foule Factory.

The objective of this project is to develop techniques to facilite development, deployment, and monitoring of crowd-based participative applications. This requires handling complex workflows with multiple participants, incertainty in data collections, incentives, skills of contributors, ... To overcome these challenges, Headwork will define rich workflows with multiple participants, data and knowledge models to capture various kind of crowd applications with complex data acquisition tasks and human specificities. We will also address methods for deploying, verifying, optimizing, but also monitoring and adapting crowd-based workflow executions at run time.

9.2.3. IPL HAC-SPECIS: High-performance Application and Computers, Studying PErformance and Correctness In Simulation (2016-2020)

- Link to website
- Led by Arnaud Legrand (Inria Grenoble Rhône-Alpes)
- Participants: Thierry Jéron, The Anh Pham.
- Partners: Inria project-teams Avalon (Lyon), POLARIS (Grenoble), HiePACS, STORM (Bordeaux), MExICo (Saclay), MYRIADS, SUMO (Rennes), VeriDis (Nancy).

The Inria Project Lab HAC-SPECIS (High-performance Application and Computers, Studying PErformance and Correctness In Simulation, is a transversal project internal to Inria. The goal of the HAC SPECIS project is to answer the methodological needs raised by the recent evolution of HPC architectures by allowing application and runtime developers to study such systems both from the correctness and performance point of view. Inside this project, we collaborate with Martin Quinson (Myriads team) on the dynamic formal verification of high performance runtimes and applications. The PhD of The Anh Pham is granted by this project.

This year we have been mainly interested in the extension of the SimGrid programming model of MPI with synchronization primitives, the formalisation in ATL, of this model, and its adaptation to dynamic partial-order-reduction methods (DPOR) that allow to reduce the explored state space. A prototype implementation of an existing method that combines DPOR with true-concurrency models has been experimented on toy examples. The Anh Pham completed his PhD in december 2019.

9.2.4. National informal collaborations

The team collaborates with the following researchers:

- Béatrice Bérard (LIP6, Paris 6) on problems of opacity and diagnosis, and on problems related to logics and partial orders for security;
- Patricia Bouyer (LSV, ENS Paris-Saclay) on the analysis of probabilistic timed systems and quantitative aspects of verification;
- Thomas Chatain and Stefan Haar (Inria team MExICo, LSV, ENS Paris-Saclay) on topics related to concurrency and time, and to modeling and verification of metro networks, multimodal systems and passenger flows;
- Gwenaël Delaval and Éric Rutten (Inria team Ctrl-A, LIG, Université Grenoble-Alpes) on the control of reconfigurable systems and the link between Reax and Heptagon/BZR (http://bzr.inria.fr/);
- Serge Haddad (Inria team MExICo, LSV, ENS Paris-Saclay) on opacity and diagnosis;
- Loïg Jézéquel (LS2N, Université de Nantes) on stochastic and timed nets, and on distributed optimal planning;
- Didier Lime and Olivier H. Roux (LS2N, Université de Nantes) on stochastic and timed Petri nets;
- François Laroussinie (IRIF, UP7-Diderot) on logics for multi-agent systems,

9.3. International Initiatives

9.3.1. Inria International Labs

LIRIMA: International Laboratory for Research in Computer Science and Applied Mathematics

9.3.1.1. FUCHSIA

Associate Team involved in the international lab LIRIMA.

Title: Flexible user-centric higher-order systems for collective intelligence in agencies

International Partner

U. Yaoundé (Cameroon) Georges-Edouard Kouamou

Start year: 2019

See also: https://project.inria.fr/fuchsia/

Develop methods and tools, based on guarded attribute grammars, to design flexible and adaptive systems for information gathering and deliberation in order to collaboratively build expertise in health emergency situations.

9.3.2. Inria Associate Teams Not Involved in an Inria International Labs

9.3.2.1. EQUAVE

Title: Efficient Quantitative Verification

International Partner

Indian Institute of Technology Bombay (India) - Dpt of Computer Science and Engineering - S. Akshay

Start year: 2018

See also: http://www.irisa.fr/sumo/EQUAVE

Formal verification has been addressed for a long time. A lot of effort has been devoted to Boolean verification, i.e., formal analyis of systems that check whether a given property is true or false.

In many settings, a Boolean verdict is not sufficient. The notions of interest are for instance the amount of confidential information leaked by a system, the proportion of some protein after a duration in some experiment in a biological system, whether a distributed protocol satisfies some property only for a bounded number of participants... This calls for quantitative verification, in which algorithms compute a value such as the probability for a property to hold, the mean cost of runs satisfying it, the time needed to achieve a complex workflow...

A second limitation of formal verification is the efficiency of algorithms. Even for simple questions, verification is rapidly PSPACE-complete. However, some classes of models allow polynomial time verification. The key techniques to master complexity are to use concurrency, approximation, etc

The objective of this project is to study efficient techniques for quantitative verification, and develop efficient algorithms for models such as stochastic games, timed and concurrent systems.

9.3.3. Inria International Partners

9.3.3.1. Informal International Partners

The team collaborates with the following researchers:

- S. Akshay (IIT Bombay, India) on timed concurrent models;
- Andrea D'Ariano (University Roma Tre, Italy), on train regulation.
- Christel Baier (Technical University of Dresden, Germany) on verification and control of stochastic systems;
- Thomas Brihaye (Université de Mons, Belgium) on the verification of stochastic timed systems;
- Gilles Geeraerts and Jean-François Raskin, (Université Libre de Bruxelles, Belgium) on multiplayer game theory and synthesis;
- Alessandro Giua and Michele Pinna (University Cagliari, Italy) on diagnosis and unfolding techniques for concurrent systems.

- Igor Konnov (Interchain, Austria), Marijana Laźic (Technical University Munich, Germany) and Josef Widder (Interchain, Austria) on the automated verification of randomized distributed algorithms.
- Stéfane Lafortune (University of Michigan, USA) on the control of cyber-physical systems;
- Kim G. Larsen (University Aalborg, Denmark) on quantitative timed games, and on topics related to urban train systems modeling;
- John Mullins (Polytechnique Montréal, Canada) on security and opacity;
- Mickael Randour (Université de Mons, Belgium) on quantitative games for synthesis.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- S. Akshay (IIT Bombay, India) visited the team for one week.
- Christel Baier and Jakob Piribauer (TU Dresden, Germany) visited the SUMO team for one week in september.
- Khushraj Nanik Madnani (IIT Bombay, India) visited our team during two months.
- Laurie Ricker (Mount Allison University, Canada) visited the team during 2 months.
- Graeme Zinck (Mount Allison University, Canada) visited our team during four months. He obtained a 5000$ grant provided by Mitacs through a collaboration between Mount Allison University (L. Ricker) and Inria (Loïc Hélouët and Hervé Marchand). Two papers are in preparation (one regarding the enforcement of opacity for modular systems (submitted to Ifac World congress) and the other about the enforcement of concurrent secrets for multiple systems.

9.4.1.1. Internships

- Pierre Boudart, ENS Ulm, June-July 2019, Éric Fabre.
- Kritin Garg and Sharvik Mital, IIT Bombay, May-July 2019, Éric Fabre, Blaise Genest and Loïc Hélouët.
- Mathieu Poirier, ENS Rennes, May-July 2019, Éric Badouel and Adrian Puerto Aubel.
- Bastien Thomas, ENS Rennes, Feb-July 2019, Nathalie Bertrand.

TAMIS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- ANR MALTHY, Méthodes ALgébriques pour la vérification de modèles Temporisés et HYbrides, Thao Dang, 4 years, Inria and VISEO and CEA and VERIMAG
- ANR COGITO, Runtime Code Generation to Secure Devices, 3 years, Inria and CEA and ENSMSE and XLIM.
- ANR AHMA, Automated Hardware Malware Analysis, 3,5 years, JCJC.

8.1.2. DGA

- PhD grant for Nisrine Jafri (2016–2019),
- PhD grant for Lamine Noureddine (2017-2020)
- PhD grant for Christophe Genevey Metat (2018-2021)
- PhD grant for Cassius De Oliveira Puodzius (2019-2022)

8.2. European Initiatives

8.2.1. ENABLE-S3 (352)

Title: ENABLE-S3: European Initiative to Enable Validation for Highly Automated Safe and Secure Systems

Program: H2020

Duration: 05/2016 - 04/2019

Coordinator: Avl List Gmbh (Austria)

Partners:

Aalborg Universitet (Denmark); Airbus Defence And Space Gmbh (Germany); Ait Austrian Institute Of Technology Gmbh (Austria); Avl Deutschland Gmbh (Germany); Avl Software And Functions Gmbh (Germany); Btc Embedded Systems Ag (Germany); Cavotec Germany Gmbh (Germany); Creanex Oy(Finland); Ceske Vysoke Uceni Technicke V Praze (Czech Republic); Deutsches Zentrum Fuer Luft - Und Raumfahrt Ev (Germany); Denso Automotive Deutschland Gmbh (Germany); Dr. Steffan Datentechnik Gmbh (Austria); Danmarks Tekniske Universitet (Denmark); Evidence Srl (Italy); Stiftung Fzi Forschungszentrum Informatik Am Karlsruher Institut Fur Technologie (Germany); Gmv Aerospace And Defence Sa (Spain); Gmvis Skysoft Sa (Portugal); Politechnika Gdanska (Poland); Hella Aglaia Mobile Vision Gmbh (Germany); Ibm Ireland Limited (Ireland); Interuniversitair Micro-Electronica Centrum (Belgium); Iminds (Belgium); Institut National De Recherche Eninformatique Et Automatique (France); Instituto Superior De Engenharia Do Porto (Portugal); Instituto Tecnologico De Informatica (Spain); Ixion Industry And Aerospace Sl (Spain); Universitat Linz (Austria); Linz Center Of Mechatronics Gmbh (Austria); Magillem Design Services Sas (France); Magneti Marelli S.P.A. (Italy); Microeletronica Maser Slspain); Mdal (France); Model Engineering Solutions Gmbhgermany); Magna Steyr Engineering Ag & Co Kg (Austria); Nabto Aps (Denmark); Navtor As (Norway); Nm Robotic Gmbh (Austria); Nxp Semiconductors Germany Gmbh(Germany); Offis E.V.(Germany); Philips Medical Systems Nederland Bvnetherlands); Rohde & Schwarz Gmbh&Co Kommanditgesellschaft(Germany);

Reden B.V. (Netherlands); Renault Sas (France); Rugged Tooling Oyfinland); Serva Transport Systems Gmbh(Germany); Siemens Industry Software Nvbelgium); University Of Southampton (Uk); Safetrans E.V. (Germany); Thales Alenia Space Espana, Saspain); Fundacion Tecnalia Research & Innovationspain); Thales Austria Gmbh (Austria); The Motor Insurance Repair Researchcentre (Uk); Toyota Motor Europe (Belgium); Nederlandse Organisatie Voor Toegepast Natuurwetenschappelijk Onderzoek Tno (Netherlands); Ttcontrol Gmbh (Austria); Tttech Computertechnik Ag (Austria); Technische Universiteit Eindhoven (Netherlands); Technische Universitat Darmstadt (Germany); Technische Universitaet Graz (Austria); Twt Gmbh Science & Innovation (Germany); University College Dublin, National University Of Ireland, Dublin (Ireland); Universidad De Las Palmas De Gran Canaria (Spain); Universita Degli Studi Di Modena E Reggio Emilia (Italy); Universidad Politecnica De Madrid (Spain); Valeo Autoklimatizace K.S. (Czech Republic); Valeo Comfort And Driving Assistance (France); Valeo Schalter Und Sensoren Gmbh (Germany); Kompetenzzentrum - Das Virtuelle Fahrzeug, Forschungsgesellschaft Mbh (Austria); Vires Simulationstechnologie Gmbh (Germany); Teknologian Tutkimuskeskus Vtt Oy (Finland); Tieto Finland Support Services Oy (Finland); Zilinska Univerzita V Ziline (Slovakia);

Inria contact: Olivier Zendra

The objective of ENABLE-S3 (http://www.enable-s3.eu) is to establish cost-efficient cross-domain virtual and semi-virtual V&V platforms and methods for ACPS. Advanced functional, safety and security test methods will be developed in order to significantly reduce the verification and validation time but preserve the validity of the tests for the requested high operation range. ENABLE-S3 aspires to substitute today's physical validation and verification efforts by virtual testing and verification, coverage-oriented test selection methods and standardization. ENABLE-S3 is use-case driven; these use cases represent relevant environments and scenarios. Each of the models, methods and tools integrated into the validation platform will be applied to at least one use case (under the guidance of the V&V methodology), where they will be validated (TRL 5) and their usability demonstrated (TRL6). Representative use cases and according applications provide the base for the requirements of methods and tools, as well as for the evaluation of automated systems and respective safety. This project is industry driven and has the objective of designing new technologies for autonomous transportation, including to secure them. TAMIS tests its results on the case studies of the project.

Within ENABLE-S3, the contribution of the TAMIS team consists in in proposing a generic method to evaluate complex automotive-oriented systems for automation (perception, decision-making, etc.). The method is based on Statistical Model Checking (SMC), using specifically defined Key Performance Indicators (KPIs), as temporal properties depending on a set of identified metrics. By feeding the values of these metrics during a large number of simulations, and the properties representing the KPIs to our statistical model checker, we evaluate the probability to meet the KPIs. We applied this method to two different subsystems of an autonomous vehicles: a perception system (CMCDOT framework) and a decision-making system. We show that the methodology is suited to efficiently evaluate some critical properties of automotive systems, but also their limitations.

In 2019, in TAMIS, Olivier Zendra and Eduard Baranov were involved in this project. The project supported one postdoc in TAMIS starting in 2017.

8.2.2. TeamPlay (653)

Title: TeamPlay: Time, Energy and security Analysis for Multi/Many-core heterogeneous PLAtforms

Program: H2020

Duration: 01/2018 - 12/2020

Coordinator: Inria

Partners:

Absint Angewandte Informatik Gmbh (Germany), Institut National De Recherche en Informatique et Automatique (France), Secure-Ic Sas (France), Sky-Watch A/S (Danemark), Syddansk Universitet (Danemark), Systhmata Ypologistikis Orashs Irida Labs Ae (Greece), Technische Universität Hamburg-Harburg (Germany), Thales Alenia Space Espana (Spain), Universiteit Van Amsterdam (Netherlands), University Of Bristol (UK), University Of St Andrews (UK)

Inria contact: Olivier Zendra

The TeamPlay (Time, Energy and security Analysis for Multi/Many-core heterogeneous PLAtforms) project federates 6 academic and 5 industrial partners and aims to develop new, formally-motivated, techniques that will allow execution time, energy usage, security, and other important non-functional properties of parallel software to be treated effectively, and as first- class citizens. We will build this into a toolbox for developing highly parallel software for low-energy systems, as required by the internet of things, cyber-physical systems etc. The TeamPlay approach will allow programs to reflect directly on their own time, energy consumption, security, etc., as well as enabling the developer to reason about both the functional and the non-functional properties of their software at the source code level. Our success will ensure significant progress on a pressing problem of major industrial importance: how to effectively manage energy consumption for parallel systems while maintaining the right balance with other important software metrics, including time, security etc. The project brings together leading industrial and academic experts in parallelism, energy modeling/ transparency, worst-case execution time analysis, non-functional property analysis, compilation, security, and task coordination. Results will be evaluated using industrial use cases taken from the computer vision, satellites, flying drones, medical and cyber security domains. Within TeamPlay, Inria and TAMIS coordinate the whole project, while being also in charge of aspects related more specifically to security.

The permanent members of TAMIS who are involved are Olivier Zendra and Annelie Heuser.

8.2.3. SUCCESS

Title: SUCCESS: SecUre aCCESSibility for the internet of things

Program: CHIST-ERA 2015

Duration: 10/2016 - 10/2019

Coordinator: Middlesex University (UK)

Partners:

Middlesex University, School of Science and Technology (UK); Inria, TAMIS (France); Université Grenoble Alpes, Verimag (France); University of TWENTE, (Netherlands)

Inria contact: Ioana Cristescu

The objectives of the SUCCESS project is to use formal methods and verification tools with a proven track record to provide more transparency of security risks for people in given IoT scenarios. Our core scientific innovation will consist on the extension of well-known industry-strength methods. Our technological innovation will provide adequate tools to address risk assessment and adaptivity within IoT in healthcare environments and an open source repository to foster future reuse, extension and progress in this area. Our project will validate the scientific and technological innovation through pilots, one of which will be in collaboration with a hospital and will allow all stakeholders (e.g. physicians, hospital technicians, patients and relatives) to enjoy a safer system capable to appropriately handle highly sensitive information on vulnerable people while making security and privacy risks understandable and secure solutions accessible.

Within SUCCESS, the contribution of the TAMIS team consists in a framework for analyzing the security of a given IOT system, and notably whether it resists to attack. Our approach is to build a high-level model of the system, including its vulnerabilities, as well as an attacker. We represent the set of possible attacks using an attack tree. Finally, we evaluate the probability that an attack succeeds using Statistical Model Checking.

In 2019, in the TAMIS team, Delphine Beaulaton, Najah Ben Said, Ioana Cristescu and Olivier Zendra were involved in this project.

TEA Project-Team

9. Partnerships and Cooperations

9.1. International Initiatives

9.1.1. Inria International Labs

Sino-European Laboratory in Computer Science, Automation and Applied Mathematics
Associate Team involved in the International Lab:

9.1.1.1. CONVEX

Title: Compositional Verification of Cyber-Physical Systems

International Partner (Institution - Laboratory - Researcher):

CAS (China) - State Key Laboratory of Computer Science - Naijun Zhan

Start year: 2018

See also: http://convex.irisa.fr

Formal modeling and verification methods have successfully improved software safety and security in vast application domains in transportation, production and energy. However, formal methods are labor-intensive and require highly trained software developers. Challenges facing formal methods stem from rapid evolution of hardware platforms, the increasing amount and cost of software infrastructures, and from the interaction between software, hardware and physics in networked cyber-physical systems.

Automation and expressivity of formal verification tools must be improved not only to scale functional verification to very large software stacks, but also verify non-functional properties from models of hardware (time, energy) and physics (domain). Abstraction, compositionality and refinement are essential properties to provide the necessary scalability to tackle the complexity of system design with methods able to scale heterogeneous, concurrent, networked, timed, discrete and continuous models of cyber-physical systems.

Project CONVEX wants to define a CPS architecture design methodology that takes advantage of existing time and concurrency modeling standards (MARTE, AADL, Ptolemy, Matlab), yet focuses on interfacing heterogeneous and exogenous models using simple, mathematically-defined structures, to achieve the single goal of verified integration of CPS components.

Inria@SiliconValley
Associate Team involved in the International Lab:

9.1.1.2. Composite

Title: Compositional System Integration

International Partners (Institution - Laboratory - Researcher):

University of California, San Diego (United States) - Microelectronic Embedded Systems Laboratory - Rajesh Gupta

Start year: 2017

See also: http://www.irisa.fr/prive/talpin/composite

Most applications that run somewhere on the internet are not optimized to do so. They execute on general purpose operating systems or on containers (virtual machines) that are built with the most conservative assumptions about their environment. While an application is specific, a large part of the system it runs on is unused, which is both a cost (to store and execute) and a security risk (many entry points).

A unikernel, on the contrary, is a system program object that only contains the necessary the operating system services it needs for execution. A unikernel is build from the composition of a program, developed using high-level programming language, with modules of a library operating system (libOS), to execute directly on an hypervisor. A unikernel can boot in milliseconds to serve a request and shut down, demanding minimal energy and resources, offering stealthiest exposure time and surface to attacks, making them the ideal platforms to deploy on sensor networks, networks of embedded devices, smart grids and clouds.

The goal of COMPOSITE is to develop the mathematical foundations for sound and efficient composition in system programming: analysis, verification and optimization technique for modular and compositional hardware-system-software integration of unikernels. We intend to further this development with the prospect of an end-to-end co-design methodology to synthesize lean and stealth networked embedded devices.

9.1.1.3. Inria International Chairs

IIC GUPTA Rajesh

Title: End-to-end system co-design

International Partner (Institution - Laboratory - Researcher):

University of California, San Diego (United States) - Rajesh Gupta

Duration: 2017 - 2021

Start year: 2017

9.1.1.4. Insa-Inria International Chair

Shuvra Bhattacharyya

Title: System design methodologies for real-time signal and information processing

International Partner (Institution - Laboratory - Researcher):

University of Maryland (United States) - Shuvra Bhattacharyya

Duration: 2018 - 2021

Start year: 2017

9.2. International Research Visitors

9.2.1. Visits of International Scientists

- Shuvra Bhattacharyya (UMD) visited project-team TEA and IETR in the context of his Insa-Inria Chair in May, July and December. He gave numerous talks and organized a workshop for the preparation of a European project proposal.
- Rajesh Gupta (UCSD) visited project-team TEA in the context of his Inria Chair in July and gave a seminar entitled: programming human spaces.
- Niki Vazou (IMDEA) visited project-team TEA in May and gave a presentation on her POPL'20 paper: "Liquidate your assets: reasoning about resource usage in Liquid Haskell".
- Yamine Ait Ameur (IRIT) visited project-team TEA in January on the occasion of Simon Lunel's Thesis defense.
- Naijun Zhan (ISCAS) visited project-team TEA in July, in the context of associate-project CON-VEX.

- Delegates of the Sheng Yuan Honors College (BUAA) visited Inria-Irisa and Ecole Normale Supérieur de Rennes for the prospect of initiating an exchange program for graduate students, which will start in 2020.
- Zhang Bojun and Wang Zikai (BUAA) visited project-team TEA in July for an internship on verified modeling of blockchain protocols in Coq.
- Shenghao Yuan (NUAA) visited project-team TEA in July, in the context of associate-team CONVEX, and gave a presentation of the verified mini-Signal code generator developed at Nanhang University.

9.2.2. Visits to International Teams

Jean-Pierre Talpin visited UC San Diego in March, in the context of the associate-team Composite, and visited ISCAS, Beijing, in May and October, in the context of the associate-team CONVEX.

TOCCATA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. ELEFFAN

Participant: Sylvie Boldo [contact].

ELEFFAN is a Digicosme project funding the PhD of F. Faissole. S. Boldo is the principal investigator. It began in 2016 for three years. https://project.inria.fr/eleffan/

The ELEFFAN project aims at formally proving rounding error bounds of numerical schemes.

Partners: ENSTA Paristech (A. Chapoutot)

9.1.2. MILC

Participant: Sylvie Boldo [contact].

MILC is a DIM-RFSI project. It is a one-year project (2018–2019) that aims at formalizing measure theory and Lebesgue integral in the Coq proof assistant. https://lipn.univ-paris13.fr/MILC/

Partners: Université Paris 13 (M. Mayero, PI), Inria Paris, Inria Saclay

9.2. National Initiatives

9.2.1. ANR CoLiS

Participants: Claude Marché [contact], Andrei Paskevich.

The CoLiS research project is funded by the programme "Société de l'information et de la communication" of the ANR, for a period of 60 months, starting on October 1st, 2015. http://colis.irif.univ-paris-diderot.fr/

The project aims at developing formal analysis and verification techniques and tools for scripts. These scripts are written in the POSIX or bash shell language. Our objective is to produce, at the end of the project, formal methods and tools allowing to analyze, test, and validate scripts. For this, the project will develop techniques and tools based on deductive verification and tree transducers stemming from the domain of XML documents.

Partners: Université Paris-Diderot, IRIF laboratory (formerly PPS & LIAFA), coordinator; Inria Lille, team LINKS

9.2.2. ANR Vocal

Participants: Jean-Christophe Filliâtre [contact], Andrei Paskevich.

The Vocal research project is funded by the programme "Société de l'information et de la communication" of the ANR, for a period of 60 months, starting on October 1st, 2015. See https://vocal.lri.fr/

The goal of the Vocal project is to develop the first formally verified library of efficient general-purpose data structures and algorithms. It targets the OCaml programming language, which allows for fairly efficient code and offers a simple programming model that eases reasoning about programs. The library will be readily available to implementers of safety-critical OCaml programs, such as Coq, Astrée, or Frama-C. It will provide the essential building blocks needed to significantly decrease the cost of developing safe software. The project intends to combine the strengths of three verification tools, namely Coq, Why3, and CFML. It will use Coq to obtain a common mathematical foundation for program specifications, as well as to verify purely functional components. It will use Why3 to verify a broad range of imperative programs with a high degree of proof automation. Finally, it will use CFML for formal reasoning about effectful higher-order functions and data structures making use of pointers and sharing.

Partners: team Gallium (Inria Paris-Rocquencourt), team DCS (Verimag), TrustInSoft, and OCamlPro.

9.2.3. FUI LCHIP

Participant: Sylvain Conchon [contact].

LCHIP (Low Cost High Integrity Platform) is aimed at easing the development of safety critical applications (up to SIL4) by providing: (i) a complete IDE able to automatically generate and prove bounded complexity software (ii) a low cost, safe execution platform. The full support of DSLs and third party code generators will enable a seamless deployment into existing development cycles. LCHIP gathers scientific results obtained during the last 20 years in formal methods, proof, refinement, code generation, etc. as well as a unique return of experience on safety critical systems design. http://www.clearsy.com/en/2016/10/4260/

Partners: 2 technology providers (ClearSy, OcamlPro), in charge of building the architecture of the platform; 3 labs (IFSTTAR, LIP6, LRI), to improve LCHIP IDE features; 2 large companies (SNCF, RATP), representing public ordering parties, to check compliance with standard and industrial railway use-case.

The project lead by ClearSy has started in April 2016 and lasts 3 years. It is funded by BpiFrance as well as French regions.

9.2.4. ANR PARDI

Participant: Sylvain Conchon [contact].

Verification of PARameterized DIstributed systems. A parameterized system specification is a specification for a whole class of systems, parameterized by the number of entities and the properties of the interaction, such as the communication model (synchronous/asynchronous, order of delivery of message, application ordering) or the fault model (crash failure, message loss). To assist and automate verification without parameter instantiation, PARDI uses two complementary approaches. First, a fully automatic model checker modulo theories is considered. Then, to go beyond the intrinsic limits of parameterized model checking, the project advocates a collaborative approach between proof assistant and model checker. http://pardi.enseeiht.fr/

The proof lead by Toulouse INP/IRIT started in 2016 and lasts for 4 years. Partners: Université Pierre et Marie Curie (LIP6), Université Paris-Sud (LRI), Inria Nancy (team VERIDIS)

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. EMC2

Participant: Sylvie Boldo [contact].

A new ERC Synergy Grant 2018 project, called Extreme-scale Mathematically-based Computational Chemistry (EMC2) has just been accepted. The PIs are É. Cancès, L. Grigori, Y. Maday and J.-P. Piquemal. S. Boldo is part of the work package 3: validation and certification of molecular simulation results. https://www.sorbonne-universite.fr/newsroom/actualites/erc-synergy-grant-2018

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: COST (European Cooperation in Science and Technology).

Project acronym: EUTypes https://eutypes.cs.ru.nl/

Project title: The European research network on types for programming and verification

Duration: 2015-2019

Coordinator: Herman Geuvers, Radboud University Nijmegen, The Netherlands

Other partners: 36 members countries, see http://www.cost.eu/COST_Actions/ca/CA15123?parties

Abstract: Types are pervasive in programming and information technology. A type defines a formal interface between software components, allowing the automatic verification of their connections, and greatly enhancing the robustness and reliability of computations and communications. In rich dependent type theories, the full functional specification of a program can be expressed as a type. Type systems have rapidly evolved over the past years, becoming more sophisticated, capturing new aspects of the behaviour of programs and the dynamics of their execution.

This COST Action will give a strong impetus to research on type theory and its many applications in computer science, by promoting (1) the synergy between theoretical computer scientists, logicians and mathematicians to develop new foundations for type theory, for example as based on the recent development of "homotopy type theory”, (2) the joint development of type theoretic tools as proof assistants and integrated programming environments, (3) the study of dependent types for programming and its deployment in software development, (4) the study of dependent types for verification and its deployment in software analysis and verification. The action will also tie together these different areas and promote cross-fertilisation.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Jorge Sousa Pinto, professor from Universidade do Minho (Braga, Portugal, https://haslab.uminho.pt/jsp/) visited the team for 1 month in May 2019. We interact with him on the topic of the formalization of VC generation algorithms [21]. He also proposed a formalization using the Why3 tool.

VERIDIS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

Antoine Defourné's PhD thesis and Yann Duplouy's post-doctoral research are co-funded by Région Grand Est.

9.2. National Initiatives

9.2.1. PIA2 ISITE LUE

Project acronym: ISITE LUE - Digitrust

Project title: Lorraine Université d'Excellence, Citizen Trust in the Digital World

Duration: 2016 – 2020

Coordinator: Marine Minier

Participants: Margaux Durœulx, Stephan Merz

Abstract: Digitrust is one of the "impact" projects within the excellence funding acquired by University of Lorraine and supports research into different aspects related to the trustworthiness and security of digital systems. It funds the PhD thesis of Margaux Durœulx on the use of SAT techniques for assessing system reliability.

9.2.2. ANR International Project ProMiS

Project acronym: ProMiS.

Project title: Provable Mitigation of Side Channel through Parametric Verification

Duration: November 2019 – April 2022.

Coordinators: Étienne André and Jun Sun (Singapore Management University, Singapore).

Other partners: École Centrale Nantes, Singapore University of Technology and Design.

Participants: Étienne André.

Abstract: ProMiS is an international project, funded by ANR in France and by NRF in Singapore under the PRCI program.

The Spectre vulnerability has recently been reported, which affects most modern processors. The idea is that attackers can extract information about the private data using a timing attack. It is an example of side channel attacks, where secure information flows through side channels unintentionally. How to systematically mitigate such attacks is an important and yet challenging research problem.

We propose to automatically synthesize mitigation of side channel attacks (e.g., timing or cache) using well-developed verification techniques. The idea is to reduce this problem to the parameter synthesis problem of a given formalism (for instance, parametric timed automata). Given a program or system with design parameters which can be tuned to mitigate side channel attacks, our approach will automatically generate provably secure valuations of the parameters. We plan to deliver a toolkit which can be automatically applied to real-world systems.

9.2.3. ANR International Project SYMBIONT

Project acronym: SYMBIONT.

Project title: Symbolic Methods for Biological Networks.

Duration: July 2018 – June 2021.

Coordinators: Thomas Sturm and Andreas Weber (Univ. of Bonn, Germany).

Other partners: Univ. of Lille 1, Univ. of Montpellier, Inria Saclay Île de France (Lifeware), RWTH Aachen (Department of Mathematics and Joint Research Center for Computational Biomedecine), Univ. of Kassel.

Participants: Thomas Sturm, Hamid Rahkooy.

Abstract: SYMBIONT is an international interdisciplinary project, funded by ANR in France and by DFG in Germany under the PRCI program. It includes researchers from mathematics, computer science, systems biology, and systems medicine. Computational models in systems biology are built from molecular interaction networks and rate laws, involving parameters, resulting in large systems of differential equations. The statistical estimation of model parameters is computationally expensive and many parameters are not identifiable from experimental data. The project aims at developing novel symbolic methods, aiming at the formal deduction of principal qualitative properties of models, for complementing the currently prevailing numerical approaches. Concrete techniques include tropical geometry, real algebraic geometry, theories of singular perturbations, invariant manifolds, and symmetries of differential systems. The methods are implemented in software and validated against models from computational biology databases.

More information: https://www.symbiont-project.org/.

9.2.4. ANR Project Formedicis

Project acronym: Formedicis.

Project title: Formal methods for the development and the engineering of critical interactive systems.

Duration: January 2017 – December 2020.

Coordinator: Bruno d'Augsbourg (Onera).

Other partners: ENSEEIHT/IRIT Toulouse, ENAC, Université de Lorraine (Veridis).

Participants: Dominique Méry, Horatiu Cirstea.

Abstract: During the last 30 years, the aerospace domain has successfully devised rigorous methods and tools for the development of safe functionally-correct software. During this process, interactive software has received a relatively lower amount of attention. However, Human-System Interactions (HSI) are important for critical systems and especially in aeronautics: for example, the investigation into the crash of the Rio-Paris flight AF 447 in 2009 pointed out a design issue in the Flight Director interface as one of the original causes of the crash. Formedicis aims at designing a formal hub language, in which designers can express their requirements concerning the interactive behavior that must be embedded inside applications, and at developing a framework for validating, verifying, and implementing critical interactive applications expressed in that language.

More information: http://www.agence-nationale-recherche.fr/Project-ANR-16-CE25-0007.

9.2.5. ANR Project DISCONT

Project acronym: DISCONT.

Project title: Correct integration of discrete and continuous models.

Duration: March 2018 – February 2022.

Coordinator: Paul Gibson (Telecom Sud Paris), until February 2019; Dominique Méry, since March 2019.

Other partners: ENSEEIHT/IRIT Toulouse, LACL, ClearSy, Université de Lorraine (Veridis).

Participants: Dominique Méry, Zheng Cheng.

Abstract: Cyber-Physical Systems (CPSs) connect the real world to software systems through a network of sensors and actuators that interact in complex ways, depending on context and involving different spatial and temporal scales. Typically, a discrete software controller interacts with its physical environment in a closed-loop schema where input from sensors is processed and output is generated and communicated to actuators. We are concerned with the verification of the correctness of such discrete controllers, which requires correct integration of discrete and continuous models. Correctness should arise from a design process based on sound abstractions and models of the relevant physical laws. The systems are generally characterized by differential equations with solutions in continuous domains; discretization steps are therefore of particular importance for assessing the correctness of CPSs. DISCONT aims at bridging the gap between the discrete and continuous worlds of formal methods and control theory. We will lift the level of abstraction above that found in current bridging techniques and provide associated methodologies and tools. Our concrete objectives are to develop a formal hybrid model, elaborate refinement steps for control requirements, propose a rational step-wise design method and support tools, and validate them based on use cases from a range of application domains.

More information: https://fusionforge.int-evry.fr/www/discont/.

9.2.6. ANR Project PARDI

Project acronym: PARDI.

Project title: Verification of parameterized distributed systems.

Duration: January 2017 – December 2021.

Coordinator: Philippe Quéinnec (ENSEEIHT/IRIT Toulouse).

Other partners: Université Paris Sud/LRI, Université Nanterre/LIP6, Inria Nancy – Grand Est (Veridis).

Participants: Igor Konnov, Stephan Merz.

Abstract: Distributed systems and algorithms are parameterized by the number of participating processes, the communication model, the fault model, and more generally the properties of interaction among the processes. The project aims at providing methodological and tool support for verifying parameterized systems, using combinations of model checking and theorem proving. VeriDis contributes its expertise on TLA$^+$ and its verification tools, and the integration with the Cubicle model checker is a specific goal of the project.

More information: http://pardi.enseeiht.fr/.

9.2.7. Inria IPL HAC SPECIS

Project acronym: HAC SPECIS.

Project title: High-performance application and computers: studying performance and correctness in simulation.

Duration: June 2016 – June 2020.

Coordinator: Arnaud Legrand (CNRS & Inria Grenoble Rhône Alpes, Polaris).

Other partners: Inria Grenoble Rhône Alpes (Avalon), Inria Rennes Bretagne Atlantique (Myriads), Inria Bordeaux Sud Ouest (Hiepacs, Storm), Inria Saclay Île de France (Mexico), Inria Nancy Grand Est (Veridis).

Participants: Marie Duflot-Kremer, Stephan Merz.

Abstract: The goal of HAC SPECIS is to allow the study of real HPC systems with respect to both correctness and performance. To this end, this Inria Project Lab assembles experts from the HPC, formal verification, and performance evaluation communities. VeriDis contributes its expertise in formal verification techniques. In particular, our goal is to extend the functionalities of exhaustive and statistical model checking within the SimGrid platform. Yann Duplouy joined the project in December 2018 as a post-doctoral researcher with the objective of designing and implementing a statistical model checker for SimGrid.

More information: http://hacspecis.gforge.inria.fr.

9.2.8. DFG Transregional Research Center 248 CPEC

Project acronym: CPEC.

Project title: Foundations of Perspicuous Software Systems.

Duration: January 2019 – December 2022.

Coordinators: Holger Hermanns (Saarland University, Germany) and Raimund Dachselt (University of Dresden, Germany).

Other partners: Max Planck Institute for Software Systems, Saarbrücken.

Participants: Alberto Fiori, Sophie Tourret, Christoph Weidenbach.

Abstract: With cyber-physical technology increasingly impacting our lives, it is very important to ensure that humans can understand them. Systems lack support for making their behaviour plausible to their users. And even for technology experts it is nowadays virtually impossible to provide scientifically well-founded answers to questions about the exact reasons that lead to a particular decision, or about the responsibility for a malfunctioning. The root cause of the problem is that contemporary systems do not have any built-in concepts to explicate their behaviour. They calculate and propagate outcomes of computations, but are not designed to provide explanations. They are not perspicuous. The key to enable comprehension in a cyber-physical world is a science of perspicuous computing.

More information: https://www.perspicuous-computing.science/.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. ERC Matryoshka

Program: ERC.

Project acronym: Matryoshka.

Duration: April 2017 – March 2022.

Coordinator: Jasmin Blanchette (VU Amsterdam).

Participants: Antoine Defourné, Daniel El Oraoui, Mathias Fleury, Pascal Fontaine, Stephan Merz, Hans-Jörg Schurr, Sophie Tourret, Uwe Waldmann.

Abstract: Proof assistants are increasingly used to verify hardware and software and to formalize mathematics. However, despite some success stories, they remain very laborious to use. The situation has improved with the integration of first-order automatic theorem provers – superposition provers and SMT (satisfiability modulo theories) solvers – but only so much can be done when viewing automatic provers as black boxes. The purpose of Matryoshka is to deliver much higher levels of automation to users of proof assistants by fusing and extending two lines of research: automatic and interactive theorem proving. Our approach is to enrich superposition and SMT with higher-order (HO) reasoning in a careful manner, in order to preserve their desirable properties. With higher-order superposition and higher-order SMT in place, we will develop highly automatic provers building on modern superposition provers and SMT solvers, following a novel stratified architecture, and integrate them in proof assistants. Users stand to experience substantial productivity gains: From 2010 to 2016, the success rate of automatic provers on interactive proof obligations from a representative benchmark suite called Judgment Day has risen from 47% to 77%; with this project, we aim at 90%–95% proof automation.

More information: http://matryoshka.gforge.inria.fr/.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: Erasmus+.

Project acronym: PIAF.

Project title: Pensée Informatique et Algorithmique au Fondamental / Computational and Algorithmic Thinking in Primary Education.

Coordinator: Université de Liège.

Other partners: Université du Luxembourg, Saarland University, ESPE Nancy.

Participant: Marie Duflot-Kremer.

Abstract: The goal of the PIAF project is threefold: creating a repository of skills related to computational and algorithmic thinking, designing activities aiming at the acquisition of these skills, and evaluating the impact of these activities on primary school children and their computational thinking capacities.

Program: ERASMUS+.

Project acronym: ARC.

Project title: Automated reasoning in the class.

Coordinator: West University of Timisoara (Romania).

Other partners: Johaness Kepler University Linz (Austria), RWTH Aachen University (Germany), Eszterhazy Karoly University (Hungary), Université de Lorraine.

Participant: Sorin Stratulat.

Abstract: The main objective of the project is to improve the education of computer science students in fields related to computational logic, by creating innovative and advanced learning material that uses automated reasoning and by training a large number of academic staff in using this in a modern way. Thus indirectly the project objectives include the effects of increased software reliability: virus elimination, online safety, better detection of negative online phenomena (fake news, cyberbullying, etc.), and other.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Maria Paola Bonacina.

Date: 11 February 2019 – 16 February 2019.

Institution: Università degli Studi di Verona, Italy.

Host: Pascal Fontaine.

Maria Paola Bonacina is a professor at the Università degli Studi di Verona, Italy. She is well known in the community for her numerous works in the field of automated reasoning, notably in SMT, combination of theories, and procedures for first-order logic. During her one-week stay in Nancy, we particularly discussed SGGS (semantically-guided goal-sensitive theorem proving) as a means of inspiration for instantiation in SMT. We also worked on a review paper on combination of theories, published in 2019 [49].

Armin Biere.

Date: 27 May 2019 – 29 May 2019.

Institution: Johannes Keppler Universität, Linz, Austria.

Host: Christoph Weidenbach.

Armin Biere is professor at the University of Linz. He is a leading researcher in the SAT community. During his stay we discussed recent developments in SAT solving. In particular, resolution based inference and reduction mechanisms beyond subsumption resolution.

9.4.1.1. Internships

Manon Blanc

Date: 1 June 2019 – 31 July 2019

Institution: ENS Cachan

Host: Pascal Fontaine

In her bachelor thesis, Manon Blanc studied and experimentally evaluated two different subtropical methods for handling polynomial constraints within SMT.

Mehran Aghabozorgi

Date: 5 August 2019 – 7 October 2019

Institution: Isfahan University of Technology, Iran

Host: Christoph Weidenbach

Mehran worked on algorithms enhancing SAT pre- and inprocessing. He implemented blocked clause elimination as well as a variable elimination algorithm aiming at smaller clause sets.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

Thomas Sturm visited the University of Bonn (Institute of Computer Science II) for 4 weeks during 2019, and the University of Kassel (Mathematical Institute). Topics included perspectives for SMT Solving in symbolic reaction network analysis, toricity of steady state varieties, scaling methods for systems of ordinary differential equations (ODE), and logic approaches for the classification of real singularities of ODE.

ACUMES Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- **Project OPERA** (2019-2021): Adaptive planar optics
  This project is composed of Inria teams NACHOS, ACUMES and HIEPACS, CNRS CRHEA lab. and company NAPA. Its objective is the characterization and design of new meta-surfaces for optics (opera web site).

8.2. European Initiatives

8.2.1. Collaborations in European Programs, Except FP7 & H2020

Program: COST

Project acronym: CA18232

Project title: Mathematical models for interacting dynamics on networks

Duration: October 2019 - September 2013

Coordinator: University of Ljubljana (Prof. Marjeta Kramar Fijavz)

Other partners: see https://www.cost.eu/actions/CA18232/#tabs|Name:parties

Abstract: Many physical, biological, chemical, financial or even social phenomena can be described by dynamical systems. It is quite common that the dynamics arises as a compound effect of the interaction between sub-systems in which case we speak about coupled systems. This Action shall study such interactions in particular cases from three points of view:

- the abstract approach to the theory behind these systems,
- applications of the abstract theory to coupled structures like networks, neighbouring domains divided by permeable membranes, possibly non-homogeneous simplicial complexes, etc.,
- modelling real-life situations within this framework.

The purpose of this Action is to bring together leading groups in Europe working on a range of issues connected with modelling and analysing mathematical models for dynamical systems on networks. It aims to develop a semigroup approach to various (non-)linear dynamical systems on networks as well as numerical methods based on modern variational methods and applying them to road traffic, biological systems, and further real-life models. The Action also explores the possibility of estimating solutions and long time behaviour of these systems by collecting basic combinatorial information about underlying networks.

8.3. International Initiatives

8.3.1. PHC Utique

Program: Program Hubert Curien PHC Utique (Tunisia)

Project acronym: NAMReD

Project title: Novel Algorithms and Models for Data Reconstruction

Duration: January 2018 - December 2020

Coordinator: A. Habbal and M. Kallel (Univ. Tunis al Manar)

Abstract: The project goal is the design of new and efficient algorithms tailored for data reconstruction involving ill-posed problems. We rely on an original use of game theory and p-Kirchhoff methods. We apply these approaches for missing data recovery and image restoration.

8.3.2. PHC Procope

Program: Program Hubert Curien Procope (Germany)

Project title: Non-local conservation laws for engineering applications

Duration: January 2019 - December 2020

Coordinator: P. Goatin and S. Göttlich (Univ. Mannheim)

Abstract: This project tackles theoretical and numerical issues arising in the mathematical study of conservation laws with non-local flux functions. These equations appear in a variety of applications, ranging from traffic flows to industrial processes and biology, and are intended to model macroscopically the action of non-local interactions occurring at the microscopic level. The team, bi-located in France and Germany, has complementary skills covering the analysis, numerical approximation and optimization of non-linear hyperbolic systems of conservation laws, and their application to the modeling of vehicular and pedestrian traffic flows, manufacturing systems and other industrial problems. Based on the members expertise and on the preliminary results obtained by both teams, the project will focus on the following interconnected aspects: The treatment of boundary conditions, both from the analytical and the numerical point of views, in order to provide a sound basis to address specific problems arising in the applications. The development of efficient, high-order finite volume numerical schemes for the computation of approximate solutions of non-local equations. The investigation of optimal control problems with corresponding optimality systems and the design of appropriate and adaptive optimization algorithms. Targeted applications include vehicular traffic (mainly in connection with vehicle-to-vehicle communication and consumption/pollution estimation), crowd motion (in connection with safe building evacuation procedures), and manufacturing systems (intelligent production). The impact of the project is therefore twofold: while addressing major mathematical advances in the theory and numerical approximation of highly non-standard problems, it puts the basis for innovative tools to handle modern applications in engineering sciences.

8.3.3. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

8.3.3.1. NOLOCO

Title: Efficient numerical schemes for non-local transport phenomena

International Partner (Institution - Laboratory - Researcher):

Universidad del Bio-Bio (Chile) - Luis Miguel Villada Osorio

Start year: 2018

See also: https://team.inria.fr/acumes/assoc-team/noloco/

This project tackles theoretical and numerical issues arising in the mathematical study of conservation laws with non-local flux functions. These equations include in a variety of applications, ranging from traffic flows to industrial processes and biology, and are intended to model macroscopically the action of non-local interactions occurring at the microscopic level.

The team, bi-located in France and Chile, has complementary skills covering the analysis, numerical approximation and optimization of non-linear hyperbolic systems of conservation laws, and their application to the modeling of vehicular and pedestrian traffic flows, sedimentation and other industrial problems.

Based on the members' expertise and on the preliminary results obtained by the team, the project will focus on the following aspects:

- The development of efficient, high-order finite volume numerical schemes for the computation of approximate solutions of non-local equations.
- The sensitivity analysis of the solutions on model parameters or initial conditions.

The impact of the project is therefore twofold: while addressing major mathematical advances in the theory and numerical approximation of highly non-standard problems, it puts the basis for innovative tools to handle modern applications in engineering sciences.

8.3.4. Inria International Partners

8.3.4.1. ORESTE

Title: Optimal REroute Strategies for Traffic managEment

International Partner (Institution - Laboratory - Researcher):

University of California Berkeley (United States) - Electrical Engineering and Computer Science (EECS) (EECS) - Alexandre M. Bayen

Duration: 2018 - 2022

Start year: 2018

See also: https://team.inria.fr/acumes/assoc-team/oreste

The rapidly changing transportation ecosystem opens new challenges in traffic modeling and optimization approaches. We will focus in particular on the two following aspects:

Route choice apps impact. The vast use of personal route choice systems through phone applications or other devices is modifying the traditional flow of networks, requiring new models for accounting of the guidance impact. Indeed, routing apps have changed traffic patterns in the US and Europe, leading to new congestion patterns where previously no traffic was observed. Over the last decade, GPS enabled smart phones and connected personal navigation devices have disrupted the mobility landscape. Initially, the availability of traffic information led to better guidance of a small portion of motorists in the system. But as the majority of the driving public started to use apps, the systematic broadcasting of “selfish” best routes led to the worsening of traffic in numerous places, ultimately leading to the first lawsuit against one specific company in particular (Waze) accused to be the cause of these problems. This is just the beginning of an evolution, which, if not controlled and regulated, will progressively asphyxiate urban landscapes (already nearly hundreds of occurrences of this phenomenon are noticed by the popular media, which indicates the presence of probably thousands of such issues in the US alone). Traffic managers are typically not equipped to fix these problems, and typically do not fund this research, as in order to be able to regulate and fix the problem, fundamental science needs to be advanced, modeling and game theory in particular, so remediation can happen (for which the traffic managers are equipped). In this project, we will mainly focus on the development and study of new macroscopic dynamical models to describe the aforementioned phenomena, and we will explore control strategies to mitigate their impact.

Autonomous vehicles. Besides, the foreseen deployment of connected and autonomous vehicles (CAVs) opens new perspectives both in traffic modeling and control. Indeed, CAVs are expected to modify the classical macroscopic traffic dynamics due to their peculiar motion laws, which are more uniform than human drivers’ and follow different rules. Besides, due to their extended information on neighboring traffic conditions, the resulting dynamics would have a non-local character, justifying the use of rapidly developing non-local models. In any case, the different behavior of autonomous vehicles requires the design of new multi-class models capable of accounting for different vehicle classes characteristics and mutual interactions. Moreover, CAVs could be used as endogenous variable speed limiters, thus providing new action points to control traffic flow. Preliminary results show that the presence of few controlled vehicles can positively affect traffic conditions. In this setting, the interaction of AVs with the surrounding traffic can be described by strongly coupled PDE-ODE systems, which have been largely studied by the ACUMES team. Yet, the study of CAVs impact in realistic situations requires further research, in particular towards model validation, for which the Berkeley team will provide the necessary data.

8.3.4.2. Informal International Partners

University of Milano Bicocca, Mathematics and Applications (M. Garavello: https://sites.google.com/site/maurogaravello/)

University of Rutgers - Camden, Department of Mathematical Science (B. Piccoli: https://piccoli.camden.rutgers.edu/)

Argonne National Laboratory, Mathematics and Computer Science Division (Jonathan Ozik: https://www.anl.gov/profile/jonathan-ozik, Stefan Wild: https://www.anl.gov/profile/stefan-m-wild)

Virginia Polytechnic Institute and State University (Robert B. Gramacy: https://www.stat.vt.edu/people/stat-faculty/gramacy-robert.html)

University of Texas Arlington (S. Roy, https://mentis.uta.edu/explore/profile/souvik-roy)

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- J. Friedrich (January, June-July, November 2019, Univ. Mannheim, Germany): non-local traffic flow models.
- J. Kotz (November 2019, Univ. Mannheim, Germany): augmented macroscopic traffic flow models at junctions.
- L.M. Villada (November 2019, University of Bio-Bio): finite volume schemes for non-local systems of conservation laws.
- R. Ordonez (November-December 2019, Univ. Concepcion, Chile): finite volume schemes for non-local systems of conservation laws.
- R. Bürger (December 2019, Univ. Concepcion, Chile): finite volume schemes for non-local systems of conservation laws.
- M. Kallel (December 2019, Univ. Tunis al Manar, Tunisia): Game theory for inverse problems.

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

- F.A. Chiarello visited Mannheim University (S. Göttlich) for 3 months in March-May 2019.

BONUS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- *CPER Data (2015-2020)*: in this project, that promotes research and software development related to advanced data science, the BONUS team is the scientific leader (N. Melab) of one of the three research lines of the project "Optimization and High-Performance Computing". In this context, a two-year (2018-2019) engineer (J-Y. Ji) is supported to develop a software demonstrator on decomposition-based big optimization. In addition, the team is co-leader of the workpackage/lever "Research infrastructures" related to the Grid'5000 nation-wide experimental testbed. This allowed to extend the testbed at Lille with a GPU-powered cluster highly important for the BONUS project. In addition, two engineers have been hired for the system & network administration of the testbed, user support and development.
- *CPER ELSAT (2015-2020)*: in this project, focused on ecomobility, security and adaptability in transport, the BONUS team is involved in the transversal research line: planning and scheduling of maintenance logistics in transportation. The team got support for a one-year (2017-2018) post-doc position (M. Rahimi) and a one-year (2019-2020) engineer position (N. Aslimani).

9.2. National Initiatives

9.2.1. ANR

- *Bilateral ANR/RGC France/Hong Kong PRCI* (2016-2021), "Big Multi-objective Optimization" in collaboration with City University of Hong Kong

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: H2020

Project acronym: SYNERGY

Project title: Synergy for Smart Multi-Objective Optimisation

Duration: 02 2016 - 03 2019

Coordinator: Jožef Stefan Institute (JSI), Ljubljana, Slovenia

Other partners: University of Lille (France), Cologne University of Applied Sciences (Germany)

Abstract: Many real-world application areas, such as advanced manufacturing, involve optimization of several, often time-consuming and conflicting objectives. For example, they require the maximization of the product quality while minimizing the production cost, and rely on demanding numerical simulations in order to assess the objectives. These, so-called multi-objective optimization problems can be solved more efficiently if parallelization is used to execute the simulations simultaneously and if the simulations are partly replaced by accurate surrogate models.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: COST CA15140

Project acronym: ImAppNIO

Project title: Improving applicability of nature-inspired optimization by joining theory and practice

Duration: 2016-2019

Coordinator: Thomas Jansen

Abstract: The main objective of the COST Action is to bridge this gap and improve the applicability of all kinds of nature-inspired optimisation methods. It aims at making theoretical insights more accessible and practical by creating a platform where theoreticians and practitioners can meet and exchange insights, ideas and needs; by developing robust guidelines and practical support for application development based on theoretical insights; by developing theoretical frameworks driven by actual needs arising from practical applications; by training Early Career Investigators in a theory of nature-inspired optimisation methods that clearly aims at practical applications; by broadening participation in the ongoing research of how to develop and apply robust nature-inspired optimisation methods in different application areas.

9.3.3. Collaborations with Major European Organizations

University of Mons, Belgium, Parallel surrogate-assisted optimization, large-scale exact optimization, two joint PhDs (M. Gobert and G. Briffoteaux).

University of Luxembourg, Q-Learning-based Hyper-Heuristic for Generating UAV Swarming Behaviours.

University of Coimbra and University of Lisbon, Portugal, Exact and heuristic multi-objective search.

University of Manchester, United Kingdom, Local optimality in multi-objective optimization.

University of Elche and University of Murcia, Spain, Matheuristics for DEA.

University of Mohamed V, Morocco, Large scale (multi-objective) optimization.

9.4. International Initiatives

9.4.1. Inria International Labs

9.4.1.1. Other IIL projects

Title: Frontiers in Massive Optimization and Computational Intelligence (MODO)

International Partner (Institution - Laboratory - Researcher): Shinshu University, Japan

Start year: 2017

See also: https://sites.google.com/view/lia-modo/

Abstract: The aim of MODO is to federate French and Japanese researchers interested in the dimensionality, heterogeneity and expensive nature of massive optimization problems. The team receives a yearly support for international exchanges and shared manpower (joint PhD students).

9.4.2. Inria Associate Teams Not Involved in an Inria International Labs

Title: Three-fold decomposition in multi-objective optimization (D^3MO)

International Partner (Institution - Laboratory - Researcher): University of Exeter, UK

Start year: 2018

9.4.3. Inria International Partners

9.4.3.1. Informal International Partners

- School of Public Health and Preventive Medicine, Monash University, Australia (ranked 73th over 1000 in the Shangai international ranking).
- Instituto Federal de Educação, Ciência e Tecnologia do Ceará, Maracanaú, Brazil.

9.4.4. Participation in Other International Programs

Title: **Evolutionary many-objective optimization: application to smart cities and engineering design**

International Partner (Institution - Laboratory - Researcher): CINVESTAV-IPN, Mexico

Start year: 2016

Abstract: The project is co-funded by ECOS Nord, France and ANUIES, Mexico. It is focused on evolutionary many-objective optimization and its application to smart cities and engineering design.

Title: **Bridging the gap between exact methods and heuristics for multi-objective search (MOCO-Search)**

International Partner (Institution - Laboratory - Researcher): University of Coimbra and University of Lisbon, Portugal

Start year: 2018

Website: http://sites.google.com/view/moco-search/

Abstract: This international project for scientific cooperation (PICS), funded by CNRS and FCT, aims to fill the gap between exact and heuristic methods for multi-objective optimization. The goal is to establish the link between the design principles of exact and heuristic methods, to identify features that make a problem more difficult to be solved by each method, and to improve their performance by hybridizing search strategies. Special emphasis is given to rigorous performance assessment, benchmarking, and general-purpose guidelines for the design of exact and heuristic multi-objective search.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Luís Paquete, University of Coimbra, Portugal, April 2019
- Darrell Whitley, Colorado State University, USA, Invited Professor, July 2019
- Minami Miyakawa, Shinshu University, Japan, October 2019
- Renzo Massobrio, Republica University, Uruguay, January to March 2019
- Bernabe Dorronsoro, University of Cadiz, Spain, March 2019
- Rachid Ellaia, University of Mohamed V, Morocco, April 2019

9.5.1.1. Internships

- Kazuki Maeda, Shinshu University, Japan, November-December 2019
- Kyo Migishima, Shinshu University, Japan, November-December 2019

9.5.2. Visits to International Teams

9.5.2.1. Explorer programme

- T. Carneiro, Cray Inc., Seattle, WA, USA, December 2019
- E-G. Talbi, University of Elche, Spain, November 2019
- E-G. Talbi, University of Luxembourg, Luxembourg, June 2019
- E-G. Talbi, University of Bangkok, Thailand, January 2019
- E-G. Talbi, University of Colorado, USA, November 2019
- E-G. Talbi, University of Mohamed V, Morocco, April 2019
- A. Liefooghe, Shinshu University, Japan, May 2019
- B. Derbel, University of Coimbra, Portugal, October 2019
- A. Liefooghe, University of Coimbra, Portugal, October 2019
- N. Melab, University of Mons, Belgium, working meetings throughout the year

CAGE Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- ANR SRGI, for *Sub-Riemannian Geometry and Interactions*, coordinated by **Emmanuel Trélat**, started in 2015 and runs until 2020. Other partners: Toulon University and Grenoble University. SRGI deals with sub-Riemannian geometry, hypoelliptic diffusion and geometric control.
- ANR Finite4SoS, for *Commande et estimation en temps fini pour les Systèmes de Systèmes*, coordinated by Wilfrid Perruquetti, started in 2015 and run up to this year. Other partners: Inria Lille, CAOR - ARMINES. Finite4SoS aims at developing a new promising framework to address control and estimation issues of Systems of Systems subject to model diversity, while achieving robustness as well as severe time response constraints.
- ANR QUACO, for *QUAntum COntrol: PDE systems and MRI applications*, coordinated by Thomas Chambrion, started in 2017 and runs until 2021. Other partners: Lorraine University. QUACO aims at contributing to quantum control theory in two directions: improving the comprehension of the dynamical properties of controlled quantum systems in infinite-dimensional state spaces, and improve the efficiency of control algorithms for MRI.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

Program: H2020-EU.1.3.1. - Fostering new skills by means of excellent initial training of researchers

Call for proposal: MSCA-ITN-2017 - Innovative Training Networks

Project acronym: QUSCO

Project title: Quantum-enhanced Sensing via Quantum Control

Duration: From November 2017 to October 2021.

Coordinator: Christiane Koch

Coordinator for the participant Inria: Ugo Boscain

Abstract: Quantum technologies aim to exploit quantum coherence and entanglement, the two essential elements of quantum physics. Successful implementation of quantum technologies faces the challenge to preserve the relevant nonclassical features at the level of device operation. It is thus deeply linked to the ability to control open quantum systems. The currently closest to market quantum technologies are quantum communication and quantum sensing. The latter holds the promise of reaching unprecedented sensitivity, with the potential to revolutionize medical imaging or structure determination in biology or the controlled construction of novel quantum materials. Quantum control manipulates dynamical processes at the atomic or molecular scale by means of specially tailored external electromagnetic fields. The purpose of QuSCo is to demonstrate the enabling capability of quantum control for quantum sensing and quantum measurement, advancing this field by systematic use of quantum control methods. QuSCo will establish quantum control as a vital part for progress in quantum technologies. QuSCo will expose its students, at the same time, to fundamental questions of quantum mechanics and practical issues of specific applications. Albeit challenging, this reflects our view of the best possible training that the field of quantum technologies can offer. Training in scientific skills is based on the demonstrated tradition of excellence in research of the consortium. It will be complemented by training in communication and commercialization. The latter builds on strong industry participation whereas the former existing expertise on visualization and gamification and combines it with more traditional means of outreach to realize target audience specific public engagement strategies.

8.3. International Research Visitors

8.3.1. Internships

Rosa Kowalewski made an internship under the supervision of Barbara Gris from January to May 2019.

CAGIRE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. SEIGLE

Participants: Enrique Gutierrez Alvarez, Jonathan Jung, Vincent Perrier.

SEIGLE means "Simulation Expérimentation pour l'Interaction de Gouttes Liquides avec un Ecoulement fortement compressible". It is a 3-year program which has started since October 2017 and was funded by Régional Nouvelle-Aquitaine, ISAE-ENSMA, CESTA and Inria. The interest of understanding aerodynamic mechanisms and liquid drops atomization is explained by the field of applications where they play a key role, specially in the new propulsion technologies through detonation in the aerospace as well as in the securities field. The SEIGLE project was articulated around a triptych experimentation, modeling and simulation. An experimental database will be constituted. It will rely on a newly installed facility (Pprime), similar to a supersonic gust wind tunnel/ hypersonic from a gaseous detonation tube at high pressure. This will allow to test modeling approaches (Pprime / CEA) and numerical simulation (Inria / CEA) with high order schemes for multiphasic compressible flows, suitable for processing shock waves in two-phase media.

9.1.2. HPC scalable ecosystem

Participants: Jonathan Jung, Vincent Perrier, [A two-year Post-doc starting in 2019 or 2020].

HPC scalable ecosystem is a 3-year program funded by Région Nouvelle-Aquitaine (call 2018), Airbus, CEA-CESTA, University of Bordeaux, INRA, ISAE-ENSMA and Inria. A two-year post-doc will be hired in 2019 or 2020. The objective is to extend the prototype developed in [44] to high order (discontinuous Galerkin) and non-reactive diffusive flows in 3d. The same basis will be developed in collaboration with Pprime for WENO based methods for reactive flows.

9.2. National Initiatives

9.2.1. GIS Success

Participant: Pascal Bruel.

We are members of the CNRS GIS Success (Groupement d'Intérêt Scientifique) organised around two of the major CFD codes employed by the Safran group, namely AVBP and Yales2. This year, the evaluation of the capability of the compressible module of Yales2 has started.

9.2.2. ANR MONACO_2025

Participant: Rémi Manceau.

The ambition of the MONACO_2025 project, coordinated by Rémi Manceau, is to join the efforts made in *two different industrial sectors* in order to tackle the industrial simulation of transient, turbulent flows affected by buoyancy effects. It brings together two academic partners, the project-team Cagire hosted by the university of Pau, and the institute Pprime of the CNRS/ENSMA/university of Poitiers (PPRIME), and R&D departments of two industrial partners, the PSA group and the EDF group, who are major players of the automobile and energy production sectors, respectively.

- The main **scientific objective** of the project is to make a breakthrough in *the unresolved issue* of the modelling of turbulence/buoyancy interactions in transient situations, within the continuous hybrid RANS/LES paradigm, which consists in preserving a computational cost compatible with industrial needs by relying on statistical approaches where a fine-grained description of the turbulent dynamics is not necessary. The transient cavity flow experiments acquired during MONACO_2025 will provide the partners and the scientific community with *an unrivalled source of knowledge* of the physical mechanisms that must be accounted for in turbulence models.

- The main **industrial objective** is *to make available computational methodologies* to address dimensioning, reliability and security issues in buoyancy-affected transient flows. It is to be emphasized that such problems are *not tackled using CFD at present in the industry*. At the end of MONACO_2025, a panel of methodologies, ranging from simple URANS to sophisticated hybrid model based on improved RANS models, will be evaluated in transient situations, against the dedicated cavity flow experiments and a real car underhood configuration. This final benchmark exercise will form *a decision-making tool* for the industrial partners, and will thus pave the way towards high-performance design of low-emission vehicles and highly secure power plants. In particular, the project is in line with the *Full Digital 2025 ambition*, e.g., the declared ambition of the PSA group to migrate, within the next decade, to a design cycle of new vehicles nearly entirely based on CAE (computer aided engineering), without recourse to expensive full-scale experiments.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. SOPRANO

Participants: Pascal Bruel, Rémi Manceau, Franck Mastrippolito.

Topic: MG-1.2-2015 - Enhancing resource efficiency of aviation

Project acronym: SOPRANO

Project title: Soot Processes and Radiation in Aeronautical inNOvative combustors

Duration: 01/09/2016 - 31/08/2020

Coordinator: SAFRAN

Other partners:

- France: CNRS, CERFACS, INSA Rouen, SAFRAN SA, Snecma SAS, Turbomeca SA.
- Germany: DLR, GE-DE Gmbh, KIT, MTU, RRD,
- Italy: GE AVIO SRL, University of Florence
- United Kingdom: Rolls Royce PLC, Imperial College of Science, Technology and Medecine, Loughborough University.

Abstract: For decades, most of the aviation research activities have been focused on the reduction of noise and NOx and CO2 emissions. However, emissions from aircraft gas turbine engines of non-volatile PM, consisting primarily of soot particles, are of international concern today. Despite the lack of knowledge toward soot formation processes and characterization in terms of mass and size, engine manufacturers have now to deal with both gas and particles emissions. Furthermore, heat transfer understanding, that is also influenced by soot radiation, is an important matter for the improvement of the combustor's durability, as the key point when dealing with low-emissions combustor architectures is to adjust the air flow split between the injection system and the combustor's walls. The SOPRANO initiative consequently aims at providing new elements of knowledge, analysis and improved design tools, opening the way to: • Alternative designs of combustion systems for future aircrafts that will enter into service after 2025 capable of simultaneously reducing gaseous pollutants and particles, • Improved liner lifetime assessment methods. Therefore, the SOPRANO project will deliver more accurate experimental and numerical methodologies for predicting the soot emissions in academic or semi-technical combustion systems. This will contribute to enhance the comprehension of soot particles formation and their impact on heat transfer through radiation. In parallel, the durability of cooling liner materials, related to the walls air flow rate, will be addressed by heat transfer measurements and predictions. Finally, the expected contribution of SOPRANO is to apply these developments in order to determine the main promising concepts, in the framework of current low-NOx technologies, able to control the emitted soot particles in terms of mass and size over a large range of operating conditions without compromising combustor's liner durability and performance toward NOx emissions.

In the SOPRANO project, our objective is to complement the experimental (ONERA) and LES (CERFACS) work by RANS computations of the flow around a multiperforated plate, in order to build a database making possible a parametric study of mass, momentum and heat transfer through the plate and the development of multi-parameter-dependent equivalent boundary conditions. Franck Mastrippolito, the post-doc recruited by mid-january 2019, performed simulations aimed at reproducing the experiment of ONERA Toulouse carried out in the same workpackage. The configuration is that of an effusion plate with a gyration angle of 90 degrees and the turbulence model is EBRSM. Franck presented his results in October 2019 during the ITR meeting in Florence (Italy).

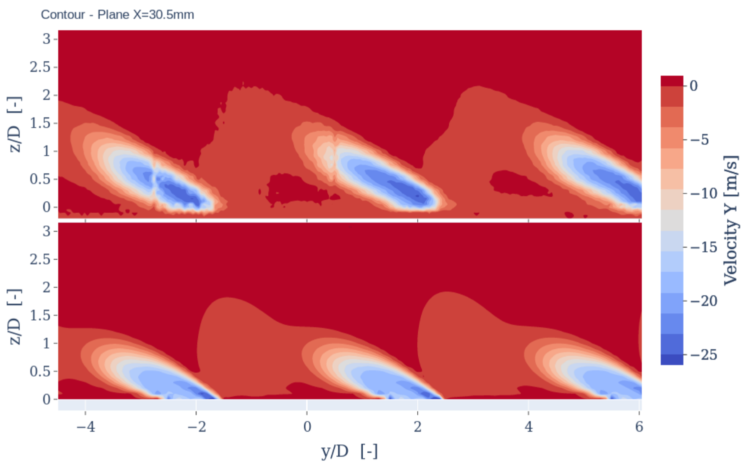


Figure 2. Simulation of the ONERA SOPRANO configuration: example of experimental (top) vs numerical (bottom) results concerning the mean velocity field.

9.4. International Initiatives

9.4.1. Informal International Partners

- Institute of Mathematics and Mathematical Modelling, Almaty, Kazakhstan
  Participant: Pascal Bruel.

  Collaboration with Drs A. Beketaeva and A. Naïmanova for the RANS simulations of a supersonic jet in crossflow configuration for a wide range of pressure ratio ([10]). This year, Pascal Bruel spent two weeks in Almaty in the framework of this partnership.

- University of Evora, Evora, Portugal
  Participant: Pascal Bruel.

  Collaboration with Dr. P. Correia related this year to the partial rewriting of a Fortran code implementing a pressure-based approach for simulating low Mach flows as well as to the promotion of such a pressure-based approach ([25]). This year, Pascal Bruel spent 5 days in Evora in the framework of this partnership.

- University of Ghent, Ghent, Belgium
  Participant: Pascal Bruel.

  Collaboration with Prof. E. Dick related to the development and the promotion of a pressure-based approach for simulating low Mach and all-Mach flows. ([25], [14])

9.4.2. Participation in International Programs

- National University of Córdoba (UNC), Córdoba, Argentina: ECOS-Sud A17A07 project
  Participant: Pascal Bruel.

  2019 was the second year of this project devoted to the simulations of the wind around aerial fuel tanks and related experiments. Pascal Bruel spent two weeks at UNC in the framework of this project.

9.5. International Research Visitors

- Prof. Sergio Elaskar (2 weeks) and PhD student Mauro Grioni (1 month) from University of Córdoba (Argentina) visited the team in the framework of the A17A07 Ecos-Sud project.
- Dr. Paulo Correia from University of Evora spent two weeks in the team in May 2019.

9.5.1. Visits of International Scientists

9.5.1.1. Internships

Mauricio Garcia Zulch from Chile spent 3 months in the team.

CARDAMOM Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Title: ETRURIA: Robust simulation tools for non-hydrostatic free surface flows

Type: Apple à Projets Recherche Région Nouvelle Aquitaine

Coordinator: M. Ricchiuto

Other partners: BRGM, UMR EPOC (P. Bonneton)

Abstract: The objective of this project is to combine high order continuous finite elements, with embedded methods and mesh adaptation in the simulation of coastal and urban inundation. Realistic validation cases will be provided by BRGM. This project co-funds (50%) the PhD of S. Michel.

8.2. National Initiatives

8.2.1. ANR VISCAP

Title: VIrtual Self-healing Composites for Aeronautic Propulsion

Type: ANR

Duration: 48 months

Starting date : 1st Jan 2018

Coordinator: Vignoles Gerard (Université de Bordeaux and LCTS - UMR 5801)

Abstract: Self-healing Ceramic-Matrix Composites (SH-CMCs) have extremely long lifetimes even under severe thermal, mechanical and chemical solicitations. They are made of ceramic fibres embedded in a brittle ceramic matrix subject to multi-cracking, yielding a damageable-elastic mechanical behaviour. These materials have the particularity of protecting themselves against corrosion by the formation of a sealing oxide that fills the matrix cracks, delaying considerably the fibres degradation. Applications encompass civil aeronautic propulsion engine hot parts and they represent a considerable market; however this is only possible if the lifetime duration of the materials is fully certified. The ambition of this innovative project is to provide reliable, experimentally validated numerical models able to reproduce the behaviour of SH-CMCs. The starting point is an existing image-based coupled model of progressive oxidative degradation under tensile stress of a mini-composite (i.e. a unidirectional bundle of fibres embedded in multi-layered matrix). Important improvements will be brought to this model in order to better describe several physic-chemical phenomena leading to a non-linear behaviour: this will require an important effort in mathematical analysis and numerical model building. A systematic benchmarking will allow creating a large database suited for the statistical analysis of the impact of material and environmental parameter variations on lifetime. Experimental verifications of this model with respect to tests carried out on model materials using in-situ X-ray tomography ? in a specially adapted high-temperature environmental & mechanical testing cell ? and other characterizations are proposed. The extension of the modelling procedure to Discrete Crack Networks for the large-scale description of the material life will be the next action; it will require important developments on mesh manipulations and on mathematical model analysis. Finally, experimental validation will be carried out by comparing the results of the newly created software to tests run on 3D composite material samples provided by the industrial partner of the project. The project originality lies in a multidisciplinary character, mixing competences in physico-chemistry, mechanics, numerical and mathematical modelling, software engineering and high-performance computing. It aims creating a true computational platform describing the multi-scale, multidimensional and multi-physics character of the phenomena that determine the material lifetime. Important outcomes in the domain of civil aircraft jet propulsion are expected, that could relate to other materials than those considered in this study.

8.2.2. FUI ICARUS

Title: Intensive Calculation for AeRo and automotive engines Unsteady Simulations.

Type: FUI

Duration: January 2017 - December 2019

Coordinator: Turbomeca, Safran group

Abstract: Large Eddy Simulation is an accurate simulation tool for turbulent flows which is becoming more and more attractive as the parallel computing techniques and platforms become more and more efficient. This project aims at improving the performances of some existing simulation tools (such as AVBP, Yales and ARGO), at developing meshing/re-meshing tools tailored to LES simulations, at improving the ergonomy of these tools to the industrial world (improved interfaces, data handling, code coupling, etc), and validate the progress made on case studies representative of typical design simulations in the automotive and aeronautic industry

8.2.3. APP University of Bordeaux

Title : Modélisation d'un système de dégivrage thermique

Type : Project University of Bordeaux

Duration : 36 months

Starting : October 2016

Coordinator : H. Beaugendre and M. Colin

Abstract : From the beginning of aeronautics, icing has been classified as a serious issue : ice accretion on airplanes is due to the presence of supercooled droplets inside clouds and can lead to major risks such as aircrash for example. As a consequence, each airplane has its own protection system : the most important one is an anti-icing system which runs permanently. In order to reduce gas consumption, de-icing systems are developed by manufacturers. One alternative to real experiment consists in developing robust and reliable numerical models : this is the aim of this project. These new models have to take into account multi-physics and multi-scale environnement : phase change, thermal transfer, aerodynamics flows, etc. We aim to use thin films equations coupled to level-set methods in order to describe the phase change of water. The overall objective is to provide a simulation plateform, able to provide a complete design of these systems.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

Program: FETHPC-02

Project acronym: ExaQute

Project title: Exascale quantification of uncertainties for technology and science simulation

Duration: June 2018 - April 2019

Coordinator: CIMNE (Spain)

Other partners: BSC (Spain), TUM (Germany), IT4 (Czech Republic), EPFL (Switzerland), UPC (Spain), Structure (Germany).

Abstract: The ExaQUte project aims at constructing a framework to enable Uncertainty Quantification and Optimization Under Uncertainties in complex engineering problems, using computational simulations on Exascale systems. The description of complex geometries will be possible by employing embedded methods, which guarantee a high robustness in the mesh generation and adaptation steps, while allowing preserving the exact geometry representation. The efficient exploitation of the Exascale system will be addressed by combining State-of-the-Art dynamic task-scheduling technologies with space-time accelerated solution methods, where parallelism is harvested both in space and time. The methods and tools developed in ExaQUte will be applicable to many fields of science and technology. The chosen application focuses on wind engineering, a field of notable industrial interest for which currently no reliable solution exist.

8.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: OCEANEraNET

Project acronym: MIDWEST

Project title: Multi-fIdelity Decision making tools for Wave Energy SysTems

Duration: December 2015 - April 2019

Coordinator: Mario Ricchiuto

Other partners: Chalmers University (Sweden), DTU Compute (Denmark), IST Lisbon (Portugal)

Abstract: Wave energy converters (WECs) design currently relies on low-fidelity linear hydrodynamic models. While these models disregard fundamental nonlinear and viscous effects - which might lead provide sub-optimal designs - high-fidelity fully nonlinear Navier-Stokes models are prohibitively computational expensive for optimization. The MIDWEST project will provide an efficient asymptotic nonlinear finite element model of intermediate fidelity, investigate the required fidelity level to resolve a given engineering output, construct a multi-fidelity optimization platform using surrogate models blending different fidelity models. Combining know how in wave energy technology, finite element modelling, high performance computing, and robust optimization, the MIDWEST project will provide a new efficient decision making framework for the design of the next generation WECs which will benefit all industrial actors of the European wave energy sector.

8.4. International Initiatives

8.4.1. Inria Associate Teams Not Involved in an Inria International Labs

8.4.1.1. HAMster

Title: High order Adaptive moving MeSh finiTE elements in immeRsed computational mechanics

International Partner (Institution - Laboratory - Researcher):

Duke (United States) - Civil and Environmental Engineering and Mechanical Engineering and Material Science - Guglielmo Scovazzi

Inria Bordeaux -SO (France) - CARDAMOM team - Mario Ricchiuto

Start year: 2017

See also: https://team.inria.fr/athamster/

This project focuses on adaptive unstructured mesh finite element-type methods for fluid flows with moving fronts. These fronts may be interfaces between different fluids, or fluid/solid, and modelling or physical fronts (e.g. shock waves) present in the flow. The two teams involved in the project have developed over the years complementary strategies, one focusing more on an Eulerian description aiming at capturing fronts on adaptive unstructured grids, the other is working more on Lagrangian approaches aiming at following exactly some of these features. Unfortunately, classical Lagrangian methods are at a disadvantage in the presence of complex deformation patterns, especially for fronts undergoing large deformations, since the onset of vorticity quickly leads to mesh rotation and eventually tangling. On the other end, capturing approaches, as well as Immersed Boundary/Embedded (IB/EB) methods, while providing enormous flexibility when considering complex cases, require a careful use of mesh adaptivity to guarantee an accurate capturing of interface physics. The objective of this team is to study advanced hybrid methods combining high order, adaptive, monotone capturing techniques developed in an Eulerian or ALE setting, with fitting techniques and fully Lagrangian approaches.

8.4.2. Inria International Partners

8.4.2.1. Inria International Chairs

IIC ABGRALL Rémi

Title: Numerical approximation of complex PDEs & Interaction between modes, schemes, data and ROMs

International Partner (Institution - Laboratory - Researcher):

ETH Zurich (Switzerland) - Institut fur Mathematik & Computational Science - Rémi Abgrall

Duration: 2019 - 2023

Start year: 2019

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Claes Eskilsson, associated professor at Aalborg University, visited Mario Ricchiuto in Jul 2019.
- Francois Morency, Professeur at Ecole de Technologie Supérieure de Montréal has visited Héloïse Beaugendre to work on aircraft icing, roughness modeling and performance degradation, in January 2019 and July 2019.
- Masahito Ohta, Professor at Tokyo University of Science visited Mathieu Colin in Dec 2019.
- Nicolas Perinet, Postocdoral fellow at University of Chile has visited Mario Ricchiuto to work on the benchmarking of the SLOWS CODE in October 2019.
- Guglielmo Scovazzi, Prof. at Duke University, has visited M. Ricchiuto in the summer to work on the shifted boundary method;
- Davide Torlo, PhD candidate at U. Zurich, visited M. Ricchiuto in June 2019 to work on relaxation finite element approximations of the shallow water equations

8.5.1.1. Internships

- Mirco Ciallella (Inria, M. Sc. Student). Until Jan 2019.
- Simon Le Berre (Inria, M. Sc. Student). From Apr 2019 until Sep 2019.

CELESTE Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

Sylvain Arlot and Matthieu Lerasle are part of the ANR grant FAST-BIG (Efficient Statistical Testing for high-dimensional Models: application to Brain Imaging and Genetics), which is lead by Bertrand Thirion (Inria Saclay, Parietal).

COMMANDS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. IPL

8.1.1.1. Algae in Silico

Inria Project Lab ALGAE IN SILICO (2014-2018) was dedicated to provide an integrated platform for numerical simulation of microalgae “from genes to industrial process“. Commands joined the project in 2017 to tackle the optimization aspects. Our previous collaborations with teams Modemic and Biocore on bioreactors [27], [15] have been renewed in this framework.

8.1.1.2. Cosy

Inria Project Lab COSY (started in 2017) aims at exploiting the potential of state-of-art biological modelling, control techniques, synthetic biology and experimental equipment to achieve a paradigm shift in control of microbial communities. More precisely, we plan to determine and implement control strategies to make heterogeneous communities diversify and interact in the most profitable manner. Study of yeast cells has started in collaboration with team Lifeware (G. Batt) in the framework of the PhD of V. Andreani, and is pursued in the Postdoc of D. Lunz (started Nov. 2019).

CQFD Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. QuAMProcs of the program Project Blanc of the ANR

The mathematical analysis of metastable processes started 75 years ago with the seminal works of Kramers on Fokker-Planck equation. Although the original motivation of Kramers was to « elucidate some points in the theory of the velocity of chemical reactions », it turns out that Kramers' law is observed to hold in many scientific fields: molecular biology (molecular dynamics), economics (modelization of financial bubbles), climate modeling, etc. Moreover, several widely used efficient numerical methods are justified by the mathematical description of this phenomenon.
Recently, the theory has witnessed some spectacular progress thanks to the insight of new tools coming from Spectral and Partial Differential Equations theory.
Semiclassical methods together with spectral analysis of Witten Laplacian gave very precise results on reversible processes. From a theoretical point of view, the semiclassical approach allowed to prove a complete asymptotic expansion of the small eigenvalues of Witten Laplacian in various situations (global problems, boundary problems, degenerate diffusions, etc.). The interest in the analysis of boundary problems was rejuvenated by recent works establishing links between the Dirichlet problem on a bounded domain and the analysis of exit event of the domain. These results open numerous perspectives of applications. Recent progress also occurred on the analysis of irreversible processes (e.g. on overdamped Langevin equation in irreversible context or full (inertial) Langevin equation).
The above progresses pave the way for several research tracks motivating our project: overdamped Langevin equations in degenerate situations, general boundary problems in reversible and irreversible case, non-local problems, etc.

8.1.2. Chaire Stress Test of the Ecole Polytechnique

The Chaire "Stress Testing" is a specific research program between Ecole Polytechnique, BNP Paribas, Fondation de l'Ecole Polytechnique, and is hosted at Polytechnique by the Center of Applied Mathematics. This research project is part of an in-depth reflection on the increasingly sophisticated issues surrounding stress tests (under the impulse of the upcoming European Banking regulation). Simulation of extreme adverse scenarios is an important topic to better understand which critical configurations can lead to financial and systemic crises. These scenarios may depend on complex phenomena, for which we partially lack information, making the modeling incomplete and uncertain. Last, the data are multivariate and reflect the dependency between driving variables. From the above observations, different lines of research are considered:
1. the generation of stress test and meta-modeling scenarios using machine learning;
2. the quantification of uncertainties in risk metrics;
3. modeling and estimation of multidimensional dependencies.

8.1.3. ANR StocMC (2014-2018) of the program Project Blanc of the ANR

The involved research groups are Inria Rennes/IRISA Team SUMO; Inria Rocquencourt Team Lifeware; LIAFA University Paris 7; Bordeaux University.
The aim of this research project is to develop scalable model checking techniques that can handle large stochastic systems. Large stochastic systems arise naturally in many different contexts, from network systems to system biology. A key stochastic model we will consider is from the biological pathway of apoptosis, the programmed cell death.

8.1.4. ANR BNPSI: Bayesian Non Parametric methods for Signal and Image Processing

Statistical methods have become more and more popular in signal and image processing over the past decades. These methods have been able to tackle various applications such as speech recognition, object tracking, image segmentation or restoration, classification, clustering, etc. We propose here to investigate the use of Bayesian nonparametric methods in statistical signal and image processing. Similarly to Bayesian parametric methods, this set of methods is concerned with the elicitation of prior and computation of posterior distributions, but now on infinite-dimensional parameter spaces. Although these methods have become very popular in statistics and machine learning over the last 15 years, their potential is largely underexploited in signal and image processing. The aim of the overall project, which gathers researchers in applied probabilities, statistics, machine learning and signal and image processing, is to develop a new framework for the statistical signal and image processing communities. Based on results from statistics and machine learning we aim at defining new models, methods and algorithms for statistical signal and image processing. Applications to hyperspectral image analysis, image segmentation, GPS localization, image restoration or space-time tomographic reconstruction will allow various concrete illustrations of the theoretical advances and validation on real data coming from realistic contexts.

8.1.5. Gaspard Monge Program for Optimisation and Operational Research (2017-2019)

The involved research groups are Inria Bordeaux Sud-Ouest Team CQFD and Thales Optronique. This new collaboration with Thales Optronique that started in October 2017 is funded by the Fondation Mathématique Jacques Hadamard. This is the continuation of the PhD Thesis of A. Geeraert. The objective of this project is to optimize the maintenance of a multi-component equipment that can break down randomly. The underlying problem is to choose the best dates to repair or replace components in order to minimize a cost criterion that takes into account costs of maintenance but also the cost associated to the unavailability of the system for the customer. In the PhD thesis of A. Geeraert, the model under consideration was rather simple and only a numerical approximation of the value function was provided. Here, our objective is more ambitious. A more realistic model will be considered and our aim is to provide a tractable quasi-optimal control strategy that can be applied in practice to optimize the maintenance of such equipments.

8.1.6. Mission pour les initiatives transverses et interdisciplinaires, Défi Modélisation du Vivant, projet MISGIVING

The aim of MISGIVING (MathematIcal Secrets penGuins dIVING) is to use mathematical models to understand the complexity of the multiscale decision process conditioning not only the optimal duration of a dive but also the diving behaviour of a penguin inside a bout. A bout is a sequence of succesive dives where the penguin is chasing prey. The interplay between the chasing period (dives) and the resting period due to the physiological cost of a dive (the time spent at the surface) requires some kind of optimization.

8.2. European Initiatives

8.2.1. Collaborations in European Programs, Except FP7 & H2020

Program: Direcion General de Investigacion Cientifica y Tecnica, Gobierno de Espana

Project acronym: GAMECONAPX

Project title: Numerical approximations for Markov decision processes and Markov games

Duration: 01/2017 - 12/2019

Coordinator: Tomas Prieto-Rumeau, Department of Statistics and Operations Research, UNED (Spain)

Abstract:
This project is funded by the Gobierno de Espana, Direcion General de Investigacion Cientifica y Tecnica (reference number: MTM2016-75497-P) for three years to support the scientific collaboration between Tomas Prieto-Rumeau, Jonatha Anselmi and Francois Dufour. This research project is concerned with numerical approximations for Markov decision processes and Markov games. Our goal is to propose techniques allowing to approximate numerically the optimal value function and

the optimal strategies of such problems. Although such decision models have been widely studied theoretically and, in general, it is well known how to characterize their optimal value function and their optimal strategies, the explicit calculation of these optimal solutions is not possible except for a few particular cases. This shows the need for numerical procedures to estimate or to approximate the optimal solutions of Markov decision processes and Markov games, so that the decision maker can really have at hand some approximation of his optimal strategies and his optimal value function. This project will explore areas of research that have been, so far, very little investigated. In this sense, we expect our techniques to be a breakthrough in the field of numerical methods for continuous-time Markov decision processes, but particularly in the area of numerical methods for Markov game models. Our techniques herein will cover a wide range of models, including discrete- and continuous-time models, problems with unbounded cost and transition rates, even allowing for discontinuities of these rate functions. Our research results will combine, on one hand, mathematical rigor (with the application of advanced tools from probability and measure theory) and, on the other hand, computational efficiency (providing accurate and ?applicable? numerical methods). In this sense, particular attention will be paid to models of practical interest, including population dynamics, queueing systems, or birth-and-death processes, among others. So, we expect to develop a generic and robust methodology in which, by suitably specifying the data of the decision problem, an algorithm will provide the approximations of the value function and the optimal strategies. Therefore, the results that we intend to obtain in this research project will be of interest for researchers in the fields of Markov decision processes and Markov games, both for the theoretical and the applied or practitioners communities

8.3. International Initiatives

8.3.1. Declared Inria International Partners

Tree-Lab, ITT. TREE-LAB is part of the Cybernetics research line within the Engineering Science graduate program offered by the Department of Electric and Electronic Engineering at Tijuana's Institute of Technology (ITT), in Tijuana Mexico. TREE-LAB is mainly focused on scientific and engineering research within the intersection of broad scientific fields, particularly Computer Science, Heuristic Optimization and Pattern Analysis. In particular, specific domains studied at TREE-LAB include Genetic Programming, Classification, Feature Based Recognition, Bio-Medical signal analysis and Behavior-Based Robotics. Currently, TREE-LAB incorporates the collaboration of several top researchers, as well as the participation of graduate (doctoral and masters) and undergraduate students, from ITT. Moreover, TREE-LAB is actively collaborating with top researchers from around the world, including Mexico, France, Spain, Portugal and USA.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Oswaldo Costa (Escola Politécnica da Universidade de São Paulo, Brazil) collaborate with the team on the theoretical aspects of continuous control of piecewise-deterministic Markov processes. He visited the team during two weeks in december 2019.

Tomas Prieto-Rumeau (Department of Statistics and Operations Research, UNED, Madrid, Spain) visited the team during one week in 2019. The main subject of the collaboration is the approximation of Markov Decision Processes

Anna Jaskiewicz (Politechnika Wrocławska) visited the team during one week in 2019. The main subject of the collaboration is the approximation of Markov Decision Processes

8.4.2. Visits to International Teams

Pierrick Legrand visited the Instituto Tecnológico de Tijuana from 08/12/2019 to 17/12/2019.

DEFI Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. EVE

- Title : Virtual prototyping of EVE engines
- Type : Co-funded from Region Aquitaine and Inria
- Duration : 36 months
- Starting : October 2018
- Coordinator : P.M. Congedo
- Abstract : The main objective of this thesis is the construction of a numerical platform, for permitting an efficient virtual prototyping of the EVE expander. This will provide EXOES with a numerical tool, that is much more predictive with respect to the tools currently available and used in EXOES, by respecting an optimal trade-off in terms of complexity/cost needed during an industrial design process.i Two research axes will be mainly developed. First, the objective is to perform some high-predictive numerical simulation for reducing the amount of experiments, thanks to a specific development of RANS tools (Reynolds Averaged Navier-Stokes equations) for the fluids of interest for EXOES. These tools would rely on complex thermodynamic models and a turbulence model that should be modified. The second axis is focused on the integration of the solvers of different fidelity in a multi-fidelity platform for performing optimization under uncertainties. The idea is to evaluate the system performances by using massively the low-fidelity models, and by correcting these estimations via only few calculations with the high-fidelity code.

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

7.2.1.1. UTOPIAE

Program: H2020 MSCA-ITN
Project acronym: UTOPIAE
Project title: Handling the unknown at the edge of tomorrow
Duration: January 2017- December 2020
Coordinator: M. Vasile (Strathclyde University)
Other partners: see http://utopiae.eu/ for additional details
UTOPIAE is a European research and training network looking at cutting edge methods bridging optimisation and uncertainty quantification applied to aerospace systems. The network will run from 2017 to 2021, and is funded by the European Commission through the Marie Skłodowska-Curie Actions of H2020. The network is made up of 15 partners across 6 European countries, including the UK, and one international partner in the USA, collecting mathematicians, engineers and computer scientists from academia, industry, public and private sectors.
Mission statement : To train, by research and by example, 15 Early Stage Researchers in the field of uncertainty quantification and optimisation to become leading independent researchers and entrepreneurs that will increase the innovation capacity of the EU. To equip the researchers with the skills they will need for successful careers in academia and industry. To develop fundamental mathematical methods and algorithms to bridge the gap between Uncertainty Quantification and Optimisation and between Probability Theory and Imprecise Probability Theory for Uncertainty Quantification to efficiently solve high-dimensional, expensive and complex engineering problems.

7.3. International Initiatives

7.3.1. Inria International Labs

P.M. Congedo is the Inria Coordinator of the CWI-Inria Inria International Lab.

IIL CWI-Inria

Associate Team involved in the International Lab:

7.3.1.1. COMMUNES

Title: Computational Methods for Uncertainties in Fluids and Energy Systems

International Partner (Institution - Laboratory - Researcher):

CWI (Netherlands) - Scientific Computing Group - Daan Crommelin

Start year: 2017

See also: https://project.inria.fr/inriacwi/projects/communes/

This project aims to develop numerical methods capable to take into account efficiently unsteady experimental data, synthetic data coming from numerical simulation and the global amount of uncertainty associated to measurements, and physical-model parameters. We aim to propose novel algorithms combining data-inferred stochastic modeling, uncertainty propagation through computer codes and data assimilation techniques. The applications of interest are both related to the exploitation of renewable energy sources: wind farms and solar Organic Rankine Cycles (ORCs).

7.3.1.2. Informal International Partners

University of Zurich : R. Abgrall. Collaboration on high order adaptive methods for CFD and uncertainty quantification.

Politecnico di Milano, Aerospace Department (Italy) : Pr. A. Guardone. Collaboration on ALE for complex flows (compressible flows with complex equations of state).

von Karman Institute for Fluid Dynamics (Belgium). With Pr. T. Magin we work on Uncertainty Quantification problems for the identification of inflow condition of hypersonic nozzle flows.

Rutgers University. Collaboration with Pr. F. Cakoni on transmission eigenvalues.

University of Delaware. Collaboration with Pr. D. Colton on inverse scattering theory

Ecole Nationale des Ingénieurs de Tunis. Collaboration with Pr. M. Bellasoued on inverse scattering problems

Faculté des Sciences de Sfax. Collaboration with Pr. S. Chaabane on inverse problems for singular parameters

University of Sousse. Collaboration with Pr. M. Khenissi on transmission eigenvalues

Colorado School of Mines. Collaboration with F. Pourahmadian on differential LSM

ns of solution derivatives.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

- Fioralba Cakoni and David Colton, 1 week, March 2019

7.4.1.1. PostDocs, Internships

- PostDoc, Xiaoli Liu, Sampling methods for time dependent problems, H. Haddar
- Master thesis, Marwa Mansouri, Inside-outside duality with artificial backgrounds, L. Chesnel and H. Haddar.
- PostDoc, Imen Mekkaoui, In-vivo cardiac diffusion magnetic resonanace imaging: simulations and parameters estimation, Jing Rebecca Li and Jan Hesthaven.
- Master thesis, Try Nguyen Tran, French-Vietnam Master Program in Applied Mathematics, Jing Rebecca Li
- Master thesis, Nouha jenhani, ENIT, LAMSIN, H. Haddar
- Master thesis, Amal Labidi, ENIT, LAMSIN, H. Haddar

DISCO Project-Team

6. Partnerships and Cooperations

6.1. Regional Initiatives

Islam Boussaada is a deputy director of the IRS iCODE Institute, the institute for control and decision of the Idex Paris Saclay (http://icode-institute.fr).

- The project *Distributed Algorithms for Microbiological Systems* was funded by iCODE.
- The project *Symbolic/Numerical Methods and Implementations in Delayed-Control design* was funded by iCODE.
- The project *From modeling to control of microalgae growth in photo-bioreactor* was funded by iCODE.
- The project *Distributed Algorithms for Microbiological systems* was funded by iCODE.

6.2. National Initiatives

Islam Boussaada is a member of the administration council of the Association SAGIP (https://www.sagip.org), which structures and promotes the disciplines of automatic control and industrial engineering at the national level.

6.2.1. ANR

Giorgio Valmorbida is a member of the ANR HANDY - Hybrid And Networked Dynamical sYstems (http://projects.laas.fr/handy). Project Summary: Networked dynamical systems are ubiquitous in current and emerging technologies. From energy grids, fleets of connected autonomous vehicles to online social networks, the same scenario arises in each case: dynamical units interact locally to achieve a global behavior. When considering a networked system as a whole, very often continuous-time dynamics are affected by instantaneous changes, called jumps, leading to so-called hybrid dynamical systems. The jumps may originate from (i) the intrinsic dynamics of the nodes, like in multimedia delivery with fixed rate encoding, (ii) intrinsic limitations of the control actions, possibly constrained to a finite set of possible selections, like in power converters within energy grids, (iii) the creation/loss of links or the addition/removal of nodes like in renewable energy systems and social networks. Hybrid phenomena thus play an essential role in these control applications, and call upon the development of novel adapted tools for stability and performance analysis and control design. In this context, the aim of HANDY project is to provide methodological control-oriented tools for realistic networked models, which account for hybrid phenomena.

6.3. European Initiatives

6.3.1. Collaborations in European Programs, Except FP7 & H2020

Program: **COST Action**

Project acronym: FRACTAL

Project title: Fractional-order systems; analysis, synthesis and their importance for future design

Duration: November 2016 - October 2020

Coordinator: Jaroslav Koton Czech Republic

Abstract: Fractional-order systems have lately been attracting significant attention and gaining more acceptance as generalization to classical integer-order systems. Mathematical basics of fractional-order calculus were laid nearly 300 years ago and since that it has gained deeply rooted mathematical concepts. Today, it is known that many real dynamic systems cannot be described by a system of simple differential equation or of integer-order system. In practice we can encounter such systems in electronics, signal processing, thermodynamics, biology, medicine, control theory, etc. The Action will favor scientific advancement in above mentioned areas by coordinating activities of academic research groups towards an efficient deployment of fractal theory to industry applications.

Program: **PHC AURORA**

Project acronym: -

Project title: Control and Observation of Nonlinear Systems

Duration: 01/2019-12/2019

Coordinator: Giorgio VALMORBIDA

Other partners: NTNU, Norvège

Abstract: Control theory and controller design for linear dynamical systems is well developed. The same cannot be said for nonlinear systems and searching for a general set of design tools applicable to any nonlinear system may be futile. Restricting the class of system dynamics with the aim of developing a more complete set of controller design tools for such a restricted model class therefore appears to be a reasonable approach. One such restricted class of system dynamics is the class of polynomial dynamical systems, for which stability analysis and controller design tools based on Convex Optimization has recently flourished, using so-called Sum of Squares (SOS) programming. Three topics were studied: - Time discretization techniques. SOS programming for discrete time system is less developed than for continuous time systems. This research task will then study discretization techniques leading to polynomial or rational models. In particular we will develop methods to compare the continuous time system and the discretized one by, for instance, comparing estimates of the region of attraction of stable equilibria. - Observer design. In many applications, not all states are measured, and therefore they have to be inferred using a state observer. Note that the so-called Certainty Equivalence Principle does not in general hold for nonlinear systems. This research task will therefore address observer design using SOS programming, and study the effects of interactions between controller design and observer design on the stability of the overall system. - Benchmark application. CentraleSupelec has a cart and pendulum experimental setup. The complexity of SOS-based controller design for this system is near the limit of what can be accommodated by current optimization packages and computational resources. This research task will test the limits of available numerical solution tools and provide a convincing demonstration of the capabilities of SOS-based controller design.

Program: **PHC BALATON**

Project acronym: SadHuB

Project title: Analysis of stabilizability of delayed dynamical system as function of the systems parameters and the time delays with applications to human balancing

Duration: 01/2018-12/2019

Coordinator: Islam Boussaada

Other partners: Budapest University of Technology and Economics, Hungary

Abstract: Motivated by a class of Time-delay systems occurring in modeling of many mechanical engineering applications, this project aims to associate researchers from control theory, applied mathematics and mechanical engineering to build together a general methodology for the analysis and control of mechanical/bio-mechanical structures. In particular, the human balance is often considered as a control system which operates in the presence of delays, primarily due to the time it takes to acquire the information needed for decision-making, to create control decisions, and to execute these decisions. A particular interest will be devoted to the delayed human balance, where a depthful study of the delay effect on the stability is expected.

6.4. International Initiatives

6.4.1. Inria International Partners

6.4.1.1. Informal International Partners

- Louisiana State University, Baton Rouge, USA
- Rutgers University, USA
- CINVESTAV, IPN, Mexico-City, Mexico
- Southern Illinois University, USA
- The University of Texas at Austin, Dept. of Aerospace Engineering & Engineering Mechanics, USA
- City University of Hong Kong, China
- Czech technical university in Prague, Czech Republic
- Budapest University of Technology and Economics, Hungary
- Katholieke Universiteit Leuven, Belgium
- Blikent University, Turkey
- Northeastern University, China
- Northeastern University, Boston, USA
- Universidad de Chile, Chile
- School of Mathematics, University of Leeds, U.K.
- UNICAMP, Brazil
- Kyoto University, Japan
- University Badji Mokhtar-Annaba, Algeria
- University Mouloud-Mammeri Tizi Ouzou, Algeria
- Universitat Politècnica de Catalunya, Spain
- University of Melbourne, Australia

6.4.2. Participation in Other International Programs

The team is member of the GDRI (International Research Group funded by CNRS) SpaDisco (following the GDRI Delsys) since 2017.

6.5. International Research Visitors

6.5.1. Visits of International Scientists

Jie Chen, CityU Hong Kong, 16-20 Dec 2019.

André Fioravanti, UNICAMP, Brazil, 1-7 Dec 2019.

Dan Ma, Northeastern University, 16-20 Dec 2019.

Hitay Özbay, Bilkent University, 4-8 Dec 2019.

Matheus Souza, UNICAMP, Brazil, 1-7 Dec 2019.

Joao Manoel Gomes da Silva Jr, UFRGS, Brazil, 15 Jul -15 Ago 2019.

Ross Drummond, University of Oxford, U.K., 1-7 Dec 2019.

Yutaka Yamamoto, Kyoto University, Japan, 30 oct - 8 Dec 2019.

6.5.1.1. Internships

Master internship: Lotfi Baour, Qualitative behaviour of two models of bacteria communication, Université de Cergy-Pontoise. Supervisors: Catherine Bonnet, Walid Djema, Matthias Fuegger and Thomas Nowak.

Master internship: Khaoula El Farhani, Modeling, estimation and control of microalgae growth for energy production and synthesis of molecules of high added values, CentraleSupelec, 05-09/2019. Supervisors: Sette Diop and Islam Boussaada.

Master internship: Jawher Kahouli, estimation and modelling of microalgae growth in photobioreactor, IPSA/Sup'Biotech,02-08/2019. Supervisors: Islam Boussaada, Ali El Ati and Jean-Yves Trosset.

Master internship: Robin Lacombe, qualification and start-up of Synoxis nano 2l photobioreactor, IPSA/Sup'Biotech,02-08/2019. Supervisors: Islam Boussaada, Ali El Ati and Jean-Yves Trosset.

Master internship: Lucas Leclerc, Modelling of bacteria communication through EDO/EDP, CentraleSupélec. Supervisor: Catherine Bonnet, Matthias Fuegger and Thomas Nowak.

Master internship: Javier Eduardo Pereyra Zamundio, New backstepping design using satificial delays for systems with pointwise delays, CINVESTAV, Instituto Politecnico Nacional. Supervisors: Sabine Mondié, Frédéric Mazenc.

6.5.2. Visits to International Teams

Islam Boussaada visited Budapest University of Technology and Economics during 1-7 Dec 2019.

Giorgio Valmorbida visited the University of Oxford 15-17 Jul 2019.

Giorgio Valmorbida visited the UFRGS, CEFET-Divinopolis, and the UNICAMP, Brazil 26 Jul - 6 Ago 2019.

ECUADOR Project-Team (section vide)

ELAN Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. National Collaborations

- Long-term collaboration with Christophe Prud'homme and Vincent Chabannes (Université de Strasbourg and Centre de modélisation et de simulation de Strasbourg).

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. GEM

Title: from GEometry to Motion, inverse modeling of complex mechanical structures

Programm: H2020

Type: ERC

Duration: September 2015 - August 2021

Coordinator: Inria

Inria contact: Florence BERTAILS-DESCOUBES

With the considerable advance of automatic image-based capture in Computer Vision and Computer Graphics these latest years, it becomes now affordable to acquire quickly and precisely the full 3D geometry of many mechanical objects featuring intricate shapes. Yet, while more and more geometrical data get collected and shared among the communities, there is currently very little study about how to infer the underlying mechanical properties of the captured objects merely from their geometrical configurations. The GEM challenge consists in developing a non-invasive method for inferring the mechanical properties of complex objects from a minimal set of geometrical poses, in order to predict their dynamics. In contrast to classical inverse reconstruction methods, my proposal is built upon the claim that 1/ the mere geometrical shape of physical objects reveals a lot about their underlying mechanical properties and 2/ this property can be fully leveraged for a wide range of objects featuring rich geometrical configurations, such as slender structures subject to frictional contact (e.g., folded cloth or twined filaments). To achieve this goal, we shall develop an original inverse modeling strategy based upon a/ the design of reduced and high-order discrete models for slender mechanical structures including rods, plates and shells, b/ a compact and well-posed mathematical formulation of our nonsmooth inverse problems, both in the static and dynamic cases, c/ the design of robust and efficient numerical tools for solving such complex problems, and d/ a thorough experimental validation of our methods relying on the most recent capturing tools. In addition to significant advances in fast image-based measurement of diverse mechanical materials stemming from physics, biology, or manufacturing, this research is expected in the long run to ease considerably the design of physically realistic virtual worlds, as well as to boost the creation of dynamic human doubles.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Declared Inria International Partners

- Long-term partnership with Rahul Narain (University of Minnesota, USA, and IIT Delhi, INDIA) and Rahul Narain's PhD student Jie Li (University of Minnesota, USA).
- Long-term partnership with Alexandre-Derouet-Jourdan (OLM Digital, JAPAN).

FACTAS Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- The team co-advises a PhD (G. Bose) with the CMA team of LEAT (http://leat.unice.fr/pages/activites/cma.html) funded by the Labex UCN@Sophia on the co-conception of Antennas and Filters.
- The team participates in the project ToMaT, "Multiscale Tomography: imaging and modeling ancient materials, technical traditions and transfers", funded by the Idex UCA$^{\text{Jedi}}$ ("programme structurant Matière, Lumière, Interactions"). This project brings together researchers in archaeological, physical, and mathematical sciences, with the purpose of modeling and detecting low level signals in 3-D images of ancient potteries. The other concerned scientists are from CEPAM-CNRS-UCA (project coordinator: Didier Binder), Nice http://www.cepam.cnrs.fr, the team Morpheme, CNRS-I3S-Inria http://www.inria.fr/equipes/morpheme, and IPANEMA, CNRS, Ministère de la Culture et de la Communication, Université Versailles Saint Quentin http://ipanema.cnrs.fr/. Since March 2018, they co-advise together the post-doctoral research of Vanna Lisa Coli, see Section 6.6 , and this year the internship training of Pat Vatiwutipong.

8.2. National Initiatives

8.2.1. ANR MagLune

The ANR project MagLune (Magnétisme de la Lune) was active from July 2014 to August 2019. It involved the Cerege (Centre de Recherche et d'Enseignement de Géosciences de l'Environnement, joint laboratory between Université Aix-Marseille, CNRS and IRD), the IPGP (Institut de Physique du Globe de Paris) and ISTerre (Institut des Sciences de la Terre). Associated with Cerege were Inria (Apics, then Factas team) and Irphe (Institut de Recherche sur les Phénomènes Hors Équilibre, joint laboratory between Université Aix-Marseille, CNRS and École Centrale de Marseille). The goal of this project (led by geologists) was to understand the past magnetic activity of the Moon, especially to answer the question whether it had a dynamo in the past and which mechanisms were at work to generate it. Factas participated in the project by providing mathematical tools and algorithms to recover the remanent magnetization of rock samples from the moon on the basis of measurements of the magnetic field it generates. The techniques described in Section 6.1 were instrumental for this purpose.

8.2.2. ANR Repka

ANR-18-CE40-0035, "REProducing Kernels in Analysis and beyond", starting April 2019 (for 48 months).

Led by Aix-Marseille Univ. (IMM), involving Factas team, together with Bordeaux (IMB), Paris-Est, Toulouse Universities.

The project consists of several interrelated tasks dealing with topical problems in modern complex analysis, operator theory and their important applications to other fields of mathematics including approximation theory, probability, and control theory. The project is centered around the notion of the so-called reproducing kernel of a Hilbert space of holomorphic functions. Reproducing kernels are very powerful objects playing an important role in numerous domains such as determinantal point processes, signal theory, Sturm-Liouville and Schrödinger equations.

This project supports the PhD of M. Nemaire within Factas, co-advised by IMB partners.

8.3. European Initiatives

8.3.1. Collaborations with Major European Organizations

Factas is part of the European Research Network on System Identification (ERNSI) since 1992.

System identification deals with the derivation, estimation and validation of mathematical models of dynamical phenomena from experimental data.

8.4. International Initiatives

8.4.1. Inria International Partners

8.4.1.1. Informal International Partners

Following two Inria Associate teams (2013-2018) and a MIT-France seed funding (2014-2018), the team has a strong and regular collaboration with the Earth and Planetary Sciences department at Massachusetts Institute of Technology (Cambridge, MA, USA) and with the Mathematics department of Vanderbilt University (Nashville, TN, USA) on inverse problems for magnetic microscopy applied to the analysis of ancient rock magnetism.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

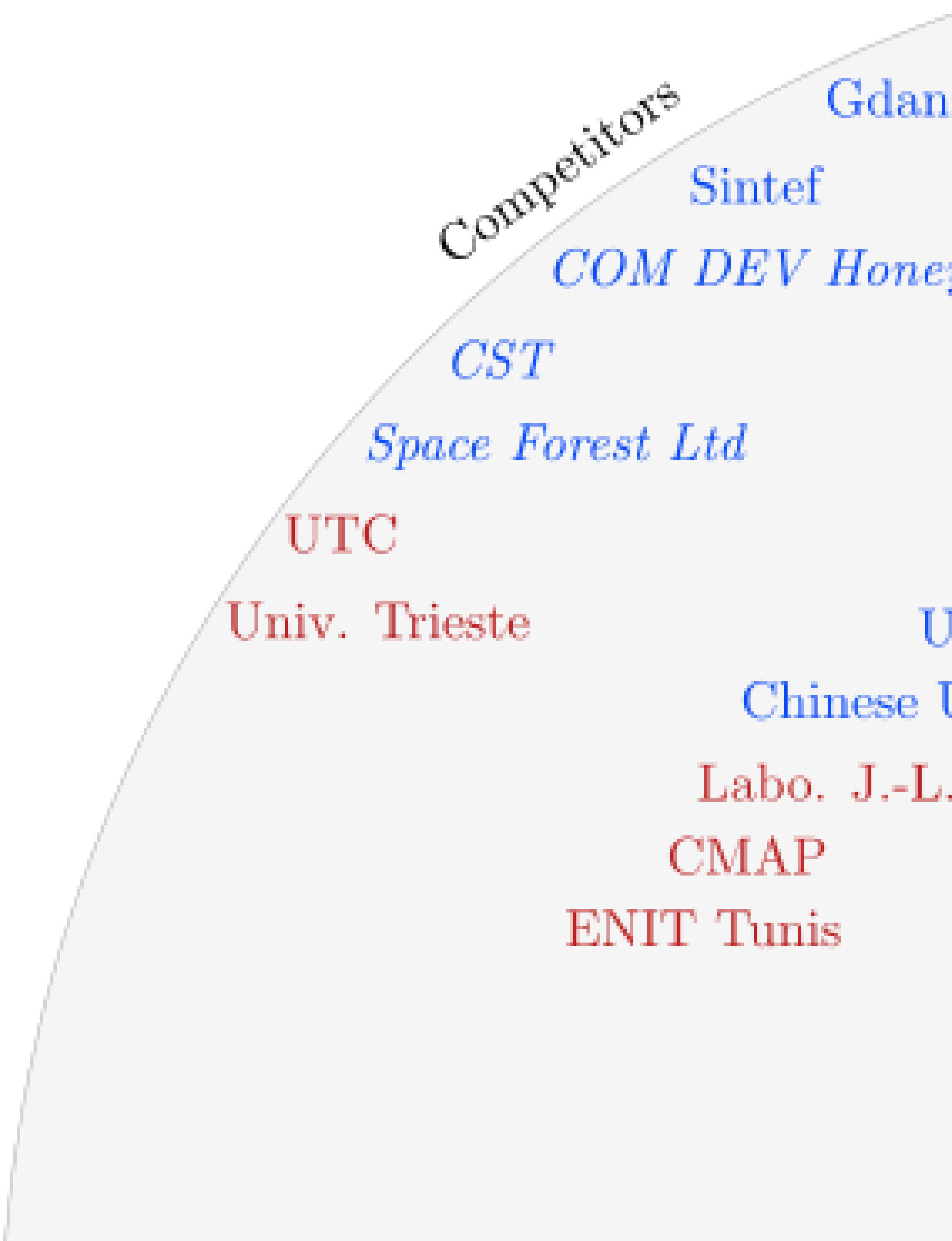
- Smain Amari (Royal Military College of Canada, Kingston, Canada), February 4-9.
- Jonathan Partington (Univ. of Leeds, England), February 4-7.
- Dmitry Ponomarev (T.U. Vienna, Vienna, Austria), June 24.
- Élodie Pozzi (St Louis Univ., St Louis, Missouri, USA), Brett Wick (Washington Univ., St Louis, Missouri, USA), January 9-10.
- Yves Rolain (Vrije Universiteit Brussel, VUB, Brussels, Belgium), February 5-7.
- Maxim Yattselev (University of Indianapolis, Purdue University at Indianapolis, USA), June 29-July 1.

8.5.1.1. Internships

- Paul Asensio, École Centrale Lyon, *Study of silent current sources in electroencephalography (EEG) and magnetoencephalography (MEG)*; advisors: L. Baratchart, J. Leblond.
- Masimba Nemaire, MathMods Master, *Study of silent current sources in EEG and MEG*; advisors: L. Baratchart, J. Leblond.
- Tuong Vy Nguyen Hoang, *Mathematical Circuit Modeling for Antennas*; advisors: F. Seyfert, M. Olivi.
- Pat Vatiwutipong, MathMods Master, *Properties of the d-Radon transform and applications to imaging issues in archaeology*; advisors: V. L. Coli, J. Leblond.

8.6. List of international and industrial partners

Figure 10 sums up who are our main collaborators, users and competitors.


Competitors
Sintef
COM DEV
CST
Space Forest Ltd
UTC
Univ. Trieste
CMAP
ENIT Tunis

GAMMA Project-Team

6. Partnerships and Cooperations

6.1. National Initiatives

6.1.1. ANR

6.1.1.1. ANR IMPACTS 2018-2021

Ideal Mesh generation for modern solvers and comPuting ArchiteCTureS.

- Coordinateur : Adrien Loseille
- The rapid improvement of computer hardware and physical simulation capabilities has revolutionized science and engineering, placing computational simulation on an equal footing with theoretical analysis and physical experimentation. This rapidly increasing reliance on the predictive capabilities has created the need for rigorous control of numerical errors which strongly impact these predictions. A rigorous control of the numerical error can be only achieved through mesh adaptivity. In this context, the role of mesh adaptation is prominent, as the quality of the mesh, its refinement, and its alignment with the physics are major contributions to these numerical errors. The IMPACTS project aims at pushing the envelope in mesh adaptation in the context of large size, very high fidelity simulations by proposing a new adaptive mesh generation framework. This framework will be based on new theoretical developments on Riemannian metric-field and on innovative algorithmic developments coupling a unique cavity-operator with an advancing-point techniques in order to produce high quality hybrid, curved and adapted meshes.

GEOSTAT Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

Geostat is a member of the GPR ("Grand Projet de Recherche") **ORIGINS** ("Origine, évolution, matière primordiale, nucléosynthèse, complexification, étoiles, planètes, Terre, habitabilité, climat, biodiversité, homininés, big data, sociologie, médiation scientifique) carried by Laboratoire d'Astrophysique de Bordeaux (LAB) (M. Gargaud). Geostat is involved in the axis "Data Science pour les Sciences de Origins".

9.2. National Initiatives

- ANR project *Voice4PD-MSA*, led by K. Daoudi, which targets the differential diagnosis between Parkinson's disease and Multiple System Atrophy. The total amount of the grant is 468555 euros, from which GeoStat has 203078 euros. The duration of the project is 42 months. Partners: CHU Bordeaux (Bordeaux), CHU Toulouse, IRIT, IMT (Toulouse).
- Prolongation for A. El Aouni in 2019 (4 months) through the program "BOOSTE TON DOC" of the Toubkal PHC project PHC-Toubkal project "Caractérisation multi-capteurs et suivi spatio-temporel de l'Upwelling sur la côte atlantique marocaine par imagerie satellitaire", which finished December 2018.
- GEOSTAT is a member of ISIS (Information, Image & Vision), AMF (Multifractal Analysis) GDRs.
- GEOSTAT is participating in the CNRS IMECO project *Intermittence multi-échelles de champs océaniques : analyse comparative d'images satellitaires et de sorties de modèles numériques*. CNRS call AO INSU 2018. PI: F. Schmitt, DR CNRS, UMR LOG 8187. Duration: 2 years.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

GENESIS Program: supported by Deutsche Forschungsgemeinde (DFG) and the Agence national de recherche (ANR). *GENeration and Evolution of Structures in the ISm.* Duration: start 1.5. 2017, 3 years. Coordinator: N. Schneider (I. Physik, Cologne). Other partners: Cologne (R. Simon, N. Schneider, V. Ossenkopf, M. Roellig), LAB (S. Bontemps, A. Roy, L. Bonne, F. Herpin, J. Braine, N. Brouillet, T. Jacq), ATN Canberra (Australia), LERMA Paris (France), MPIfR Bonn (Germany), CEA Saclay (France), ITA/ZAH Heidelberg (Germany), Institute of Astronomy, Cardiff (UK), ESO (Germany, Chile), CfA Harvard (USA), IPAG Grenoble (France), Argelander Institut Bonn (Germany), CASS San Diego (USA), University of Sofia (Bulgaria). Web site: link.

9.4. International Initiatives

9.4.1. Inria exploratory action

TRACME This project focuses on modelling a physical system from measurements on that system. How, starting from observations, to build a reliable model of the system dynamics? When multiple processes interact at different scales, how to obtain a significant model at each of these scales? The goal is to provide a model simple enough to bring some understanding of the system studied, but also a model elaborated enough to allow precise predictions. In order to do so, this project proposes to identify causally equivalent classes of system states, then model their evolution with a stochastic process. Renormalizing these equations is necessary in order to relate the scale of the continuum to that, arbitrary, at which data are acquired. Applications primarily concern natural sciences. PI: N. Brodu.

9.4.2. Participation in Other International Programs

9.4.2.1. IFCAM: Generalization for land cover identification. Geostat and the Indo-French Centre For Applied Mathematics

Land cover classification from satellite imagery is an important application for agriculture, environmental monitoring, tracking changes for emergency, etc. The typical methodology is to train a machine learning algorithm to recognize specified classes (urban, forest, fields, etc...) over regions of interest and classify new images when they become available. This proposal investigates how to use local context and how to best sample the data in order to provide the best generalization ability. Data will be sampled on reference locations and used for training and validation.

PIs: N. Brodu (Geostat) and D. Singh (IIT Roorkee).

Duration: 3 years. Starting 2018.

9.5. Introduction

9.5.1. Visits of International Scientists

- D. Singh [IIT Rookee, June 2019]

9.5.1.1. Internships

- D. Nash, level L3, intern in June 2019. Supervisor: N. Brodu.

9.5.2. Visits to International Teams

- PhD student A. Rashidi met with Dr Francis Bach of Inria Paris on optimization methods. first meeting was on November 2019.
- A. Rashidi registered for "Inversion et imagerie haute resolution" lectures of Dr. Francois Giovannelli, starting from January 2020.
- A. Rashidi participated in PRAIRE artificial intelligence summer school in October 2019 at Paris.

I4S Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. SYSIFE

Participant: Ivan Guéguen.

Type: CPER + REVES project funding

Objectif: Development of a test bench for railways testing

Duration: 2019 - 2020

Coordinator : IFSTTAR

Partners: Cerema, ColasRail, Edilon, SNCF Réseau, Railenium, Vossloh

Inria contact: Ivan Guéguen

8.1.2. SHM-TGROUT

Participant: Xavier Chapeleau.

Type: Weamec regional cluster

Objectif: to assess the suitability of several non-destructive methods to detect and track the damage for metal pipes.

Duration: 2019 - 2020

Coordinator : IFSTTAR

Partners: University of Nantes, STX

Inria contact: Xavier Chapeleau

Abstract:

The cement bond between metal pipes is a very common technique in the offshore environment, particularly in the "oil and gas" sector. This technique has been used in the offshore wind sector installed to connect the structure (jacket or monopile) to its foundation. A small-scale sample of this type of cement connection was sized, and instrumented it with several technologies. sensors (including fiber optic sensors) and subjected it to axial fatigue stresses. Although the results of the instrumentation are still in operation, the damage could be detected by the various methods tested. A new trial is planned in the first half of 2020 to confirm the results obtained.

8.1.3. MUSIWIND

Participants: Xavier Chapeleau, Laurent Mevel, Frederic Gillot.

Type: RFI WIZE

Objectif: Qualify a very high precision sensor for vibratory monitoring of wind turbines, develop monitoring algorithms using SSI methods and validation indicators

Duration: 12 months in 2020

Coordinator : IFSTTAR

Partners: Inria, SERCELL, VALOREM

Inria contact: Xavier Chapeleau

Abstract: Structural health monitoring of wind turbines is becoming a real economic issue for the managers of these structures. Indeed, they are more and more demanding of new structural health control techniques that enable the implementation of an automated and planned monitoring strategy to ensure the structural integrity of their wind turbines throughout their lifetime, particularly in the case of exceptional events such as storm or earthquake. In this business sector where innovation is crucial to stay competitive, the project MusiWind aims at the hardware, software and scientific development of a new device for monitoring the structural integrity of wind turbines and their qualification in real conditions. Through a multi-sensor approach, the project integrates in particular the newQuietSeisTM low-noise accelerometer (developed by SERCEL) with a generic data acquisition card Pegase 3 (developed by IFSTTAR) on which is embedded innovative signal processing (data analysis) developed by the Ifsttar / Inria I4S joint research team. Statistical inference algorithms meant to extract structural information under ambient excitation. The originality of the project will be to develop identification methods as well as multi-varied damage indicators that merge data froms ensors of different types and qualities, as well as the fusion of complementary physical characteristics.

8.1.4. SURFEOL: SURveillance et Fiabilité des Fondations d'EOLiennes

Participants: Xavier Chapeleau, Michael Doehler, Laurent Mevel, Flavien Bouché.

The regional project SURFEOL was in collaboration with les Chantiers de l'Atlantique and ended in 2017. Many months of data were collected. Three main axes were investigated.

- Study of monitoring of off shore wind turbines
- Laboratory experiments for fatigue monitoring using fiber optic sensors
- Development of a monitoring system based on optical gages and test in real conditions on a marine buoy

A Master 2 internship was dedicated on the analysis of multiple months of data by means of data analysis and subspace identification techniques.

8.1.5. Collaboration with IETR

Participants: Vincent Le Cam, David Pallier.

The thesis is directed by Sébastien Pillement at IETR. It is funded by RFI WISE Electronique Professionnelle within the SENTAUR project. The objective is to correct the time drift of the quartz in wireless sensor networks. Quartz modelizations, test platforms under real GPS conditions have been built. First results are based on Kalman algorithms to correct drift[34].

8.1.6. Collaboration with GeM

Participants: Laurent Mevel, Michael Doehler.

I4S' PhD student Md Delwar Hossain Bhuyan has done his PhD on damage localization on civil structures in collaboration with GeM (Institute of Civil and Mechanical Engineering), Université de Nantes, and successfully defended in November 2017. In the follow-up, a mockup of the Saint Nazaire bridge has been funded by GeM in 2018 for damage localization, and tests on it are ongoing [25].

8.1.7. Vibration analysis by video image processing for civil engineering structure monitoring

Participants: Bian Xiong, Qinghua Zhang.

- Type: ARED (Allocations de Recherche Doctorale)
- Objective: to develop video-based methods for civil engineering structure monitoring.
- Duration: 2018 - 2021
- Coordinator : Inria
- Partners: IFSTTAR
- Inria contact: Qinghua Zhang
- Abstract:

The I4S team develops real-time vibration analysis methods for the monitoring of civil engineering structures (bridges, buildings, etc.), usually based on mechanical sensors integrated into the monitored structures. In parallel, the team works also on image processing techniques for non-destructive testing of civil engineering construction materials. This PhD project, co-supervised with Vincent Baltazart (IFSTTAR researcher), aims to combine the two approaches in order to develop a method of vibration analysis based on image processing. Given a sequence of images of the structure to be monitored, the motion signal of the structure is derived from video image analysis, then methods of vibration analysis are applied to this motion signal. Such a solution will have the advantage of avoiding the integration of mechanical sensors into monitored structures and simplifying the maintenance of the monitoring system

8.2. National Initiatives

8.2.1. CEA List : Acoustic High Frequency synchronous and wireless

Participants: Vincent Le Cam, Arthur Bouché.

In the area of infrastructure, strengthening links with CEA-LIST and Alstom-Rail will focus on non-destructive ultrasonic testing methods for rails. We will focus in particular on the opening of cracks in the passage of the trains, which requires a very precise synchronization of the various sensors. In 2019 the first tests of validation on the site of Bar le Duc with the help of the prototype were conclusive: capacities to emit and receive ultrasonic waves in 1.4 km of rail by perfectly synchronized materials (until the microsecond UT). In 2020 the objectives of the future contract will be:

- make several boxes to carry out more complete tests
- conducting qualification test campaigns (according to CDC Alstom)
- upgrade the high frequency daughter card (with PEGASE 3 more globally)

8.2.2. ANR Resbati

Participants: Ludovic Gaverina, Jean Dumoulin.

Type: ANR

Objectif: In-situ measurements of thermal wall resistance

Duration: 10/2016 to 10/2019

Coordinator: Laurent Ibos

Partners : IFSTTAR, CERTES, CEREMA, CSTB, LNE, THEMACS, AFNOR

Inria contact: Jean Dumoulin

Abstract: RESBATI is an applied research project whose objective is to develop a field measurement device that meets precise specifications to systematically measure the level of thermal insulation of building walls. The preferred metrological tool is infrared thermography. A smart logger and a protype have been developed and presented. A full autonomous system has been studied and developed for in-situ measurement on existing building envelope. In parallel, thermal resistance estimation method was studied. First experiments were carried out with a first generation prototype in 2019. For this purpose different instrumented building walls were built and qualified at CSTB before carrying out in-situ evaluations of the prototype.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. INFRASTAR(Innovation and Networking for Fatigue and Reliability Analysis of Structures – Training for Assessment of Risk)

Participants: Xavier Chapeleau, Antoine Bassil.

Call: H2020-MSCA-ITN-2015 (Horizon 2020 Marie-Sklodowska Curie Actions Innovative Training Networks)

Type of Action: MSCA-ITN-ETN

Objective: Improve energy performance of building design

Duration: 48 months since 2016 May 1st

Coordinator: Odile Abraham (IFSTTAR)

Academic and industrial Partners: IFSTTAR, UNIVERSITY OF AALBORG, BAM, EPFL, GuD Consult Gmbh, COWI A/S, NeoStrain, PHIMECA

Inria contact: X. Chapeleau

Website: http://infrastar.eu/

Abstract: This thesis work aims to develop and validate a method for monitoring crack openings using distributed fiber optics strain measurements. First, the various existing theories on strain transfer from the host material to the optical fiber are presented, with their validity domain. The problem of perfect interfacial bonding is then studied and a three-layer analytical model capable of handling imperfect bonding case is proposed. This model is then generalized to multi-layer systems. Experimental studies validating this new model are presented. They show that it is possible to monitor crack openings up to 1 mm with an error of less than 10% for a fiber optic cable glued on the surface. Cables embedded in concrete show less accurate results. The type of cable, the bonding length and the hardening of the concrete material also influence the accuracy of the estimated crack openings. Finally, the results of case studies on laboratory-size reinforced concrete samples are presented. They show the optical fibers capacity to detect cracks as early as ultrasonic sensors and to monitor the opening of multiple micro cracks.

8.3.1.2. DESDEMONA(DEtection of Steel Defects by Enhanced MONitoring and Automated procedure for self-inspection and maintenance)

Participants: Jean Dumoulin, Laurent Mevel, Michael Doehler, Xavier Chapeleau.

Call: H2020 -Call: RFCS-2017 (Call of the research programme of the Research Fund for Coal and Steel - 2017)

Type of Action: RFCS-RPJ (Research project)

Objective: DESDEMONA objective is the development of novel design methods, systems, procedure and technical solution, to integrate sensing and automation technologies for the purpose of self-inspection and self-monitoring of steel structures.

Duration: 36 months since 2018 June 1st

Coordinator: Pr. Vincenzo Gatulli (La Sapienza University of Rome)

Academic and industrial Partners: Sapienza Università di Roma (Italy), Universidad de Castilla – La Mancha, (Spain), Universidade do Porto (Portugal), Università di Pisa (Italy), IFSTTAR (France), Aiviewgroup srl (Italy), Sixense systems (France), Ecisa compania general de construcciones sa (Spain), Università di Cassino e del Lazio Meridionale (Italy), Universidad de Alicante (Spain), Inria (France).

Inria contact: J. Dumoulin and L. Mevel

Website: http://www.desdemonaproject.eu

Abstract: DESDEMONA objective is the development of novel design methods, systems, procedure and technical solution, to integrate sensing and automation technologies for the purpose of self-inspection and self-monitoring of steel structures. The approach will lead to an increment of the service life of existing and new steel civil and industrial infrastructure and to a decrease in the cost associated to inspections, improving human activities performed in difficult conditions, safety and workers' potential by the use of advanced tools. The research aims to expand beyond the current state-of-the-art new high-quality standard and practices for steel structure inspection and maintenance through the interrelated development of the following actions: i) steel structure geometry and condition virtualization through data fusion of image processing, thermography and vibration measurements; ii) developing a procedure for steel defect detection by robotic and automatic systems such as Unmanned Aerial Vehicles (UAV) and ground mobile robots iii) embedding sensor systems to revalorize and transform steel elements and structures into self-diagnostic (smart) elements and materials even through nanotechnologies, iv) realizing an experimental lab-based apparatus and a series of case studies inspected by intelligent and robotic systems. The project outcome will have an impact on the reduction of the cost of steel structures inspection and maintenance and on the increase of user safety and comfort in industrial and civil environment. The proposal with a multidisciplinary approach fulfils the objectives of the Strategic Research Agenda of the European Steel Technology Platform.

8.3.2. Collaborations in European Programs, Except FP7 & H2020

8.3.2.1. COST Action TU 1402

Participants: Michael Doehler, Laurent Mevel.

L. Mevel is member of the management committee of the COST Action.

M. Doehler is co-leader of working group 2 "SHM strategies and structural performance" and member of the steering committee.

Type: COST

Objective: Quantifying the value of structural health monitoring

Duration: 11/2014 - 4/2019

Coordinator: S. Thoens (DTU Denmark)

Partner: 29 countries, see https://www.cost.eu/actions/TU1402

Inria contact: Laurent Mevel

Abstract: Since 2014, until 2018, the COST Action has altogether around 120 participants from over 25 countries. This Action aims to develop and describe a theoretical framework, together with methods, tools, guidelines, examples and educational activities, for the quantification of the value of SHM.

8.4. International Initiatives

8.4.1. Collaboration with University of British Columbia, Canada

Participants: Laurent Mevel, Michael Doehler, Alexander Mendler.

Alexander Mendler's PhD thesis started in September 2018 co-supervised by M. Doehler and C. Ventura. A. Mendler spent 6 months in Rennes in 2019 thanks to a MITACS grant.

8.4.2. Collaboration with BAM, Germany

Participants: Laurent Mevel, Michael Doehler, Eva Viefhues.

Eva Viefhues is currently PhD student of Laurent Mevel and Michel Doehler in Berlin, financed by BAM. M. Doehler is also associate researcher at BAM since 2016. Besides the supervision of the PhD, collaboration on temperature robustness is ongoing with BAM [18], [24].

8.4.3. Collaboration with Technical University of Denmark (DTU)

Participants: Michael Doehler, Laurent Mevel.

During COST Action TU 1402 and previously at BAM, collaboration with Sebastian Thöns from DTU in Denmark started on risk analysis and SHM based reliability updating. Also, Aalborg University's PhD student Lijia Long is involved.

8.4.4. Collaboration with Aalborg University, Denmark

Participant: Michael Doehler.

Together with Structural Vibration Solutions, collaboration with Aalborg University (professor Lars Damkilde, Department of Civil Engineering) happened during the PhD of Szymon Gres on damage detection methods, with current conference publications [29], [30]. The PhD has been defended on November 19, 2019.

8.4.5. Collaboration with Laval University, Canada

Participant: Jean Dumoulin.

In the Framework of On Duty Project (http://www.ondutycanada.ca) we are working on Non Destructive Testing techniques and automation of inspection process. Jean Dumoulin spent 10 days in Canada in 2019 devoted to corrosion detection by active infrared thermography NDT approach.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Szymon Gres visited us for 2 months from January to February 2019 during his thesis.

A. Mendler got a 6 month MITACS grant to visit us from May to October 2019.

8.5.1.1. Research Stays Abroad

J. Dumoulin was with University Laval and with CNR IREA in Fall 2019.

INOCS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

ANR project AGIRE "Aide à la Gestion Intelligente des Ressources dans les Entrepôts - Decision system for smart management of resources in warehouses" in collaboration with Ecole des Mines de Saint-Etienne (Gardanne), IFSTTAR (Champs-sur-Marne), HappyChic (Tourcoing). This project addresses human resources management in warehouses which supply either sale points (B2B) or final consumers (B2C). Nowadays, such warehouses are under pressure. This is mainly due to the no inventory policy at the sale points and to the constant growth of e-commerce sales in France and Europe. In terms of logistics, this translates into an increasing number of parcels to prepare and to ship to satisfy an order, which is known typically a few hours before. Moreover, the total number of products to be packed varies very significantly from day-to-day by a factor of at least 3 (https://fr.wikipedia.org/wiki/Happychic).

The novelty of the project is twofold: (1) The human factor is explicitly be taken into account. It is integrated in the mathematical models and algorithms that are developed for the project. The aim is to improve the quality of employees' work ensuring the efficiency of the logistic system; (2) Problems at different decision levels are integrated and tackled jointly. At the tactical level, the main problematics are workload smoothing and the management of the storage zone. At operational level, the major issues concern the rearrangement of the picking zone, the picking tours, and the dynamic reorganization of activities to manage uncertainties.

ANR project PI-Commodality "Co-modal freight transportation chains: an approach based on physical internet" in collaboration with CGS-ARMINES (Paris), LAAS (Toulouse), DHL (2016 - 2019). The PI-co-modality project aims to design new sustainable logistic services between preset origins and destinations. It is based on innovative approaches both in terms of: (1) Logistics and transportation services: by considering the PI-internet approach, specifically: mesh logistics and transportation networks based on available capacities, by designing consistent integrated co-modal chains; (2) Methodology: by addressing the underlying problems according to two approaches: centralized and decentralized, by proposing news realistic models relevant for practitioner taking into account the consistency, by developing state-of-the-art decision making algorithms.

9.1.2. F.R.S.-FNRS (Belgium)

Bilevel optimization is a branch of mathematical optimization that deals with problems whose constraints embed an auxiliary optimization problem. The F.R.S.-FNRS research project "bilevel optimization" (2018-2019) will study such bilevel problems with bilinear objectives and simple second level problems. Each follower chooses one strategy in a given fixed set of limited size. Two classes of such problems will be studied: Pricing Problems and Stackelberg Security Games.

In pricing problems, prices for products must be determined to maximize the revenue of a leader given specific behaviors of customers (followers). More precisely, we will consider the single minded pricing problem and the rank pricing problem.

In Stackelberg games, mixed strategies to cover targets,must be determined in order to maximize the defender expected payoff given that attackers (followers) attack targets that maximize their own payoffs.

9.2. Regional Initiatives

9.2.1. Lille

The ELSAT research program addresses the issues involved in sustainable transportation and mobility. Within ELSAT, INOCS is involved on two projects devoted to hybrid optimization methods in logistics and to city logistics in collaboration with LAMIH (Université de Valenciennes), LGI2A (Université d'Artois) and LEOST (IFSTTAR). ELSAT is supported by the CPER 2015-2020 (State-Region Contract).

9.2.2. Brussels

ValueBugs is a citizen participatory research project, funded by INNOVIRIS (2018-2020). The objective of ValueBugs is to collectively develop a method for decentralized insect production in cities while enhancing the value of food waste on a small scale. In practical terms, peelings are consumed by insect larvae that have reached the end of their development and offer many promising outlets: feed for hens, farmed fish, pets... and much more! This new, totally innovative sector will be a new tool to be put in the hands of every citizen: we must therefore imagine it collectively.

9.3. International Initiatives

9.3.1. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

9.3.1.1. BIPLOS

Title: BIlevel Problems in LOgistics and Security

International Partner (Institution - Laboratory - Researcher):

University of Chile - Complex Engineering Systems Institute (ISCI) - Ordonez Fernando

Start year: 2017

See also: https://team.inria.fr/inocs/

This projet is devoted to bilevel optimisation problems with application in the security and logistics domains. Stackelberg games, including one defender and several followers, and competitive location problems will be considered. Mixed integer linear optimisation models and efficient algorithms to solve them will be developed.

9.3.2. Inria Associate Teams Not Involved in an Inria International Labs

9.3.2.1. LOBI

Title: Learning within Bilevel Optimization

International Partner (Institution - Laboratory - Researcher):

Polytechnique Montréal (Canada) - Research Group in Decision Analysis (GERAD) - Gilles Savard

Start year: 2018

See also: https://team.inria.fr/lobi/

The interplay between optimization and machine learning is one of the most important developments in modern computational science. Simultaneously there is a tremendous increase in the availability of large quantities of data in a multitude of applications, and a growing interest in exploiting the information that this data can provide to improve decision-making. Given the importance of big data in business analytics, its explicit integration into an optimization process is a challenge with high potential impact. The innovative project is concerned with the interconnection between machine learning approaches and a particular branch of optimization called bilevel optimization in this “big data” context. More precisely, we will focus on the development of new approaches integrating machine learning within bilevel optimization (LOBI: “learning au sein de l’Optimisation BIniveau”) for two important practical applications, the pricing problem in revenue management and the energy ressource aggregation problem in smart grids. The applications arise from current industry collaborations of the teams involved, and will serve as testbeds to demonstrate the potential impact of the proposed approach.

9.3.2.2. North-European associated team

Title: Physical-internet services for city logistics

International Partner (Institution - Laboratory - Researcher):

Norwegian School of Economics - Stein Wallace

Start year: 2017

In this project, we consider an urban logistic terminal and new logistics services which could be developed according to a Physical Internet approach. The main objective is to evaluate the services using optimization models created within the project. We are developing optimization models to identify win-win cooperation between carriers based on supply and demand. We aim to explore how to include stochasticity in the description of the supplies and demands, as well as travel times, and to what extent the plans within a day can improve by such knowledge. The second task is to develop solution algorithms for these models. These are real scientific challenges as we are facing stochastic mixed integer problems.

9.3.3. Inria International Partners

9.3.3.1. Informal International Partners

Department of Statistics and Operations Research, University of Vienna, Austria

Centre for Quantitative Methods and Operations Management, HEC-Liège, Belgium

Interuniversity Centre on Entreprise Networks, Transportation and Logistics (CIRRELT), Montreal, Canada

Department of Industrial Engineering, University of Talca, Curicó, Chile

Complex Engineering Systems Institute (ISCI), University of Chile, Santiago, Chile

Department of Mathematics, Trier University, Germany

The Centre for Business Analytics, University College Dublin, Ireland

Department of Electrical, Electronic, and Information Engineering, University of Bologna, Italy

Department of Mathematics, University of Padova, Italy

Department of Electrical and Information Engineering, University of Padova, Italy

Department of Mathematics, University of Salerno, Italy

Department of Control and Computer Engineering, Politecnico di Torino, Italy

Department of Mathematics, University of Aveiro, Portugal

Department of Statistics and Operations Research, Universidade de Lisboa, Portugal

Department of Statistics and Operational Research, University of Murcia, Spain

Institute of Mathematics, University of Seville, Spain

Stewart School of Industrial and Systems Engineering, Georgia Tech Institute of Technology, USA

9.3.4. Participation in Other International Programs

9.3.4.1. Inria International Chairs

IIC ANJOS Miguel

Title: Power Peak Minimization for the Smart Gird

International Partner (Institution - Laboratory - Researcher):

Polytechnique Montréal (Canada) - Miguel Anjos

Duration: 2016 - 2020

Start year: 2016

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Yasemin Arda Da Silveira, HEC-Liège, University of Liège, Belgium, Mar 2019
- Maria Del Carmen Gale Pola, University of Zaragoza, Spain, Feb 2019
- Anton Kleywegt, Georgia Institute of Technology, USA, from Apr 2019 until May 2019
- Daniel Pereda Herrera, University of Chile, Chile, from Nov 2019
- Sebastián Dávila, University of Chile, Chile, from June 2019 until Dec 2019
- Natividad Gonzalez Blanco, University of Sevilla, Spain, from May 2019 until July 2019
- Federica Laureanam, University of Salerno, Italy, from Feb 2019 until May 2019

9.4.1.1. Internships

Sebastián Dávila, Ph.D. student at University of Chile, June to December 2019

MATHERIALS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

The project-team is involved in several ANR projects:

- S. Boyaval is the PI of the ANR JCJC project SEDIFLO (2016-2021) to investigate new numerical models of solid transport in rivers.
- V. Ehrlacher is the PI of the ANR project COMODO (2020-2024) which focuses on the development of efficient numerical methods to simulate cross-diffusion systems on moving domains, with application to the simulation of the fabrication process of thin film solar cells. It includes research teams from Inria Lille, Inria Sophia-Antipolis and Germany.
- V. Ehrlacher is a member of the ANR project ADAPT (2018-2022), PI: D. Lombardi, Inria REO team-project. This project is concerned with the parallelization of tensor methods for high-dimensional problems.
- F. Legoll is a member of the ANR project CINE-PARA (2015-2020), PI: Y. Maday, Sorbonne Université. This project is concerned with parallel-in-time algorithms.
- T. Lelièvre is responsible of the node "Ecole des Ponts" of the ANR QuAMProcs (2019-2023), to which G. Stoltz also participates, PI: L. Michel, Université de Bordeaux.
- G. Stoltz is the PI of the ANR project COSMOS (2014-2019) which focuses on the development of efficient numerical techniques to simulate high-dimensional systems in molecular dynamics and computational statistics. It includes research teams from Institut Mines-Telecom, Inria Rennes and IBPC Paris.

Members of the project-team are participating in the following GdR:

- AMORE (Advanced Model Order REduction),
- CORREL (correlated methods in electronic structure computations),
- DYNQUA (time evolution of quantum systems, with applications to transport problems, nonequilibrium systems, etc.),
- EGRIN (gravity flows),
- MANU (MAthematics for NUclear applications),
- MASCOT-NUM (stochastic methods for the analysis of numerical codes),
- MEPHY (multiphase flows),
- NBODY (electronic structure),
- REST (theoretical spectroscopy),
- CHOCOLAS (experimental and numerical study of shock waves).

The project-team is involved in two Labex: the Labex Bezout (2011-) and the Labex MMCD (2012-).

We have invited the following national researchers to visit our team:

- A. Lozinski (University of Besançon): repeated visits during the year 2019.

8.2. European Initiatives

The ERC consolidator Grant MSMATH (ERC Grant Agreement number 614492, PI T. Lelièvre) ended in June 2019.

The ERC Synergy Grant EMC2 (ERC Grant Agreement number 810367 , PI E. Cancès, L. Grigori, Y. Maday, J-P. Piquemal) has started in September 2019.

8.3. International Initiatives

T. Lelièvre, G. Stoltz and F. Legoll participate in the Laboratoire International Associé (LIA) CNRS / University of Illinois at Urbana-Champaign on complex biological systems and their simulation by high performance computers. This LIA involves French research teams from Université de Nancy, Institut de Biologie Structurale (Grenoble) and Institut de Biologie Physico-Chimique (Paris). The LIA has been renewed for 4 years, starting January 1st, 2018.

MATHRISK Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

- ANR Cosmos 2015-2018, Participant: B. Jourdain ; Partners : Ecole des Ponts, Telecom, INIRIA Rennes and IBPC
- Labex Bezout
  http://bezout.univ-paris-est.fr

9.1.1. Competitivity Clusters

Pôle Finance Innovation

9.2. International Initiatives

9.2.1. Inria International Partners

9.2.1.1. Informal International Partners

- Center of Excellence program in Mathematics and Life Sciences at the Department of Mathematics, University of Oslo, Norway, (B. Øksendal).
- Cornell University, ORIE department (Andreea Minca)
- Roma Tor Vergata University (Lucia Caramellino)
- Ritsumeikan University (A. Kohatsu-Higa).

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Oleg Kudryavtsev (Rostov University, Russia)
- B. Stemper (Weierstrass Institute, Berlin)
- A. Kohatsu Higa (Ritsumeikan University)
- Justin Kirkby (Georgia Institute of Technology, Atlanta)
- Xiao Wei (Beijing University)
- Anton Arnold (TU Vienna)

9.3.1.1. Internships

- Baba Abdel Hamid, Inria
- Asma Sassi, Inria

9.3.2. Visits to International Teams

9.3.2.1. Research Stays Abroad

In the period 15.05 - 15. 06. 2019 Vlad Bally was an invited professor at the University Tor Vergata, Roma. Here he gave a course of 20h entitled "Integration by Parts and Convergence in Total Variation".

MCTAO Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

Sub-Riemannian Geometry and Interactions (SRGI). Started 2015 (decision ANR-15-CE40-0018), duration: 4 years. L. Rifford is a member.

Intéractions Systèmes Dynamiques Équations d'Évolution et Contrôle (ISDEEC). Started 2016 (decision ANR-16-CE40-0013), duration: 4 years. L. Rifford is a member.

Maximic: optimal control of microbial cells by natural and synthetic strategies. Started 2017, duration: 4 years. J.-B. Caillau, L. Giraldi, J.-B. Pomet are members.

9.1.2. Others

Défi InfIniti CNRS project, Control and Optimality of Magnetic Microrobots, (PI L. Giraldi). Started 2017, duration: 2 years. This project involves colleagues from Paris Sorbonne Université S. Régnier and from University of Strasbourg C. Prud'Homme's.

PGMO grant (2017-2019) on "Algebro-geometric techniques with applications to global optimal control for Magnetic Resonance Imaging (MRI)". B. Bonnard, A. Nolot and J. Rouot participate in this project, the PI is O. Cots, from ENSEIHHT, Toulouse.

PGMO grant (2019-2021) on "Sampled-Data Control Systems and Applications" (PI B. Bonnard).

The McTAO team participates in the GdR MOA, a CNRS network on Mathematics of Optimization and Applications.

J.-B. Caillau is associate researcher of the CNRS team Parallel Algorithms & Optimization at ENSEEIHT, Univ. Toulouse.

9.2. International Research Visitors

9.2.1. Visits of International Scientists

Prof. Sorin Sabau (Tokai University) visited Inria during two weeks in May 2019. He gave a talk on "The calculus of variations on Finsler manifolds".

9.2.1.1. Research Stays Abroad

- Bernard Bonnard visited the University of Hawaii at Manoa, Mars 2019 (1 month, host: M. Chyba).

MEMPHIS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

We are part of the GDR AMORE on ROMs.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects: ARIA RISE project

The overarching objective of ARIA (Accurate Roms for Industrial Applications) project is to form an international and intersectoral network of organizations working on a joint research program in numerical modelling, specifically in the fields of model reduction and convergence between data and models. Memphis team is ccordinating this 926KEuro project. 7 industrial partners are involved (VW, Valorem, Optimad, IEFluids, VirtualMech, Nurea, Esteco), 5 EU academic partners (Inria, Université de Seville, Poitecnico di Milano, Politecnico di Torino, SISSA) and 3 universities in the USA: Stanford University, Virginia Tech and University of South Carolina.

9.3. International Initiatives

9.3.1. Inria International Labs

Inria@SiliconValley
Associate Team involved in the International Lab:

9.3.1.1. MARE

Title: Multiscale Accurate Reduced-order model Enablers

International Partner (Institution - Laboratory - Researcher):

Stanford (United States) - VNU University of Engineering and Technology - Charbel Farhat

Start year: 2019

See also: https://team.inria.fr/memphis/mare-associate-team/

Reduced-order models (ROMs) are simplified mathematical models derived from the full set of partial differential equations governing the physics of the phenomenon of interest. We focus on ROMs that are data-driven as they are based on relevant solution data previously obtained. In particular we will focus on multiscale adaptive models where the large scales are governed by a PDE and the small scales are described by data driven models. To do that we will leverage on tools from data geometry, numerical PDEs and machine learning.

MEPHYSTO Team

6. Partnerships and Cooperations

6.1. National Initiatives

6.1.1. ANR

A. de Laire is a member of the ANR ODA project.

Title: Dispersive and random waves

ANR reference: ANR-18-CE40-0020-01

Coordinator: Nikolay Tzvetkov, Université de Cergy-Pontoise

A. Hardy is a member of the ANR BoB project.

Title: Inférence bayésienne à ressources limitées - données massives et modèles coûteux

Programme ANR: (DS0705) 2016

ANR reference: ANR-16-CE23-0003

Coordinator: R. Bardenet, CNRS & Université de Lille

Duration: October 2016 - October 2020

M. Simon has been a member of the ANR EDNHS project.

Title: Diffusion de l'énergie dans des système hamiltoniens bruités

Type: Défi de tous les savoirs (DS10) 2014

ANR reference: ANR-14-CE25-0011

Coordinator: C. Bernardin, Université de Nice

Duration: October 2014 - October 2019

6.2. European Initiatives

6.2.1. FP7 & H2020 Projects

M. Simon is a collaborator of the ERC Starting Grant HyLEF project.

Title: Hydrodynamic Limits and Equilibrium Fluctuations: universality from stochastic systems

Duration: May 2017 - April 2022

Coordinator: P. Gonçalves, Instituto Superior Técnico, Lisbon, Portugal

MINGUS Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- M. Lemou and N. Crouseilles are head of the project "MUNIQ" of ENS Rennes. This two-years project (2018-2019) intends to gather multiscale numerical methods and uncertainty quantification techniques. The MINGuS members are P. Chartier, N. Crouseilles, M. Lemou and F. Méhats and colleagues from university of Madison-Wisconsin also belong to this project.

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. MOONRISE: 2015-2019

Participants: François Castella, Philippe Chartier, Nicolas Crouseilles, Mohammed Lemou, Florian Méhats.

The project *Moonrise* submitted by Florian Méhats has been funded by the ANR for 4 years, for the period 2015-2019. This project aims at exploring modeling, mathematical and numerical issues originating from the presence of high-oscillations in nonlinear PDEs from the physics of nanotechnologies (quantum transport) and from the physics of plasmas (magnetized transport in tokamaks). The partners of the project are the IRMAR (Rennes), the IMT (Toulouse) and the CEA Cadarache. In the MINGuS team, François Castella, Philippe Chartier, Nicolas Crouseilles and Mohammed Lemou are members of the project Moonrise.

Postdocs

- Loïc Le Treust has been hired as a Postdoc, under the supervision of Philippe Chartier and Florian Méhats. His contract started in september 2015 and ended in august 2016. Loïc Le Treust is now assistant professor at the university of Marseille.
- Yong Zhang has been hired as a Postdoc, under the supervision of Philippe Chartier and Florian Méhats. His contract started in september 2015 and ended in august 2016. Yong Zhang is now professor at the Tianjin university (China).
- Xiaofei Zhao has been hired as a Postdoc from september 2015 to september 2016 under the supervision of Florian Méhats. Xiaofei Zhao is now postdoc assistant professor in the Wuhan University (China).

8.2.1.2. MFG: 2016-2020

Participant: Arnaud Debussche.

Mean Field Games (MFG) theory is a new and challenging mathematical topic which analyzes the dynamics of a very large number of interacting rational agents. Introduced ten years ago, the MFG models have been used in many areas such as, e.g., economics (heterogeneous agent models, growth modeling,...), finance (formation of volatility, models of bank runs,...), social sciences (crowd models, models of segregation) and engineering (data networks, energy systems...). Their importance comes from the fact that they are the simplest (“stochastic control"-type) models taking into account interactions between rational agents (thus getting beyond optimization), yet without entering into the issues of strategic interactions. MFG theory lies at the intersection of mean field theories (it studies systems with a very large number of agents), game theory, optimal control and stochastic analysis (the agents optimize a payoff in a possibly noisy setting), calculus of variations (MFG equilibria may arise as minima of suitable functionals) and partial differential equations (PDE): In the simplest cases, the value of each agent is found by solving a backward Hamilton-Jacobi equation whereas the distribution of the agents’ states evolves according to a forward Fokker-Planck equation. The “Master" equation (stated in the space of probability measures) subsumes the individual and collective behaviors. Finally, modeling, numerical analysis and scientific computing are crucial for the applications. French mathematicians play a world-leading role in the research on MFG: The terminology itself comes from a series of pioneering works by J.-M. Lasry and P.-L. Lions who introduced most of the key ideas for the mathematical analysis of MFG; the last conference on MFG was held last June in Paris and organized by Y. Achdou, P. Cardaliaguet and J.-M. Lasry. As testifies the proposal, the number of researchers working on MFG in France (and also abroad) is extremely fast-growing, not only because the theoretical aspects are exciting and challenging, but also because MFG models find more and more applications. The aim of the project is to better coordinate the French mathematical research on MFG and to achieve significant progress in the theory and its applications.

The partners of the project are the CEREMADE laboratory (Paris Dauphine), the IRMAR laboratory (Rennes I), the university of Nice and of Tours.

8.2.1.3. ADA: 2019-2023

Participant: Arnaud Debussche.

The aim of this project is to treat multiscale models which are both infinite-dimensional and stochastic with a theoretic and computational approach. Multiscale analysis and multiscale numerical approximation for infinite-dimensional problems (partial differential equations) is an extensive part of contemporary mathematics, with such wide topics as hydrodynamic limits, homogenization, design of asymptotic-preserving scheme. Multiscale models in a random or stochastic context have been analysed and computed essentially in finite dimension (ordinary/stochastic differential equations), or in very specific areas, mainly the propagation of waves, of partial differential equations. The technical difficulties of our project are due to the stochastic aspect of the problems (this brings singular terms in the equations, which are difficult to understand with a pure PDE's analysis approach) and to their infinite-dimensional character, which typically raises compactness and computational issues. Our main fields of investigation are: stochastic hydrodynamic limit (for example for fluids), diffusion-approximation for dispersive equations, numerical approximation of stochastic multiscale equations in infinite dimension. Our aim is to create the new tools - analytical, probabilistic and numerical - which are required to understand a large class of stochastic multiscale partial differential equations. Various modelling issues require this indeed, and are pointing at a new class of mathematical problems that we wish to solve. We also intend to promote the kind of problems we are interested in, particularly among young researchers, but also to recognized experts, via schools, conference, and books.

The partners are ENS Lyon (coordinator J. Vovelle) and ENS Rennes (Coordinator A. Debussche).

8.2.2. Fédération de Recherche : Fusion par Confinement Magnétique

We are involved in the national research multidisciplinary group around magnetic fusion activities. As such, we answer to annual calls.

8.2.3. IPL SURF

A. Debussche and E. Faou are members of the IPL (Inria Project Lab) SURF: Sea Uncertainty Representation and Forecast. Head: Patrick Vidard.

8.2.4. AdT J-Plaff

This AdT started in october 2019 and will be finished in september 2021. An engineer has been hired (Y. Mocquard) to develop several packages in the Julia langage. The J-Plaff is shared with the Fluminance team.

8.3. European Initiatives

8.3.1. Collaborations in European Programs, Except FP7 & H2020

Program: Eurofusion

Project acronym: MAGYK

Project title:

Duration: january 2019-december 2020

Coordinator: E. Sonnendrücker

Other partners: Switzerland, Germany, France, Austria, Finland.

Abstract: This proposal is aimed at developing new models and algorithms that will be instrumental in enabling the efficient and reliable simulation of the full tokamak including the edge and scrape-off layer up to the wall with gyrokinetic or full kinetic models. It is based on a collaboration between applied mathematicians and fusion physicists that has already been very successful in a previous enabling research project and brings new ideas and techniques into the magnetic fusion community. New modelling and theoretical studies to extend the modern gyrokinetic theory up to the wall including boundary conditions will be addressed, and the limits of gyrokinetics will be assessed. New multiscale methods will enable to efficiently and robustly separate time scales, which will on the one hand make gyrokinetic codes more efficient and on the other hand enable full implicit kinetic simulations. Difficult algorithmic issues for handling the core to edge transition, the singularities at the O- and X-points will be addressed. And finally, pioneering work based on recent (deep) machine learning techniques will be performed, on the one hand to automatically identify a Partial Differential Equation (PDE) from the data, which can be used for verification and sensitivity analysis purposes, and on the other hand to develop reduced order models that will define a low- cost low-fidelity model based on the original high-fidelity gyrokinetic or kinetic model that can be used for parameter scans and uncertainty quantification.

8.4. International Initiatives

8.4.1. Inria Associate Teams Not Involved in an Inria International Labs

8.4.1.1. ANTIpODE

Title: Asymptotic Numerical meThods for Oscillatory partial Differential Equations with uncertainties

International Partner (Institution - Laboratory - Researcher):

University of Wisconsin-Madison, USA (United States)

Start year: 2018

See also: https://team.inria.fr/antipode/

The proposed associate team assembles the Inria team IPSO and the research group led by Prof. Shi Jin from the Department of Mathematics at the University of Wisconsin, Madison. The main scientific objective of ANTIpODE consists in marrying uniformly accurate and uncertainty quantification techniques for multi-scale PDEs with uncertain data. Multi-scale models, as those originating e.g. from the simulation of plasma fusion or from quantum models, indeed often come with uncertainties. The main scope of this proposal is thus (i) the development of uniformly accurate schemes for PDEs where space and time high oscillations co-exist and (ii) their extension to models with uncertainties. Applications to plasmas (Vlasov equations) and graphene (quantum models) are of paramount importance to the project.

8.4.2. Inria International Partners

8.4.2.1. Informal International Partners

The members of MINGuS have several interactions with the following partners

- Europe: University of Geneva (Switzerland), University of Jaume I (Spain), University of Basque Country (Spain), University of Innsbruck (Austria), University of Ferrare (Italy), Max Planck Institute (Germany), SNS Pisa (Italy)
- USA: Georgia Tech, University of Maryland, University of Wisconsin, NYU
- Asia: Chinese Academy of Science (China), University of Wuhan (China), shanghai jiao tong university (China), National University of Singapore (Singapore)

8.4.3. Participation in Other International Programs

- SIMONS project. Erwan Faou is one of the Principal investigators of the Simons Collaboration program *Wave Turbulence*. Head: Jalal Shatah (NYU).

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Fernando Casas (University of Jaume I, Spain) was invited in the MINGuS team during 6 months (september 2018 to february 2019), funded by the Labex (CHL) Center Henri Lebesgue.
- Yingzhe Li (University of Chinese Academy of Sciences, China) is visiting the IRMAR laboratory during one year (March 2019-February 2020) thanks to a chinese grant. He is currently a PhD student advised by Yajuan Sun, professor at CAS.
- Xiaofei Zhao (University of Wuhan, China) was invited in the MINGuS team during 2 weeks (july 2019).
- Yoshio Tsutsumi (Kyoto University, Japan) was invited in the IRMAR laboratory during 2 months (october-november 2019).

8.5.1.1. Internships

- G. Barrué: Master 2 internship, A. Debussche.
- Q. Chauleur: Master 2 internship, R. Carles (CNRS, Rennes) and E. Faou.
- U. Léauté: Master 1 internship, B. Boutin (University Rennes I and N. Crouseilles).
- A. V. Tuan: Master 2 internship, M. Lemou and F. Méhats.

8.5.2. Visits to International Teams

8.5.2.1. Sabbatical programme

P. Chartier was on a sabbatical visit from the 1st of February to the 30th of September 2019 at the University of the Basque Country, Spain.

8.5.2.2. Research Stays Abroad

- P. Chartier was invited by G. Vilmart, University of Geneva, Geneva, Switzerland, January 2019.
- P. Chartier was invited by F. Casas at the university of Jaume I, Castellon, Spain, July 2019.
- P. Chartier was Invited by Q. Li at the university of Wisconsin, Madison, USA, September 2019.
- P. Chartier was Invited by M. Tao at Georgia Tech, Atlanta, USA, August 2019.
- A. Debussche was invited by G. Da Prato at Scuola Normale Superiore, Pise, Italy, April 2019.
- E. Faou was a participant of the Semester *Geometry, compatibility and structure preservation in computational differential equations*, Isaac Newton Institute, Cambridge, UK (3 months stay, September-December 2019).
- M. Lemou was invited by J. Joudioux and L. Anderson, at the Albert Einstein Institute, Golm, Germany, February 2019.
- M. Lemou was invited by A. M. M. Luz at the Universidade Federal Fluminense, Rio de Janeiro, Brazil, April 2019.
- M. Lemou was invited by S. Jin at Shanghai Jiao Tong University, Shanghai, China, April 2019.
- M. Lemou was invited by J. Ben-Artzi at the university of Cardiff, Cardiff, UK, May 2019.
- M. Lemou was invited by G. Vilmart, University of Geneva, Geneva, Switzerland, January 2019.
- M. Lemou was Invited by Q. Li at the university of Wisconsin, Madison, USA, September 2019.
- M. Lemou was Invited by M. Tao at Georgia Tech, Atlanta, USA, August 2019.
- F. Méhats was invited by A. de la Luz at the Universidade Federal Fluminense, Rio de Janeiro, Brazil, April 2019.
- F. Méhats was invited by G. Vilmart, University of Geneva, Geneva, Switzerland, January 2019.

MISTIS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

MISTIS is involved in the 4-year ANR project ExtremReg (2019-2023) hosted by Toulouse University. This research project aims to provide new adapted tools for nonparametric and semiparametric modeling from the perspective of extreme values. Our research program concentrates around three central themes. First, we contribute to the expanding literature on non-regular boundary regression where smoothness and shape constraints are imposed on the regression function and the regression errors are not assumed to be centred, but one-sided. Our second aim is to further investigate the study of the modern extreme value theory built on the use of asymmetric least squares instead of traditional quantiles and order statistics. Finally, we explore the less-discussed problem of estimating high-dimensional, conditional and joint extremes

The financial support for MISTIS is about 15.000 euros.

9.1.2. Grenoble Idex projects

MISTIS is involved in a transdisciplinary project **NeuroCoG** and in a newly accepted cross-disciplinary project (CDP) **Risk@UGA**. F. Forbes is also a member of the executive committee and responsible for the *Data Science for life sciences* work package in another project entitled **Grenoble Alpes Data Institute**.

- The main objective of the RISK@UGA project is to provide some innovative tools both for the management of risk and crises in areas that are made vulnerable because of strong interdependencies between human, natural or technological hazards, in synergy with the conclusions of Sendai conference. The project federates a hundred researchers from Human and Social Sciences, Information & System Sciences, Geosciences and Engineering Sciences, already strongly involved in the problems of risk assessment and management, in particular natural risks. The PhD thesis of Meryem Bousebata is one of the eleven PhDs funded by this project.
- The NeuroCoG project aims at understanding the biological, neurophysiological and functional bases of behavioral and cognitive processes in normal and pathological conditions, from cells to networks and from individual to social cognition. No decisive progress can be achieved in this area without an aspiring interdisciplinary approach. The interdisciplinary ambition of NeuroCoG is particularly strong, bringing together the best scientists, engineers and clinicians at the crossroads of experimental and life sciences, human and social sciences and information and communication sciences, to answer major questions on the workings of the brain and of cognition. One of the work package entitled InnobioPark is dedicated to Parkinson's Disease. The PhD thesis of Veronica Munoz Ramirez is one of the three PhDs in this work package.
- The Grenoble Alpes Data Institute aims at undertaking groundbreaking interdisciplinary research focusing on how data change science and society. It combines three fields of data-related research in a unique way: data science applied to spatial and environmental sciences, biology, and health sciences; data-driven research as a major tool in Social Sciences and Humanities; and studies about data governance, security and the protection of data and privacy. In this context, a 2-year multi-disciplinary projects has been granted in November 2018 to Mistis in collaboration with the Grenoble Institute of Neuroscience. The objective of this project is to develop a statistical learning technique that is able to solve a problem of tracking and analyzing a large population of single molecules. The main difficulties are: 1) the large number of observations to analyse, 2) the noisy nature of the signals, 3) the definition of a quality index to allow the elimination of poor-quality data and false positive signals. We also aim at providing a powerful, well-documented and open-source software, that will be user-friendly for non-specialists.

Also in the context of the Idex associated with the Université Grenoble Alpes, Alexandre Constantin was awarded half a PhD funding from IRS (Initiatives de Recherche Stratégique), 50 keuros.

9.1.3. Competitivity Clusters

The MINALOGIC VISION 4.0 project:MISTIS is involved in a three-year (2016-19) project. The project is led by VI-Technology, a world leader in Automated Optical Inspection (AOI) of a broad range of electronic components. The other partners are the G-Scop Lab in Grenoble and ACTIA company based in Toulouse. Vision 4.0 (in short Vi4.2) is one of the 8 projects labeled by Minalogic, the digital technology competitiveness cluster in Auvergne-Rhône-Alpes, that has been selected for the Industry 4.0 topic in 2016, as part of the 22nd call for projects of the FUI-Régions, for a total budget of the project of 3,4 Meuros.

Today, in the printed circuits boards (PCB) assembly industry, the assembly of electronic cards is a succession of ultra automated steps. Manufacturers, in constant quest for productivity, face sensitive and complex adjustments to reach ever higher levels of quality. Project VI4.2 proposes to build an innovative software solution to facilitate these adjustments, from images and measures obtained in automatic optical inspection (AOI). The idea is - from a centralized station for all the assembly line devices - to analyze and model the defects finely, to adjust each automatic machine, and to configure the interconnection logic between them to improve the quality. Transmitted information is essentially of statistical nature and the role of sc mistis is to identify which statistical methods might be useful to exploit at best the large amount of data registered by AOI machines. Preliminary experiments and results on the Solder Paste Inspection (SPI) step, at the beginning of the assembly line, helped determining candidate variables and measurements to identify future defects and to discriminate between them. More generally, the idea is to analyze two databases at both ends (SPI and Component Inspection) of the assembly process so as to improve our understanding of interactions in the assembly process, find out correlations between defects and physical measures and generate accordingly proactive alarms so as to detect as early as possible departures from normality.

9.1.4. Networks

MSTGA and AIGM INRA (French National Institute for Agricultural Research) networks: F. Forbes and J.B Durand are members of the INRA network called AIGM (ex MSTGA) network since 2006, http://carlit.toulouse.inra.fr/AIGM, on Algorithmic issues for Inference in Graphical Models. It is funded by INRA MIA and RNSC/ISC Paris. This network gathers researchers from different disciplines. MISTIS co-organized and hosted 2 of the network meetings in 2008 and 2015 in Grenoble.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

VHIA ERC project (2015-19).

MISTIS is involved in R. Horaud's ERC advanced Grant entitled Vision and Hearing In Action. VHIA studies the fundamentals of audio-visual perception for human-robot interaction.

9.3. International Initiatives

9.3.1. Inria International Labs

International Laboratory for Research in Computer Science and Applied Mathematics
Associate Team involved in the International Lab:

9.3.1.1. SIMERG2E

Title: Statistical Inference for the Management of Extreme Risks, Genetics and Global Epidemiology

International Partner (Institution - Laboratory - Researcher):

UGB (Senegal) Abdou Kâ Diongue

Start year: 2018

See also: http://mistis.inrialpes.fr/simerge

SIMERG2E is built on the same two research themes as SIMERGE, with some adaptations to new applications: 1) Spatial extremes, application to management of extreme risks. We address the definition of new risk measures, the study of their properties in case of extreme events and their estimation from data and covariate information. Our goal is to obtain estimators accounting for possible variability, both in terms of space and time, which is of prime importance in many hydrological, agricultural and energy contexts. 2) Classification, application to genetics and global epidemiology. We address the challenge to build statistical models in order to test association between diseases and human host genetics in a context of genome-wide screening. Adequate models should allow to handle complexity in genomic data (correlation between genetic markers, high dimensionality) and additional statistical issues present in data collected from a family-based longitudinal survey (non-independence between individuals due to familial relationship and non-independence within individuals due to repeated measurements on a same person over time).

9.3.2. Inria Associate Teams Not Involved in an Inria International Labs

9.3.2.1. LANDER

Title: Latent Analysis, Adversarial Networks, and DimEnsionality Reduction

International Partner (Institution - Laboratory - Researcher):

La Trobe university, Melbourne (Australia) - Department of Mathematics - Hien Nguyen

Start year: 2019

See also: https://team.inria.fr/mistis/projects/lander/

The collaboration is based on three main points, in statistics, machine learning and applications: 1) clustering and classification (mixture models), 2) regression and dimensionality reduction (mixture of regression models and non parametric techniques) and 3) high impact applications (neuroimaging and MRI). Our overall goal is to collectively combine our resources and data in order to develop tools that are more ubiquitous and universal than we could have previously produced, each on our own. A wide class of problems from medical imaging can be formulated as inverse problems. Solving an inverse problem means recovering an object from indirect noisy observations. Inverse problems are therefore often compounded by the presence of errors (noise) in the data but also by other complexity sources such as the high dimensionality of the observations and objects to recover, their complex dependence structure and the issue of possibly missing data. Another challenge is to design numerical implementations that are computationally efficient. Among probabilistic models, generative models have appealing properties to meet all the above constraints. They have been studied in various forms and rather independently both in the statistical and machine learning literature with different depths and insights, from the well established probabilistic graphical models to the more recent (deep) generative adversarial networks (GAN). The advantages of the latter being primarily computational and their disadvantages being the lack of theoretical statements, in contrast to the former. The overall goal of the collaboration is to build connections between statistical and machine learning tools used to construct and estimate generative models with the resolution of real life inverse problems as a target. This induces in particular the need to help the models scale to high dimensional data while maintaining our ability to assess their correctness, typically the uncertainty associated to the provided solutions.

9.3.3. Inria International Partners

9.3.3.1. Informal International Partners

The context of our research is also the collaboration between MISTIS and a number of international partners such as the statistics department of University of Michigan, in Ann Arbor, USA, the statistics department of McGill University in Montreal, Canada, Université Gaston Berger in Senegal and Universities of Melbourne and Brisbane in Australia.

The main other active international collaborations in 2019 are with:

- E. Deme and A. Diop from Gaston Berger University in Senegal.
- N. Wang and C-C. Tu from University of Michigan, Ann Arbor, USA.
- Guillaume Kon Kam King, Stefano Favaro, Pierpaolo De Blasi, Collegio Carlo Alberto, Turin, Italy.
- Igor Prünster, Antonio Lijoi, and Riccardo Corradin Bocconi University, Milan, Italy.
- Bernardo Nipoti, Trinity College Dublin, Ireland.
- Yeh Whye Teh, Oxford University and DeepMind, UK.
- Stephen Walker, University of Texas at Austin, USA.
- Alex Petersen, University of California Santa Barbara, USA.
- Dimitri van de Ville, EPFL, University of Geneva, Switzerland.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Bernardo Nipoti, assistant professor at Milano Bicocca University, Italy, visited for a month in 2019 (three visits in February, April and September).
- Natalie Karavarsamis, assistant professor at La Trobe University in Melbourne, Australia, visited for a week in November 2019.
- Hien Nguyen, researcher at La Trobe University in Melbourne, Australia, visited for a month in November 2019.
- Darren Wraith, assistant professor at QUT, Brisbane, Australia, visited for 2 weeks in December 2019 and January 2020.
- Aboubacrène Ag Ahmad, PhD student at Univ. Gaston Berger, Senegal visited from September 2019 until November 2019.

9.4.1.1. Internships

Sharan Yalburgi did an internship of three months with Julyan Arbel on *Bayesian deep learning for model selection and approximate inference*.

9.4.1.2. Research Stays Abroad

Mariia Vladimirova visited David Dunson at Duke University for three months (Nov 2019 - Jan 2020).

MODAL Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. ONCOLille partnership

Participants: Sophie Dabo-Niang, Cristian Preda.

ONCOLille is a regional scientific interest group whose purpose is to develop fundamental, translational (pre-clinical) and clinical interdisciplinary cancer research, particularly in the field of resistance to therapies. Sophie Dabo-Niang is member of the executive group.

9.2. National Initiatives

9.2.1. Programme of Investments for the Future (PIA)

Bilille is a member of the PIA "Infrastructures en biologie-santé" IFB, French Institute of Bioinformatics (https://www.france-bioinformatique.fr/en). As the co-head of the platform, Guillemette Marot is thus involved in this network.

9.2.2. RHU PreciNASH

Participant: Guillemette Marot.

RHU PreciNASH

Acronym: PreciNASH

Project title: Non-alcoholic steato-hepatitis (NASH) from disease stratification to novel therapeutic approaches

Coordinator: F. Pattou

Duration: 5 years

Partners: FHU Integra and Sanofi

Abstract: PreciNASH, project coordinated by Pr. F. Pattou (UMR 859, EGID), aims at better understanding non alcoholic stratohepatitis (NASH) and improving its diagnosis and care. In this RHU, Guillemette Marot supervises a 2 years post-doc, as her team EA 2694 is a member of the FHU Integra. EA 2694 is involved in the WP1 for the development of a clinical-biological model for the prediction of NASH. Other partners of the FHU are UMR 859, UMR 1011 and UMR 8199, these last three teams being part of the labex EGID (European Genomic Institute for Diabetes). Sanofi is the main industrial partner of the RHU PreciNASH. The whole project will last 5 years (2016-2021).

9.2.3. CNRS PEPS Blanc – BayesRealForRNN project

Participants: Pascal Germain, Vera Shalaeva.

BayesRealForRNN project: PAC-Bayesian theory for recurrent neural networks: a control theoretic approach

Coordinator: Mihaly Petreczky, CNRS, UMR 9189 CRIStAL, Université de Lille

Year: 2019

Abstract: The project proposes to analyze the mathematical correctness of deep learning algorithms by combining techniques from control theory and PAC-Bayesian statistical theory. More precisely, the project proposes to concentrate on recurrent neural networks (RNNs), develop their structure theory using techniques from contol theory, and then apply this structure theory to derive PAC-Bayesian error bounds for RNNs.

9.2.4. CNRS AMIES PEPS 2 - DiagChange project

Participants: Cristian Preda, Quentin Grimonprez.

DiagChange

Coordinator: Cristian Preda, Inria MODAL

Year: 2019

Abstract: The project proposes to study the topic of change detection distribution for multivariate signal in a industrial context.The project is in collaboration with the Diagrams start-up.

9.2.5. AMIES PEPS 1 - CADIS2

Participants: Serge Iovleff, Sophie Dabo-Niang, Cristian Preda.

Partners: Société SIRS https://www.sirs-fr.com/sirs/fr/

Acronym: CADIS2

Project title: Classification Automatique D'Images Sentinel-2

Coordinator: Serge Iovleff

Year: 2019

Duration: 1 year

Abstract: In the context of several European projects, SIRS is in charge of exploring the improvements to be made to the "High Resolution Layers" as well as future prototypes such as "CORINE Land Cover +", on a European scale using the Sentinel-2 images, through the project H2020 "ECoLaSS". The CADIS2 project aims to develop, study and implement supervised classification methods to classify trees in predefined forest areas by SIRS.

9.2.6. AMIES PEPS 2 - MadiPa

Participants: Stéphane Girard, Serge Iovleff.

Partners: Société Phimeca http://phimeca.com/, Mistis team Inria Grenoble Rhône-Alpes

Acronym: MadiPa

Project title: Modèles Auto-associatifs pour la Dispersion de Polluants dans l'Atmosphère

Coordinator: Stéphane Iovleff

Duration: 18 month (start in december 2019)

Abstract: Our goal is to develop a method for predicting the dispersion of pollutants in the atmosphere from an initial emission map and meteorological data. A map of the probabilities of exceeding a critical threshold of pollutants will be estimated thanks to the construction of a meta-model: the large dimension of the problem is reduced by the use of auto-associative models, a non-linear extension of the Principal Components Analysis.

9.2.7. ANR

9.2.7.1. ANR APRIORI

Participants: Benjamin Guedj, Pascal Germain, Hemant Tyagi, Vera Shalaeva.

APRIORI 2019–2023, ANR PRC

PAC-Bayesian theory and algorithms for deep learning and representation learning.

Main coordinator of the project: Emilie Morvant, Université Jean Monnet.

Funding: 300k EUR.

2 partners - MODAL (Inria LNE), Hubert Curien Lab. (UMR CNRS 5516).

9.2.7.2. ANR BEAGLE

Participants: Benjamin Guedj, Pascal Germain.

BEAGLE 2019–2023, ANR JCJC

PAC-Bayesian theory and algorithms for agnostic learning

Main coordinator of the project: Benjamin Guedj

Funding: 180k EUR

The consortium also includes Pierre Alquier (RIKEN AIP, Japan), Peter Grünwald (CWI, The Netherlands), Rémi Bardenet (UMR CRIStAL 9189).

9.2.7.3. ANR SMILE

Participants: Christophe Biernacki, Vincent Vandewalle.

SMILE Project-2018-2022

ANR project (ANR SMILE - Statistical Modeling and Inference for unsupervised Learning at LargE-Scale)

Main coordinator of the project: Faicel Chamroukhi, LMNO, Université de Caen

4 partners - MODAL (Inria LNE), LMNO UMR CNRS 6139 (Caen), LMRS UMR CNRS 6085 (Rouen), LIS UMR CNRS 7020 (Toulon).

9.2.7.4. ANR TheraSCUD2022

Participant: Guillemette Marot.

Acronym: TheraSCUD2022

Project title: Targeting the IL-20/IL-22 balance to restore pulmonary, intestinal and metabolic homeostasis after cigarette smoking and unhealthy diet

Coordinator: P. Gosset

Duration: 3 years (2017-2020)

Partners: CIIL Institut Pasteur de Lille and UMR 1019 INRA Clermont-Ferrand

Abstract: TheraSCUD2022, project coordinated by P. Gosset (Institut Pasteur de Lille), studies inflammatory disorders associated with cigarette smoking and unhealthy diet (SCUD). Guillemette Marot is involved in this ANR project as head of bilille platform, and will supervise 1 year engineer on integration of omic data. The duration of this project is 3 years (2017-2020).

9.2.8. Working groups

Sophie Dabo-Niang belongs to the following working groups:

- STAFAV (STatistiques pour l'Afrique Francophone et Applications au Vivant)
- ERCIM Working Group on computational and Methodological Statistics, Nonparametric Statistics Team

Benjamin Guedj belongs to the following working groups (GdR) of CNRS:

- ISIS (local referee for Inria Lille - Nord Europe)
- MaDICS
- MASCOT-NUM (local referee for Inria Lille - Nord Europe).

Guillemette Marot belongs to the StatOmique working group.

9.2.9. Other initiatives

Participants: Serge Iovleff, Cristian Preda, Vincent Vandewalle.

Serge Iovleff is the head of the project CloHe granted in 2016 by the Mastodons CNRS challenge "Big data and data quality". The project is axed on the design of classification and clustering algorithms for mixed data with missing values with applications to high spatial resolution multispectral satellite image time-series. Website. Cristian Preda and Vincent Vandewalle are also members of the CloHe project.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

PERF-AI project (Nov 2018 - Nov 2020, involving Benjamin Guedj, Vincent Vandewalle - hired Florent Dewez, Arthur Taelpert). Two partners: Inria LNE and the company Safety Line (Paris, France).

Commercial aviation is already responsible for 3% of the total CO2 emissions, and with a constant growth rate of 5% per year, traffic will double within the next decade. With the support of new technologies such as Big Data, Artificial Intelligence, in-flight connectivity, major improvements can be introduced to optimize flight trajectories. PERF-AI focuses on the challenge of minimizing fuel consumption throughout the flight. The aim of PERF-AI is to provide a flight trajectory optimization prototype that implements new machine learning performance models.

The first step of the project that was carried out in the first year was to define, implement and test narrow system identification techniques. Several Machine Learning methods have been tried and have provided very encouraging initial results.

PERF-AI main objective is to provide a computation engine that can be used in two ways:

- support update of FMS that integrate individual aircraft performance models, that allow to perform accurate trajectory prediction;
- perform trajectory optimization on the ground using most accurate aircraft performance models.

9.3.2. Collaborations with Major European Organizations

Sophie Dabo-Niang is chair of EMS-CDC (European Mathematical society-Committe of Developing Countries).

Sophie Dabo-Niang is a member of the executive committee of CIMPA (International Centre of Pure and Applied Mathematics)

9.4. International Initiatives

9.4.1. Inria International Labs

9.4.1.1. 6PAC (IIL CWI-Inria)

Scientific leaders: Benjamin Guedj, Peter Grünwald.

Other members: Emilie Kaufmann (Inria LNE, EPI SequeL), Wouter Koolen (CWI).

Title: Making Probably Approximately Correct Learning Active, Sequential, Structure-aware, Efficient, Ideal and Safe

International Partner (Institution - Laboratory - Researcher):

CWI (Netherlands) - Machine Learning Group - Peter Grünwald (head)

Start year: 2018, renewed for 2019 and 2020

Webpage: https://bguedj.github.io/6pac/index.html

This project roots in statistical learning theory, which can be viewed as the theoretical foundations of machine learning. The most common framework is a setup in which one is given n training examples, and the goal is to build a predictor that would be efficient on new (similar) data. This efficiency should be supported by PAC (Probably Approximately Correct) guarantees, e.g. upper bounds on the excess risk of a predictor that hold with high probability. Such guarantees however often hold under stringent assumptions which are typically never met in real-life application, e.g., independent, identically distributed data. More realistic modelling of data has triggered many research efforts in several directions: first, accommodating possible data (e.g., dependent, heavy-tailed), and second, in the direction of sequential learning, in which the predictor can be built on the fly, while new data is gathered. We believe that an ever more realistic paradigm is active learning, a setup in which the learner actively requests data (possibly facing constraints, such as storage, velocity, cost, etc.)

and adapts its queries to optimize its performance. The 3-years objective of 6PAC (where 6 stands for Sequential, Active, Efficient, Structured, Ideal, Safe - the six research directions we intend to contribute to) is to pave the way to new PAC generalization and sample-complexity upper and lower bounds beyond batch learning. Our ambition is to contribute to several learning setups, ranging from sequential learning (where data streams are collected) to adaptive and active learning (where data streams are requested by the learning algorithm).

9.4.2. Inria International Partners

9.4.2.1. Declared Inria International Partners

A byproduct of Benjamin Guedj's sabbatical position at University College London (UCL) since Dec 2018 is a strengthened link between UCL and Inria. DGDS has established contact with UCL President in April 2019 and a MoU has been signed between UCL and Inria in December 2019. A research group (known as Inria@UCL) has been established by Benjamin Guedj within UCL, Department for Computer Science, Centre for Artificial Intelligence. Inria@UCL initiative is expected to grow in 2020 and possibly evolve into a joint team or more. A strategic partnership between Inria and UCL will be explored in 2020.

SIMERGE

Title: Statistical Inference for the Management of Extreme Risks and Global Epidemiology

International Partner (Institution - Laboratory - Researcher):

UGB (Senegal) - LERSTAD - Abdou Ka Diongue

Serge Iovleff and Sophie Dabo-Niang are associated members of SIMERGE.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Mihai Cucuringu (University of Oxford) visited Hemant Tyagi in January 2019 for a research visit of 1 week.
- Martin Wahl (Humboldt Universität from Berlin) visited Alain Celisse in March 2019 for a research visit of 1 week and November 2019 for a research visit of 1 week.
- Apoorv Vikram Singh is currently visiting Hemant Tyagi to work on a research project which is jointly supervised by Hemant Tyagi and Mihai Cucuringu (University of Oxford). The duration of the visit is 4 months (October 1, 2019 - January 31, 2020) and is partly funded by the Alan Turing Institute, London.
- Abdou Kâ Diongue visited Serge Iovleff in June 2019 for one month.

9.5.2. Visits to International Teams

9.5.2.1. Sabbatical programme

Since Dec 2018, Benjamin Guedj is on sabbatical at University College London (UCL). He is a PI of the UCL Centre for Artificial Intelligence (UCL AI) and a visiting researcher at the Alan Turing Institute. This has led to the Inria@UCL initiative, see supra.

9.5.2.2. Research Stays Abroad

- Sophie Dabo-Niang has visited University of Kuala Lumpur, Malaysia in August 2019 and University of Mohamed V, Morroco in December 2019.
- Serge Iovleff has visited University Gaston Berger, Senegal in February 2019 and gave a course entitled “Introduction to Statistical Learning”.
- Hemant Tyagi visited Mihai Cucuringu and Benjamin Guedj at the Alan Turing Institute, UK from in October 2019.
- Alain Celisse visited Markus Reißand Martin Wahl at the Humboldt Universität, Germany in March and December 2019.
- Alain Celisse visited Benjamin Guedj at the University College London, UK in February-March and July-August 2019.
- Pascal Germain visited Benjamin Guedj at University College London, UK on several occasions totalling about 1.5 month in 2019.
- Cristian Preda visited Amarioarei Alexandru at University of Bucharest on several occasions totalling about 1 week in 2019.

MOKAPLAN Project-Team

6. Partnerships and Cooperations

6.1. National Initiatives

6.1.1. ANR

V. Duval is the PI of the CIPRESSI (ANR JCJC) project. Its aim is to develop novel numerical schemes which respect the continuous nature of the variational problems in image or signal processing.

J-D. Benamou and G. Carlier are members of the ANR MFG (ANR-16-CE40-0015-01). Scientific topics of the project: Mean field analysis Analysis of the MFG systems and of the Master equation Numerical analysis Models and applications

J-D. Benamou G. Carlier F-X. Vialard and T. O. Gallouët are members of ANR MAGA (ANR-13-JS01-0007-01). The Monge-Ampère equation is a fully nonlinear elliptic equation, which plays a central role in geometry and in the theory of optimal transport. However, the singular and non-linear nature of the equation is a serious obstruction to its efficient numerical resolution. The first aim of the MAGA project is to study and to implement discretizations of optimal transport and Monge-Ampère equations which rely on tools from computational geometry (Laguerre diagrams). In a second step, these solvers will be applied to concrete problems from various fields involving optimal transport or Monge-Ampère equations such as computational physics: early universe reconstruction problem, congestion/incompressibility constraints economics: principal agent problems, geometry: variational problems over convex bodies, reflector and refractor design for non-imaging optics

T. O. Gallouët is member of the ANR GEOPOR (JCJC of C. Cancès) Scientific topic: geometrical approach, based on Wasserstein gradient flow, for multiphase flows in porous media. Theory and Numerics.

T. O. Gallouët is member of the ANR MESA (JCJC of M. Fathi) Scientific topic: Stein methods.

6.2. European Initiatives

6.2.1. FP7 & H2020 Projects

J-D. Benamou and Giorgi Rukhaia are members of ROMSOC ITN-EID.

6.3. International Initiatives

6.3.1. Inria International Partners

6.3.1.1. Informal International Partners

The team has strong ties with Technische Universität München, dept. of Math. (Profs. Daniel Matthes, Gero Friesecke, Bernhardt Schmitzer)

6.4. International Research Visitors

6.4.1. Visits of International Scientists

15-28/02 Visit of Prof. Yanir Rubinstein (University of Maryland).

6.4.2. Visits to International Teams

6.4.2.1. Research Stays Abroad

P. Pegon has been invited by Maria Colombo (Chair of Mathematical Analysis, Calculus of Variations and PDEs) at EPFL, Lausanne for 4 months (Feb-June 2019) to work on optimal and branched transport problems.

NACHOS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR project

8.1.1.1. OPERA (Adpative planar optics)

Participants: Emmanuel Agullo [HIEPACS project-team, Inria Bordeaux - Sud-Ouest], Régis Duvigneau [ACUMES project-team], Mahmoud Elsawy, Patrice Genevet [CRHEA laboratory, Sophia Antipolis], Luc Giraud [HIEPACS project-team, Inria Bordeaux - Sud-Ouest], Stéphane Lanteri.

Type: ANR ASTRID Maturation

See also: http://www-sop.inria.fr/nachos/opera/

Duration: Avril 2019 - March 2022

Coordinator: Inria

Partner: CRHEA laboratory in Sophia Antipolis and NAPA Technologies in Archamps

Inria contact: Stéphane Lanteri

Abstract: In the OPERA project, we are investigating and optimizing the properties of planar photonic devices based on metasurfaces using numerical modelling. The scientific and technical activities that constitute the project work programme are organized around 4 main workpackages. The numerical characterization of the optical properties of planar devices based on metasurfaces, as well as their optimization are at the heart of the activities and objectives of two horizontal (transversal) workpackages. These numerical methodologies will be integrated into the DIOGENeS software framework that will eventually integrates (1) discontinuous Galerkin-type methods that have been tested over the past 10 years for the discretization of Maxwell equations in time and frequency regimes, mainly for applications in the microwave band, (2) parallel resolution algorithms for sparse linear systems based on the latest developments in numerical linear algebra, (3) modern optimization techniques based on learning and metamodeling methods and (4) software components adapted to modern high performance computing architectures. Two vertical workpackages complete this program. One of them aims to demonstrate the contributions of methodological developments and numerical tools resulting from transversal workpackages through their application to diffusion/radiation control by passive planar devices. The other, more prospective, concerns the study of basic building blocks for the realization of adaptive planar devices.

8.2. European Initiatives

8.2.1. H2020 Projects

8.2.1.1. PRACE 6IP

Title: PRACE Sixth Implementation Phase (PRACE-6IP) project

See also: https://cordis.europa.eu/project/id/823767

Duration: May 2019 - December 2021

Partners: see https://cordis.europa.eu/project/id/823767

Inria contact: Luc Giraud

PRACE, the Partnership for Advanced Computing is the permanent pan-European High Performance Computing service providing world-class systems for world-class science. Systems at the highest performance level (Tier-0) are deployed by Germany, France, Italy, Spain and Switzerland, providing researchers with more than 17 billion core hours of compute time. HPC experts from 25 member states enabled users from academia and industry to ascertain leadership and remain competitive in the Global Race. Currently PRACE is finalizing the transition to PRACE 2, the successor of the initial five year period. The objectives of PRACE-6IP are to build on and seamlessly continue the successes of PRACE and start new innovative and collaborative activities proposed by the consortium. These include: assisting the development of PRACE 2; strengthening the internationally recognised PRACE brand; continuing and extend advanced training which so far provided more than 36 400 person·training days; preparing strategies and best practices towards Exascale computing, work on forward-looking SW solutions; coordinating and enhancing the operation of the multi-tier HPC systems and services; and supporting users to exploit massively parallel systems and novel architectures. A high level Service Catalogue is provided. The proven project structure will be used to achieve each of the objectives in 7 dedicated work packages. The activities are designed to increase Europe's research and innovation potential especially through: seamless and efficient Tier-0 services and a pan-European HPC ecosystem including national capabilities; promoting take-up by industry and new communities and special offers to SMEs; assistance to PRACE 2 development; proposing strategies for deployment of leadership systems; collaborating with the ETP4HPC, CoEs and other European and international organisations on future architectures, training, application support and policies. This will be monitored through a set of KPIs.

8.2.1.2. EPEEC

Title: European joint effort toward a highly productive programming environment for heterogeneous exascale computing

Program: H2020

See also: https://epeec-project.eu

Duration: October 2018 - September 2021

Coordinator: Barcelona Supercomputing Center

Partner: Barcelona Supercomputing Center (Spain)

Coordinator: CEA

Partners:

- Fraunhofer–Gesellschaft (Germany)
- CINECA (Italy)
- IMEC (Blegium)
- INESC ID (Portugal)
- Appentra Solutions (Spain)
- Eta Scale (Sweden)
- Uppsala University (Sweden)
- Inria (France)
- Cerfacs (France)

Inria contact: Stéphane Lanteri

EPEEC's main goal is to develop and deploy a production-ready parallel programming environment that turns upcoming overwhelmingly-heterogeneous exascale supercomputers into manageable platforms for domain application developers. The consortium will significantly advance and integrate existing state-of-the-art components based on European technology (programming models, runtime systems, and tools) with key features enabling 3 overarching objectives: high coding productivity, high performance, and energy awareness. An automatic generator of compiler directives will provide outstanding coding productivity from the very beginning of the application developing/porting process. Developers will be able to leverage either shared memory or distributed-shared memory programming flavours, and code in their preferred language: C, Fortran, or C++. EPEEC will ensure the composability and interoperability of its programming models and runtimes, which will incorporate specific features to handle data-intensive and extreme-data applications. Enhanced leading-edge performance tools will offer integral profiling, performance prediction, and visualisation of traces. Five applications representative of different relevant scientific domains will serve as part of a strong inter-disciplinary co-design approach and as technology demonstrators. EPEEC exploits results from past FET projects that led to the cutting-edge software components it builds upon, and pursues influencing the most relevant parallel programming standardisation bodies.

8.3. International Initiatives

8.3.1. Participation in Other International Programs

8.3.1.1. International Initiatives

PHOTOM

Title: PHOTOvoltaic solar devices in Multiscale computational simulations

International Partners:

Center for Research in Mathematical Engineering, Universidad de Concepcion (Chile), Rodolfo Araya

Laboratório Nacional de Computação Científica (Brazil), Frédéric Valentin

Instito de Matemáticas, PUCV (Chile), Diego Paredes

Duration: 2018 - 2020

Start year: 2018

See also: http:////www.photom.lncc.br

The work consists of devising, analyzing and implementing new multiscale finite element methods, called Multiscale Hybrid-Mixed (MHM) method, for the Helmholtz and the Maxwell equations in the frequency domain. The physical coefficients involved in the models contain highly heterogeneous and/or high contrast features. The goal is to propose numerical algorithms to simulate wave propagation in complex geometries as found in photovoltaic devices, which are naturally prompt to be used in massively parallel computers. We demonstrate the well-posedness and establish the optimal convergence of the MHM methods. Also, the MHM methods are shown to induce a new face-based a posteriori error estimator to drive space adaptivity. An efficient parallel implementation of the new multiscale algorithm assesses theoretical results and is shown to scale on a petaflop parallel computer through academic and realistic two and three-dimensional solar cells problems.

8.3.1.2. Informal International Partners

Prof. Kurt Busch, Humboldt-Universität zu Berlin, Institut für Physik, Theoretical Optics & Photonics

8.3.1.3. Inria International Chairs

IIC VALENTIN Frédéric

Title: Innovative multiscale numerical algorithms for wave-matter interaction models at the nanoscale

International Partner (Institution - Laboratory - Researcher):

Laboratório Nacional de Computação Científica (Brazil), Frédéric Valentin

Duration: 2018 - 2022

Start year: 2018

See also: https://www.lncc.br/~valentin/

The project addresses complex three-dimensional nanoscale wave-matter interaction models, which are relevant to the nanophotonics and nanophononics fields, and aims at devising innovative multi-scale numerical methods, named Multiscale Hybrid-Mixed methods (MHM for short), to solve them with high accuracy and high performance.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- David Pardo (Basque Center for Applied Mathematics, Spain) at Inria, France, April 2-5, 2019.
- Christophe Geuzaine (University of Liège, Belgium) at Inria, France, April 29-30, 2019.
- Jean-Francois Remacle (Ecole Polytechnique de Louvain, Belgium) at Inria, France, April 29-30, 2019.
- Jay Gopalakrishnan (University of Portland, USA) at Inria, France, June 4-5, 2019.

NANO-D Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

- An IDEX UGA grant is covering post-doc of Didier Devaurs, starting from December.
- Inria CORDI-S post-doctoral fellowship was obtained for Agnieszka Karczynska.

7.2. National Initiatives

7.2.1. ANR

In 2019, NANO-D had funding from one ANR program:

- **ANR PRCI**: covered the end of the PhD thesis of Guillaume Pages.

7.3. European Initiatives

7.3.1. Collaborations with Major European Organizations

The European Bioinformatics Institute (EMBL-EBI), Protein Data Bank in Europe (PDBe) team, Hinxton (UK)

We are collaborating on the integration of methods developed in the team into the PDBe web resource.

The Institute Laue-Langevin (ILL), the bioSANS team, Grenoble (France)

We are collaborating on the development of neutron small-angle scattering software

7.4. International Initiatives

7.4.1. Inria Associate Teams Not Involved in an Inria International Labs

7.4.1.1. FlexMol

Title: Algorithms for Multiscale Macromolecular Flexibility

International Partner (Institution - Laboratory - Researcher):

Rocasolano Institute of Physical Chemistry (IQFR-CSIC), Madrid, Spain (Spain) - Pablo Chacon

Start year: 2019

See also: https://team.inria.fr/nano-d/research/flexmol/

Molecular flexibility is essential to link structure and function of many biological macromolecules. Changes in protein conformation play a vital role in biochemical processes, from biopolymer synthesis to membrane transport. Many proteins can drastically alter their architecture and display considerable interdomain flexibility, as found in their 3D structures. For example, proteins rely on flexibility to respond to environmental changes, ligand binding and chemical modifications. Also, protein flexibility is tightly bound to their stability and is fundamental for drugs to exert biological effects.

Thus, one of the main challenges in the field of computational structural biology is to predict and explain molecular flexibility and corresponding conformational changes. For example, currently there are no methods that can reliably predict structural changes in proteins upon their binding. However, these are crucial to predict the structure of protein complexes with large conformational changes upon binding. To give another example, flexibility of the protein binding pocket is the major hurdle in reliable prediction of protein-ligand interactions for computer-aided drug design. Finally, intrinsic flexibility of macromolecules is nowadays the limiting factor for high-resolution experimental structure determination.

The partners of this associate team proposal comprise world-leading teams working with sound mathematical representations and techniques in the field of structural bioinformatics. These include spherical harmonics, normal modes analysis, high-order fast Fourier transforms, and more. The partners have very similar interests, but complimentary expertise. The goal of this collaboration is to mutually explore novel computational techniques for emerging problems in structural biology and bioinformatics related to molecular flexibility. This problem can be tackled at different scales. Large-scale flexibility of macromolecules can be efficiently described using collective coordinates. We will try to represent these in polynomial spaces, such that a practical flexible docking method can be based on this representation. Other applications include 3D shape reconstruction and scattering problems. Local molecular flexibility can be modelled using various techniques, including robotics-inspired methods, fragment libraries, etc. Here, our goal will be to rapidly sample the conformational space, and to construct a potential energy function applicable to flexible molecules. The ultimate goal of the project is to combine multiple levels of representation of molecular flexibility together. The project outcome will be built around innovative computer-aided drug-design algorithm with applications to prediction and computational design of important pharmaceutical targets such as antibodies.

7.4.2. Inria International Partners

7.4.2.1. Declared Inria International Partners : BIOTOOLS

Title: Novel Computational Tools for Structural Bioinformatics

International Partner (Institution - Laboratory - Researcher):

MIPT (Russia (Russian Federation)) - Department of Control and Applied Mathematics - Vadim Strijov

Duration: 2016 - 2020

Start year: 2016

Abstract : The general scientific objectives of the forthcoming collaboration are the new developments of computational tools for structural bioinformatics. In particular, we plan to collaborate on several subjects: 1. Development of tractable approximations for intractable combinatorial problems in structural biology. 2. Development of new computational tools for scattering experiments. 3. Machine learning for structural bioinformatics.

7.4.2.2. Informal International Partners

- University of Stony Brook, lab of Dima Kozakov (USA). We have been collaborating on the development of novel protein docking methods.
- University of Vilnius, department of Bioinformatics (Lithuania). We have been collaborating on the development of novel protein docking methods.
- KU Copenhagen (Denmark), department of Chemistry. We collaborated on the integrative structural biology approaches.
- Francis Crick Institute, London (UK), Biomolecular Modelling Laboratory. We collaborate on the development of flexible protein docking methods.
- University of Oslo. Ongoing collaboration on modeling protein systems guided by small-angle Xray and neutron small-angle scattering.
- University of Bergen, Norway. Ongoing collaboration on novel methods for normal mode analysis of protein structures.
- Nagoya University and RIKEN Center for Computational Science, Kobe, Japan. We collaborated on novel algorithms for scattering methods.

- University of Kansas, bioinformatics unit, USA. We have been collaborating on modeling protein-protein interactions.

7.4.3. Participation in Other International Programs

Our team has obtained the PHC Gilibert grant for a 2-year collaboration with the Vilnius University (Lithuania). Our partner is the Department of Bioinformatics, http://www.bti.vu.lt/en/departments/department-of-bioinformatics.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- Karina Dos Santos Machado, lecturer at the Federal University of Rio Grande (FURG, Brazil), Oct 2018 - Oct 2019.
- Vadim Strijov, professor at the department of Intelligent Systems, MIPT Moscow MIPT Moscow, July-August 2019.

7.5.1.1. Internships

- Khalid Mustafin (MIPT Moscow, Russia), Sep 2018 - Feb 2019.
- Ilia Igashov (MIPT Moscow, Russia), Nov 2018 - Apr 2020.
- Dmitrii Zhemchuzhnikov (UGA Grenoble), May 2019 - Sep 2019.

7.5.2. Visits to International Teams

- Sergei Grudinin visited the team of Ilia Vakser at Kansas University, Oct 15-31, 2019.

7.5.2.1. Explorer programme

- Sergei Grudinin visited Florence Tama and Osamu Miyashita, Nagoya University and RIKEN Center for Computational Science, Kobe, Japan. This was supported by the Exploration Japon 2019 program.
- Sergei Grudinin visited the team of Reidar Lund at University of Oslo, and the team of Nathalie Reuter at University of Bergen, Norway. Supported by the ÅSGARD 2019 program.

NECS Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

DATASAFE (Understanding data accidents for traffic safety). PI: M.L. Delle Monache (2018-2019)
DATASAFE is a two years project funded by Grenoble Data Institute, with the aim to understand from real traffic data the behavior of traffic in the moments preceding an accident. The general approach is to use novel statistical techniques in order to learn traffic characteristics that can be used to develop new traffic models. Bayesian approaches are used to (supervised) classification and (unsupervised) clustering in order to respectively predict collision occurrences and discover traffic patterns.

MAVIT (Modeling autonomous vehicles in traffic flow). PI: M.L. Delle Monache (2018-2019)
MAVIT is a two year project funded by the University Grenoble Alpes, MSTIC department. The goal of this project is to develop a unified micro-macro approach for traffic management, involving human and autonomous vehicles drivers by providing analytical and numerical tools for traffic modeling, estimation and control. We will work towards field operational tests, by using instrumented cars to collect data on AVs trajectory and their interaction with the traffic flow with human drivers. The proposed research provides new mathematical models, computational/software tools, and engineering solutions for the control of human controlled vehicles via intelligently controlled AVs in the traffic stream. Moreover, the control of traffic via moving actuators provides a new alternative to contemporary control technologies, such as ramp metering and variable speed limits; even when AVs comprise a tiny fraction of the total fleet, these techniques may be viable, and rapidly configurable. This research considers new types of traffic models, new control algorithms for traffic flow regulation, and new sensing and control paradigms that are enabled by a small number of controllable systems anticipated in a flow. Specifically, the research focuses on new (1) micro-macro models to model few AVs in a flow; (2) estimation techniques for AV interactions with the traffic flow; (3) developing and assessing dynamical controllers to mitigate traffic events

SPACE (NanoSatellite Project: Advanced modelling and Control of attitude dynamics for quantum communication). PI: H. Fourati (2018-2019)
SPACE is a two-year project funded by the IDEX University Grenoble Alpes. It aims to launch an exploratory study to find the required minimal data we need to collect and combine for software design of Nanosatellite Attitude Determination and Control System (ADCS).

CAPTIMOVE (CAPture et analyse d'acTivités humaInes par MOdules inertiels : vers une solution adaptée à la naVigation multimodalE urbaine intelligente). PI: H. Fourati (2018-2019)
Mobility is currently evolving in urban scenarios and multimodality today is the key tomore efficient transportation. It is important to analyze the ecological impact of the varioustransportation modes, to be able to detect the mode used by the commuter and the rule usedto switch from one mode to another. The ultimate goal is to suggest smarter itineraries tocommuters. To this purpose, detection and classification of activities in human mobility fromhis principal residence to his destination (for example, place of work, place of entertainment,etc.) is an important study to carry out. We aim to identify, with high precision, the natureof the transportation modes used during the day (walking, cycling, public transportation, car,etc.) as well as transitions from one mode to another. To reach this goal, we will use inertial and attitude modules, embedded in most inertial units, connected watches and smartphones.These technological tools constitute truly innovative and promising instrumentation for bothnon-invasive automatic capture information in situ, over extended periods, only for accurateand reliable analysis of activities of a person during his/her trip. In terms of research, we willexploit techniques from Machine Learning and state estimation to address this issue. A studyshall be conducted to determine the type, number and location of sensors to be used., Issuesrelated to the quality of data to be provided to algorithms and how to detect and discarderroneous ones from our computation process, will be also addressed. This research finds itsmajor future interest later in the development of a multimodal

intelligent navigation systemfor indoor and outdoor environments. These results, once obtained, can also be used to studyand analyze the behavior (choice) of users regarding pedestrian navigation (walking) or theuse of modes of transport (convenience, cost, speed, safety and more and more frequentlyeffects on the environment) or respect for the privacy of individuals (dynamic anonymizationof data while retaining their usefulness).

9.2. National Initiatives

DOOM (Systems-theory for the Disorders Of Online Media). 80 PRIME from CNRS MITI (2019–2022). PI: P. Frasca
Online social media have a key role in contemporary society and the debates that take place on them are known to shape political and societal trends. For this reason, pathological phenomena like the formation of "filter bubbles" and the viral propagation of "fake news" are observed with concern. The scientific assumption of this proposal is that these information disorders are direct consequences of the inherent nature of these communication media, and more specifically of the collective dynamics of attention thereby. In order to capture these dynamics, this proposal advocates the mathematical modelling of the interplay between the medium (algorithmic component) and the users (human component). The resulting dynamics shall be explored by a system-theoretic approach, using notions such as feedback and stability. This quantitative and rigorous approach will not only unlock fundamental insights but also deliver suggestions on suitable policies to manage the media.

HANDY (Hybrid and Networked Dynamical Systems). ANR PRC (2019-2022). Co-PI: P. Frasca
Networked dynamical systems are ubiquitous in current and emerging technologies. From energy grids, fleets of connected autonomous vehicles to online social networks, the same scenario arises in each case: dynamical units interact locally to achieve a global behavior. When considering a networked system as a whole, very often continuous-time dynamics are affected by instantaneous changes, called jumps, leading to so-called hybrid dynamical systems. Hybrid phenomena thus play an essential role in these control applications, and call upon the development of novel adapted tools for stability and performance analysis and control design. In this context, the aim of HANDY project is to provide methodological control-oriented tools for realistic networked models, which account for hybrid phenomena. The project brings together researchers from LAAS in Toulouse, CRAN in Nancy, GIPSA in Grenoble and LSS in Gif-sur-Yvette, with expertise in various domains of automatic control, ranging from geometric control and optimization, switched systems, hybrid dynamics, nonlinear control, and multi-agent systems. See also: http://projects.laas.fr/handy

AgileWorld-MRSEI. PI: A. Kibangou AgileWorld is an ANR-MRSEI project (2018-2020), which aims at building an European network for an innovative training on road transportation systems in a connected world. The funding will help to prepare and then submit a proposal for the MSCA-ITN 2019 call. For this purpose a workshop was organized in November 2019 with the partners of the project in Grenoble.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

COST (Mathematical models for interacting dynamics on networks). Action no. 18232, 2019-2023, Management committee substitute member. PI: M.L. Delle Monache
Many physical, biological, chemical, financial or even social phenomena can be described by dynamical systems. It is quite common that the dynamics arises as a compound effect of the interaction between sub-systems in which case we speak about coupled systems. This Action shall study such interactions in particular cases from three points of view: 1. the abstract approach to the theory behind these systems, 2. applications of the abstract theory to coupled structures like networks, neighbouring domains divided by permeable membranes, possibly non-homogeneous simplicial complexes, etc., 3. modelling real-life situations within this framework. The purpose of this Action is to bring together leading groups in Europe working on a range of issues connected with modelling and analysing mathematical models for dynamical systems on networks. It aims to develop a semigroup approach to various (non-)linear dynamical systems on networks as well as numerical methods based on modern variational methods and applying them to road traffic, biological systems,

and further real-life models. The Action also explores the possibility of estimating solutions and long time behaviour of these systems by collecting basic combinatorial information about underlying networks

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

MEMENTO (ModEling autonoMous vEhicles iN Traffic flOw). International Partner: Vanderbilt University, Nashville (United States) - Dan Work, Start year: 2018. See also: http://necs.inrialpes.fr/memento/index.html

PI: M.L. Delle Monache

In recent years, the strategic priorities of automotive and transportation systems focus on research, development and adoption of automation-related technologies as they emerge. As these technology developments are introduced in the traffic stream, an open question is how the mathematical models that are at the heart of transportation planning and operations will need to be advanced to accommodate these changes. The goal of the NeCS-Vanderbilt, MEMENTO, associate team is to create a multidisciplinary environment to model autonomous vehicles (AV) in human traffic flow. Specifically, our goal is to develop a unified micro-macro approach for traffic management, involving human drivers and autonomous vehicles by providing analytical and numerical tools for traffic modeling, estimation and control. We will work towards field operational tests, by using instrumented cars to collect data on AVs trajectories and their interaction with the traffic flow with human drivers.

9.4.2. Participation in Other International Programs

(Mean field game models for traffic application). Rutgers Global Grant - International collaborative research grant: International partner : Rutgers University - Camden (USA). PI: M.L. Delle Monache

This project focuses on the theoretical tools for traffic systems to mitigate traffic events that adversely affect. Specifically, the project will build algorithms to mitigate “phantom” traffic jams, which are instabilities caused by human driving behavior, lane changes, and other disturbances. This project is premised on the concept that connected and autonomous vehicles (CAVs) can act as instability pacifiers and enable a new era of freeway traffic management in which CAVs themselves are part of the traffic control system. The stabilizing Lagrangian (i.e., mobile) control signal will be fed directly to the vehicles, which will adjust their speed and lanes to match the requirements of the control.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Raphael Stern (University of Minnesota (USA)) visited the team in March 2019 to work with Maria Laura Delle Monache and Thibault Liard, in the framework of the associated team MEMENTO.

9.5.2. Visits to International Teams

- P. Frasca is a Visiting Scientist at the IEIIT-CNR Institute, National Research Council CNR, Turin, Italy. By this collaboration, he performs research on distributed estimation in sensor networks and distributed control of social networks. He visited Turin three times in 2019. He is also a Visiting Faculty at the Department of Applied Mathematics, University of Twente, Enschede, The Netherlands. By this collaboration, he performs research on vehicle platooning and on the dynamics of social media.
- Maria Laura Delle Monache visited Rutgers University – Camden in March and in November 2019 to work with Prof. Piccoli in the framework of the Rutgers collaborative grant.
- Maria Laura Delle Monache visited Vanderbilt University in November 2019 in the framework of the of the associated team MEMENTO.
- Stephane Mollier visited Temple University in January 2019 to discuss with Prof. Seibold concerning 2D traffic models.

- A. Kibangou visited the University of Johannesburg (South Africa) in March and November 2019. During his stay, he gave a lecture to students of Department of Town and Regional Planning of Univ. of Johannesburg on Mobility and traffic management. He also attended the first French-South African Science and Innovation days (December 2-3, 2019).

POEMS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- ANR project NonlocalDD *(Non-local domain decomposition methods in electromagnetics)*
  Partners: Inria Alpines, Inria POEMS, Inria Magique 3D
  Start: 10/2015. End: 09/2020. Administrator: Inria
  Participants of POEMS: S. Chaillat, P. Joly
  Coordinator: X. Claeys (LJLL, EPI ALPINES)
- ANR project MODULATE *(Modeling lOng-perioD groUnd motions, and assessment of their effects on Large-scale infrAsTructurEs)*
  Partners: ENSTA (UME), Inria POEMS, CentraleSupelec, BRGM, GDS
  Start: 11/2018. End: 10/2021. Administrator: ENSTA
  Participant of POEMS: S. Chaillat
  Coordinator: K. Meza Fajardo (BRGM)

8.1.2. DGA

- Contracts between DGA and POEMS:
  - Contract on *boundary element methods and high-frequency problems*
    Participants: E. Lunéville, M. Lenoir, N. Kielbasiewicz.
    Start: 10/2018. End: 09/2021. Administrator: ENSTA
    In partnership with F. Alouges and M. Aussal (CMAP, Ecole Polytechnique).
- DGA provides partial funding for several PhD students:
  - C. Bénéteau on the *asymptotic analysis of time harmonic Maxwell equations in presence of metamaterials* (Start: 10/2017)
  - D. Chicaud on *domain decomposition methods for time-harmonic electromagnetic wave problems with complex media* (Start: 10/2018)

8.2. International Initiatives

8.2.1. Inria International Partners

8.2.1.1. Informal International Partners

Juan Pablo Borthagaray (Universidad de la República, Uruguay)

Shravan Veerapaneni (Univ. of Michigan at Ann Arbor, USA)

Bojan Guzina (University of Minnesota, USA)

Jean-François Molinari (EPFL, Lausanne, Switzerland)

Fioralba Cakoni (University of Rutgers, USA)

Wilkins Aquino (Duke University, USA)

Bojan Guzina (University of Minnesota, USA)

Jorge Albella (University of Santiago de Compostela, Spain)

Carlos Perez Arancibia (Pontificia Universidad Católica, Chile)

Camille Carvalho (UC Merced, Merced, USA)

Simon Chandler Wilde (University of Reading, UK)

Mahadevan Ganesh (Colorado School of Mines, USA)
Christophe Geuzaine (Université de Liège, Belgium)
Marcus Grote (Universitaet Basel, Switzerland)
Moez Khenissi (Univesité de Sousse, Tunisia)
Sergei Nazarov (Saint-Petersburg University, Russia)
Karl-Mikael Perfekt (University of Reading, UK)
Jerónimo Rodríguez (University of Santiago de Compostela, Spain)
Ruben Rosales (MIT, USA)
Adrien Semin (TU Darmstadt, Germany)
Knut Sølna (University of California, Irvine, USA)
Catalin C. Turc (NJIT, NJ, USA)
Jun Zou (Chinese University of Hong Kong, HK)

8.3. International Research Visitors

8.3.1. Visits of International Scientists

- Mahadevan Ganesh (Colorado School of Mines, USA) — March 2019
- Carlos Jerez-Hanckes (Universidad Adolfo Ibanez, Chile) — Septembre 2019
- Shravan Veerapaneni (Univ. of Michigan at Ann Arbor, USA) — November 2019

QUANTIC Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

- **Paris EMERGENCE project ENDURANCE**: In the framework of the Paris Ile de France program “EMERGENCE”, Zaki Leghtas has received a funding for his research program "Multi-photon processes in superconducting circuits for quantum error correction". This grant of 230k euros has allowed us to purchase the experimental equipment to complement the experiment based at ENS.
- **DIM SIRTEQ PhD fellowship**: We have received funding from DIM SIRTEQ to cover half of the PhD of Jérémie Guillaud under supervision of Mazyar Mirrahimi.
- **DIM SIRTEQ project SCOOP**:Half a PhD grant for Marius Villiers, supervised by Zaki Leghtas and Audrey Cottet (ENS Paris). The project is to use quantum circuits to detect the entanglement of a single Cooper pair. University.
- **EDPIF PhD fellowship**: Ecole Doctorale de Physique en Ile de France has funded half a PhD grant for Marius Villiers.
- **DGA PhD fellowship**: Direction Générale de l’Armement has funded half a PhD grant for Camille Berdou supervised by Zaki Leghtas. The project is to build a repetition code of cat-qubits.
- **Mines Paristech PhD Fellowship**: Ecole des Mines Paristech has funded half a PhD grant for Camille Berdou.
- **PSL working group on “structural stability and chaos in open quantum systems”**: This is a Groupe de Travail with researchers from CEREMADE (Paris Dauphine) and Observatoire de Paris under the direction of Jacques Fejoz. In the framework of the PhD thesis of Michiel Burgelman, we study the dynamics of superconducting Josephson circuits driven by strong microwave drives.

7.2. National Initiatives

- **ANR project ENDURANCE**: In the framework of the ANR program “Accueil de chercheur de haut niveau”, Zaki Leghtas has received a funding for his research program "Multi-photon processes in superconducting circuits for quantum error correction". This grant of 400k euros has allowed us to purchase the experimental equipment to build a new experiment based at ENS. The project started in March 2016 for 42 months.
- **ANR project HAMROQS**: In the framework of the ANR program JCJC, Alain Sarlette has received a funding for his research program "High-accuracy model reduction for open quantum systems". This grant of 212k euros started on april 2019 and will run for 4 years.

7.3. European Initiatives

7.3.1. FP7 & H2020 Projects

Program: H2020

Type: ERC

Project acronym: ECLIPSE

Project title: Exotic superconducting CIrcuits to Probe and protect quantum States of light and mattEr

Duration: 2019-

Coordinator: Zaki Leghtas, Mines Paristech

Program: H2020

Type: Quantera

Project acronym: QuCos

Project title: Quantum Computation with Schrödinger cat states

Duration: 2019-

Coordinator: Gerhard Kirchmair, University of Innsbruck, Austria.

Inria contacts: Zaki Leghtas and Mazyar Mirrahimi

Other partners: ENS Lyon (France), Karlsruhe Institut of Technology (Germany), Quantum Machines (Israel), National Institute for Research and Development of Isotopic and Molecular Technologies, Romania.

Abstract: This project seeks to establish a radically new, alternative approach to realizing the fundamental building blocks of quantum computers with superconducting qubits. In the next 3 years, we plan to employ only a handful of realistic components to realize robust error-corrected logical quantum bits. We aim to demonstrate the same level of protection provided by a few hundreds of qubits (with properties beyond the state of the art) in today's mainstream approach of the so-called surface code architecture. Our alternative approach is known as cat codes, because it employs multiple interconnected high coherence cavity modes with non-linear dissipation, to encode a qubit in superpositions of Schrödinger cat states. Our project combines realizing the quantum processor architecture as well as the control system and the protocols that drive it, building towards a full-stack error-corrected quantum computer. The partners in our collaboration form a strong synergetic group that has the full range of expertise needed to design and realize these systems, and to obtain these challenging goals. Furthermore, all partners of our project, including both industry and academia, have worked together and published works in the fields of quantum computing and quantum information processing. We aim to implement error protected qubits, fault tolerant operations, and demonstrate the scalability of this approach by realizing a repetition code. Our project will enable quantum experiments towards the ambitious and well-defined goal of constructing a logical qubit, on which we can perform gates, and most importantly, quantum error-correction (QEC).

7.3.2. Collaborations with Major European Organizations

Partner 1: ENS Lyon

We are pursuing our interdisciplinary work about quantum control from theoretical aspects in direct collaboration with existing experiments (ENS Lyon) with the group of Benjamin Huard, former member of the QUANTIC team. Joint papers are published and underway. The ANR-JCJC project HAMROQS by Alain Sarlette has Benjamin Huard as external supporting collaborator.

Partner 2: Laboratoire Kastler Brossel

We have been continuing collaborations with the teams of Samuel Deleglise and Igor Dotsenko from Laboratoire Kastler Brossel on the theoretical analysis of their experiments.

Partner 3: Ghent University.

Alain Sarlette has been collaborating with applied mathematicians interested in quantum control at UGent in the framework of thesis co-supervisions. One PhD student has successfully defended his thesis this year (Zhifei Zhang).

7.4. International Initiatives

7.4.1. Inria International Labs

Inria@EastCoast
Associate Team involved in the International Lab:

7.4.1.1. TAQUILLA

Title: TAilored QUantum Information protocoLs for quAntum superconducting circuits

International Partner (Institution - Laboratory - Researcher):

Université Yale (United States) -Department of Applied Physics - Michel Devoret

Start year: 2019

See also: https://team.inria.fr/quantic/Taquilla.html

We seek to establish an alternative approach to quantum error correction (QEC) for superconducting qubits. This approach, developed through the Inria-Yale collaboration, is known under the name of cat codes, because it employs multiple interconnected high coherence cavity modes with non-linear dissipation to encode a qubit in superpositions of Schrödinger cat states. We aim to implement error protected qubits, fault tolerant operations, and demonstrate the scalability of this approach. Our project will enable quantum experiments towards the ambitious and well-defined goal of constructing a logical qubit, on which we can perform gates, and most importantly, QEC.

7.4.2. Participation in Other International Programs

- **Yale-ARO subaward:** In the framework of the collaborations with Yale university, Quantic team has received a sub-award of 500k dollars over 4 years starting in 2018 from Yale university. This sub-award is part of an ARO (Army Research Office) grant received by our collaborators at Yale and covers the expenses related to our collaborations (hiring of new PhD students and postdocs at Inria and travels between Inria and Yale).
- **DARPA:** Alain Sarlette is international key personnel on the DARPA project "The Quantum Computing Revolution and Optimization: Challenges and Opportunities" led by optimization researchers at Lehigh Universty. This project of about 2M dollars can fund some exchanges during the coming years.
- **Berkeley exchange initiative:** P. Rouchon and A. Sarlette have set up an exchange initiative with Birgitta Whaley about quantum control and error correction based on continuous measurements. This initiative has funded a research visit of Gerardo Cardona at Berkeley; a student from Berkeley is bound to visit us soon in return.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

P.S. Pereira da Silva (Escola Politecnica, PTC, University of Sao Paulo, Brazil) made two visits (September 16 to 27 and December 2 to 6) to investigate with Pierre Rouchon motion planning issues based on Lyapunov tracking for quantum gate generations for open quantum systems governed by Lindblad master equations.

7.5.2. Visits to International Teams

7.5.2.1. Research Stays Abroad

- In the framework of our collaborations with Yale (Taquilla associated team), Mazyar Mirrahimi and Michiel Burgelman have spent 3 months at Yale. In the same framework Philippe Campagne-Ibarcq and Christian Siegele also made a visit of 5 days during the same period.
- In the framework of the Berkeley exchange initiative, Gerardo Cardona has spent a month (October 2019) in the research group of Birgitta Whaley at Berkeley University.

RANDOPT Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- PGMO/FMJH project “AESOP: Algorithms for Expensive Simulation-Based Optimization”, 7kEUR, 2017–2019

9.2. National Initiatives

9.2.1. ANR

- ANR project “Big Multiobjective Optimization (BigMO)”, Dimo Brockhoff participates in this project through the Inria team BONUS in Lille (2017–2020)

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

- Youhei Akimoto, Tsukuba University, Japan
- Tobias Glasmachers, Ruhr University, Bochum, Germany
- Tea Tušar, Jozef Stefan Institute, Ljubljana, Slovenia

9.4. International Research Visitors

9.4.1. Visits to International Teams

9.4.1.1. Research Stays Abroad

Anne Auger and Dimo Brockhoff visited Tea Tušar (Jozef Stefan Institute, Slovenia) for two weeks in April 2019

RAPSODI Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. ERC Generator

T. Rey has been awarded an ERC Generator grant (116 545 euros) from I-SITE Université Lille - Nord Europe for his project MANAKINEQO (R-ERCGEN-19-007-REY). In the next two years, T. Rey aims at investigating mathematical properties, as well as developing efficient numerical schemes, for multiscale collisional kinetic equations of the Boltzmann type. A 20-months post-doc will be funded using this grant, as well as an international conference. Following this ERC Generator grant, T. Rey will apply for an ERC Consolidator grant.

9.1.2. Actions of Technological Development (ADT)

S. Lemaire is the PI of the ADT project ParaSkel++, which is one of the funded ADT of the Inria Lille - Nord Europe 2019 campaign. The aim of the project is to develop an optimized C++ platform for the arbitrary-order numerical approximation of PDEs by skeletal methods on general 2D/3D meshes, with a particular emphasis on the implementation of HPC facilities. L. Beaude has been hired as a development engineer for this project. She will start in February 2020.

In the same vein, T. Rey is part of the ADT project SIMPAPH led by the MEPHYSTO-POST team, that has as well been funded as a result of the Inria Lille - Nord Europe 2019 campaign. The aim is to develop robust numerical methods to solve large systems of stochastic differential equations describing (among others) particles in an optic fiber, schools of fish, or microscopic particles. The expected code will attempt to solve these multiscale problems using different approaches, and to be versatile enough to act as an industrial benchmark. A. Roget has been hired as a development engineer for this project.

9.2. National Initiatives

9.2.1. ANR

C. Chainais-Hillairet has been a member of the ANR MOONRISE project. The MOONRISE project aimed at exploring modeling, mathematical, and numerical issues originating from the presence of high oscillations in nonlinear PDEs mainly from the physics of nanotechnologies and from the physics of plasmas.

Title: MOdels, Oscillations, and NumeRIcal SchEmes

Type: Fondements du numérique (DS0705) - 2014

ANR reference: ANR-14-CE23-0007

Coordinator: F. Méhats (Université de Rennes 1)

Duration: October 2014 - June 2019

C. Chainais-Hillairet and T. Rey are members of the ANR MOHYCON project. The MOHYCON project is related to the analysis and simulation of multiscale models of semiconductors. As almost all current electronic technology involves the use of semiconductors, there is a strong interest for modeling and simulating the behavior of such devices, which was recently reinforced by the development of organic semiconductors used for example in solar panels or in mobile phones and television screens (among others).

Title: Multiscale MOdels and HYbrid numerical methods for semiCONductors

Type: Société de l’information et de la communication (DS07) - 2017

ANR reference: ANR-17-CE40-0027

Coordinator: M. Bessemoulin-Chatard (CNRS and Université de Nantes)

Duration: January 2018 - December 2020

C. Cancès is a member of the ANR COMODO project. The COMODO project focuses on the mathematical and numerical study of cross-diffusion systems in moving domains. The targeted application is the simulation of the building of solar plants by the vapour deposition process.

Title: CrOss-diffusion equations in MOving DOmains

Type: Modèles numériques, simulation, applications (CE46) - 2019

ANR reference: ANR-19-CE46-0002

Coordinator: V. Ehrlacher (École des Ponts ParisTech and Inria Paris)

Duration: January 2020 - December 2023

M. Herda is a member of the ANR JCJC MICMOV project. The MICMOV project aims at gathering PDE analysts, probability theorists, and theoretical physicists to work on the derivation of macroscopic properties of physical systems from their microscopic description. The rigorous microscopic description of moving interfaces, the understanding of macroscopic nonlocal effects, and the mathematical apprehension of the underlying atomic mechanisms, are particularly important matters of this project.

Title: MICroscopic description of MOVing interfaces

Type: Mathématiques (CE40) - 2019

Coordinator: M. Simon (Inria Lille - Nord Europe)

9.2.2. LabEx CEMPI

Title: Centre Européen pour les Mathématiques, la Physique et leurs Interactions

Coordinator: S. De Bièvre (LPP, Université de Lille)

Duration: January 2012 - December 2019, extended in 2019

Partners: Laboratoire Paul Painlevé (LPP) and Laser Physics department (PhLAM), Université de Lille

The “Laboratoire d’Excellence” Centre Européen pour les Mathématiques, la Physique et leurs Interactions (CEMPI), a project of the Laboratoire de mathématiques Paul Painlevé (LPP) and the laboratoire de Physique des Lasers, Atomes et Molécules (PhLAM), was created in the context of the “Programme d’Investissements d’Avenir” in February 2012.

The association Painlevé-PhLAM creates in Lille a research unit for fundamental and applied research and for training and technological development that covers a wide spectrum of knowledge stretching from pure and applied mathematics to experimental and applied physics.

One of the three focus areas of CEMPI research is the interface between mathematics and physics. This focus area encompasses three themes. The first is concerned with key problems of a mathematical, physical and technological nature coming from the study of complex behavior in cold atoms physics and nonlinear optics, in particular fiber optics. The two other themes deal with fields of mathematics such as algebraic geometry, modular forms, operator algebras, harmonic analysis and quantum groups that have promising interactions with several branches of theoretical physics.

9.2.3. PEPS

T. Rey has been the laureate in 2019 of a Young Researcher PEPS grant from CNRS’s INSMI (3 500 euros, from March to November 2019). The granted project aimed at investigating high-order (in time and velocity) numerical methods for approximating the solutions to the granular gases equation.

9.3. European Initiatives

C. Cancès, C. Chainais-Hillairet and B. Merlet are involved in the H2020 project EURAD (EUropean Joint Programme on RADioactive Waste Management). The aim of their project inside EURAD is to establish an energetic formulation of the Diffusion Poisson Coupled Model leading to new large-time robust numerical methods for the simulation of the corrosion processes in an underground repository.

C. Cancès is the leader of the task “Numerical methods for high-performance computing of coupled processes” within the `EURAD` project.

9.4. International Initiatives

C. Cancès is a member of the Indo-French Center for Applied Mathematics (IFCAM) project “Conservation laws: BV^s, control, interfaces” (PIs: S. Ghoshal, TIFR Centre For Applicable Mathematics, India and S. Junca, Université de Nice).

9.5. International Research Visitors

9.5.1. Visits of International Scientists

In January-February, E. Daus (TU Vienna, Austria) visited C. Cancès and C. Chainais-Hillairet during two weeks.

In 2019, RAPSODI members also invited several researchers for short visits (a week or less) in Lille.

- R. Bailo (Imperial College London, UK) came in November to work with T. Rey (funded by his Young Researcher PEPS grant).
- R. V. Sabariego (KU Leuven, Electrical Engineering ESAT/Electa, EnergyVille, Belgium) came in May to work with E. Creusé.
- E. Bretin and S. Masnou (Institut Camille Jordan, Lyon) and M. Goldman (CNRS and LJLL/Université Paris Diderot) came in June and December to work with B. Merlet.
- A. Trescases (CNRS and Institut de Mathématiques de Toulouse) came in September to work with M. Herda.
- C. Bataillon (CEA), V. Ehrlacher (École des Ponts ParisTech and Inria Paris) and C. Perrin (CNRS and Université d’Aix-Marseille) came to work with C. Cancès.
- M. Cassier (CNRS and Institut Fresnel, Marseille) came in February-March to work with S. Lemaire.

On a slightly different note, from March to October, G. Robillard has been an AIRLab resident (Artiste en Immersion Recherche dans un Laboratoire) in order to work with C. Calgaro and E. Creusé (with a support from the Communauté d’Universités et d’Établissements Lille Nord-de-France).

9.5.2. Visits to International Teams

B. Gaudeul spent two weeks in WIAS Berlin, Germany in November in order to work with J. Fuhrmann on the extension of the results obtained in [48] to Nernst–Planck–Poisson systems with ion size and solvation effects.

M. Herda spent one week at Imperial College London, UK in February to work with P. Degond on a Fokker–Planck approach to the study of robustness in gene expression.

T. Rey visited 3 times J. A. Carrillo and J. Hu at Imperial College London, UK between February and March, for 3 days long stays funded by his Young Researcher PEPS grant, to work (in particular) on the development of a new high-order numerical method for solving the granular gases equation.

C. Cancès and B. Merlet spent one week at the University of Lisbon, Portugal in December to work with L. Monsaingeon.

C. Cancès spent one week at Université de Tours to work with B. Andreianov.

B. Merlet visited E. Bretin and S. Masnou at Institut Camille Jordan in Lyon in February, and visited several times M. Goldman at LJLL/Université Paris Diderot in March, May, October, and November.

F. Chave and S. Lemaire spent 3 days at Université de Montpellier in September to work with D. A. Di Pietro on arbitrary-order polytopal methods for electromagnetism.

9.5.3. Research Stays Abroad

M. Herda was in residence at the Hausdorff Research Institute for Mathematics (University of Bonn, Germany) from May 19 to July 7 in the framework of the Junior Trimester Program in Kinetic Theory, that gave young mathematicians the opportunity to carry out collaborative research in kinetic theory. M. Herda was part of a project in collaboration with N. Ayi (Sorbonne Université), M. Breden (École Polytechnique), J. Guerand (University of Cambridge, UK), H. Hivert (Centrale Lyon), and I. Tristani (ENS Paris) on the study of a fractional kinetic Fokker–Planck equation. This collaboration has already led to the article [44], and a second article is in preparation. A collaboration was also initiated with M. Breden and A. Trescases (CNRS and Institut de Mathématiques de Toulouse) on the derivation of cross-diffusion systems from kinetic models.

REALOPT Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- **SysNum Cluster** SysNum is a Cluster of Excellence of Bordeaux Idex that aims at bringing Bordeaux academic players in the digital sciences closer to each other around large-scale distributed digital systems. The cluster is organized around 4 methodological axes (Interconnected object systems; Reliability and safety; Modeling and numerical systems; Massive and heterogeneous data) and 3 application platforms around major societal issues (ecology, mobile systems, interconnected objects and data analysis).

  François Clautiaux is leading the methodological WP on Interconnected object systems. Understanding and controlling the complexity of systems of interconnected objects is a major challenge for both industrial and everyday life applications. We think, in particular, to fields like robotics, car industry, energy distribution or smart buildings, where it is essential to tackle autonomous heterogeneous objects and to develop robust control tools to optimize their interconnections. Our research in this direction will be developed within three interconnected tasks.

9.2. International Initiatives

9.2.1. Inria International Partners

9.2.1.1. Informal International Partners

Orlando Rivera Letelier is pursuing a co-tutelle thesis (with Universidad Adolfo Ibáñez, Peñalolén, Santiago, Chile)

We continue close collaboration with the LOGIS laboratory (Universidade Federal Fluminense, Niteroi, Brazil) after the end of the Inria Associate Team SAMBA.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

Eduardo Uchoa visited the team in April 2019 for one week.

Emir Démirovic (University of Melbourne, Australia) visited the team in July for one week

Isaac Cleland (University of Auckland, New-Zealand) visited the team in July for one week

9.3.2. Visits to International Teams

9.3.2.1. Research Stays Abroad

Guillaume Marques spent 3 months in Universidade Federal Fluminense, Niteroi, Brazil (August-November 2019), financed by mobility grant of IdEx Bordeaux

SEQUEL Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. With U. INSERM 1190, CHU Lille

Participants: Odalric-Ambrym Maillard, Philippe Preux, Philippe Preux.

Title: Bandits for Health (B4H)

Type: I-SITE Lille

Coordinator: Philippe Preux

Duration: 2019–2023

Abstract: B4H is a fundamental research project on a certain type of bandit algorithms, tailored to be applied to post-surgical patient follow-up. Bandit in a non-stationary environment will be studied. This work is performed in collaboration with Pr. F. Pattou and his group.

Title: No title

Type: Informal

Coordinator: Philippe Preux

Duration: 2019–2020

Abstract: This is mostly a data analysis work in order to study whether a certain disease may be predicted based on a certain dataset collected by U. INSERM 1190. Estelle Chatelain, a BiLille engineer, is involved in this project. This work is performed in collaboration with Pr. F. Pattou and his group.

9.1.2. With Service de Radiologie et Imagerie Musculosquelettique, CHU Lille

Participants: Philippe Preux, Franck Valentini.

Title: Radiology AI Demonstrator (RAID)

Type: CPER, Région Hauts-de-France

Coordinator: Philippe Preux

Duration: 2019–2020

Abstract: The goal of the RAID project is to assess the potential of deep learning for radio analysis and patient triage. Various applications are investigated.

9.2. National Initiatives

9.2.1. ANR BOLD

Participants: Émilie Kaufmann, Michal Valko, Pierre Ménard, Xuedong Shang, Omar Darwiche Domingues.

Title: Beyond Online Learning for better Decision making

Type: National Research Agency

Coordinator: Vianney Perchet (ENS Paris-Saclay / ENSAE)

Duration: 2019–2023

Abstract: Reactive machine learning algorithms adapt to data generating processes, typically do not require large computational power and, moreover, can be translated into offline (as opposed to online) algorithms if needed. Introduced in the 30s in the context of clinical trials, online ML algorithms have been gaining a lot of theoretical interest for the last 15 years because of their applications to the optimization of recommender systems, click through rates, planning in congested networks, to name just a few. However, in practice, such algorithms are not used as much as they should, because the traditional low-level modelling assumptions they are based upon are not appropriate, as it appears.

Instead of trying to complicate and generalise arbitrarily a framework unfit for potential applications, we will tackle this problem from another perspective. We will seek a better understanding of the simple original problem and extend it in the appropriate directions. There are currently three main barriers to a broader development of online learning, that this project aim at overcoming. 1) The classical "one step, one decision, one reward" paradigm is unfit. 2) Optimality is defined with respect to worst-case generic lower bounds and mechanics behind online learning are not fully understood. 3) Algorithms were designed in a non strategic or interactive environment.

The project gathers four parnters: ENS Paris-Saclay, University of Toulouse, Inria Lille and Université Paris Descartes.

9.2.2. ANR BoB

Participant: Michal Valko.

Title: Bayesian statistics for expensive models and tall data

Type: National Research Agency

Coordinator: CNRS (Rémi Bardenet)

Duration: 2016–2020

Abstract: Bayesian methods are a popular class of statistical algorithms for updating scientific beliefs. They turn data into decisions and models, taking into account uncertainty about models and their parameters. This makes Bayesian methods popular among applied scientists such as biologists, physicists, or engineers. However, at the heart of Bayesian analysis lie 1) repeated sweeps over the full dataset considered, and 2) repeated evaluations of the model that describes the observed physical process. The current trends to large-scale data collection and complex models thus raises two main issues. Experiments, observations, and numerical simulations in many areas of science nowadays generate terabytes of data, as does the LHC in particle physics for instance. Simultaneously, knowledge creation is becoming more and more data-driven, which requires new paradigms addressing how data are captured, processed, discovered, exchanged, distributed, and analyzed. For statistical algorithms to scale up, reaching a given performance must require as few iterations and as little access to data as possible. It is not only experimental measurements that are growing at a rapid pace. Cell biologists tend to have scarce data but large-scale models of tens of nonlinear differential equations to describe complex dynamics. In such settings, evaluating the model once requires numerically solving a large system of differential equations, which may take minutes for some tens of differential equations on today's hardware. Iterative statistical processing that requires a million sequential runs of the model is thus out of the question. In this project, we tackle the fundamental cost-accuracy trade-off for Bayesian methods, in order to produce generic inference algorithms that scale favorably with the number of measurements in an experiment and the number of runs of a statistical model. We propose a collection of objectives with different risk-reward trade-offs to tackle these two goals. In particular, for experiments with large numbers of measurements, we further develop existing subsampling-based Monte Carlo methods, while developing a novel decision theory framework that includes data constraints. For expensive models, we build an ambitious programme around Monte Carlo methods that leverage determinantal processes, a rich class of probabilistic tools that lead to accurate inference with limited model evaluations. In short, using innovative techniques such as subsampling-based Monte Carlo and determinantal point processes, we propose in this project to push the boundaries of the applicability of Bayesian inference.

9.2.3. ANR Badass

Participants: Odalric-Ambrym Maillard, Émilie Kaufmann.

Title: BAnDits for non-Stationarity and Structure

Type: National Research Agency

Coordinator: Inria Lille (O. Maillard)

Duration: 2016–2020

Abstract: Motivated by the fact that a number of modern applications of sequential decision making require developing strategies that are especially robust to change in the stationarity of the signal, and in order to anticipate and impact the next generation of applications of the field, the BADASS project intends to push theory and application of MAB to the next level by incorporating non-stationary observations while retaining near optimality against the best not necessarily constant decision strategy. Since a non-stationary process typically decomposes into chunks associated with some possibly hidden variables (states), each corresponding to a stationary process, handling non-stationarity crucially requires exploiting the (possibly hidden) structure of the decision problem. For the same reason, a MAB for which arms can be arbitrary non-stationary processes is powerful enough to capture MDPs and even partially observable MDPs as special cases, and it is thus important to jointly address the issue of non-stationarity together with that of structure. In order to advance these two nested challenges from a solid theoretical standpoint, we intend to focus on the following objectives: *(i)* To broaden the range of optimal strategies for stationary MABs: current strategies are only known to be provably optimal in a limited range of scenarios for which the class of distribution (structure) is perfectly known; also, recent heuristics possibly adaptive to the class need to be further analyzed. *(ii)* To strengthen the literature on pure sequential prediction (focusing on a single arm) for non-stationary signals via the construction of adaptive confidence sets and a novel measure of complexity: traditional approaches consider a worst-case scenario and are thus overly conservative and non-adaptive to simpler signals. *(iii)* To embed the low-rank matrix completion and spectral methods in the context of reinforcement learning, and further study models of structured environments: promising heuristics in the context of e.g. contextual MABs or Predictive State Representations require stronger theoretical guarantees.

This project will result in the development of a novel generation of strategies to handle non-stationarity and structure that will be evaluated in a number of test beds and validated by a rigorous theoretical analysis. Beyond the significant advancement of the state of the art in MAB and RL theory and the mathematical value of the program, this JCJC BADASS is expected to strategically impact societal and industrial applications, ranging from personalized health-care and e-learning to computational sustainability or rain-adaptive river-bank management to cite a few.

9.2.4. Grant of Fondation Mathématique Jacques Hadamard

Participants: Michal Valko, Ronan Fruit.

Title: Theoretically grounded efficient algorithms for high-dimensional and continuous reinforcement learning

Type: PGMO-IRMO, funded by Criteo

PI: Michal Valko

Criteo contact: Marc Abeille

Duration: 2018–2020

Abstract: While learning how to behave optimally in an unknown environment, a reinforcement learning (RL) agent must trade off the exploration needed to collect new information about the dynamics and reward of the environment, and the exploitation of the experience gathered so far to gain as much reward as possible. A good measure of the agent's performance is the regret, which measures the difference between the performance of optimal policy and the actual rewards accumulated by the agent. Two common approaches to the exploration-exploitation dilemma with provably good regret guarantees are the optimism in the face of uncertainty principle and Thompson Sampling. While these approaches have been successfully applied to small environments with a finite number of states and action (tabular scenario), existing approach for large or continuous environments either rely on heuristics and come with no regret guarantees, or can be proved to achieve small regret but cannot be implemented efficiently. In this project, we propose to make a significant contribution in the understanding of large and/or continuous RL problems by developing and analyzing new algorithms that perform well both in theory and practice.

This research line can have a practical impact in all the applications requiring continuous interaction with an unknown environment. Recommendation systems belong to this category and, by definition, they can be modeled has a sequence of repeated interaction between a learning agent and a large (possibly continuous) environment.

9.2.5. With CIRAD and CGIAR

Participants: Philippe Preux, Odalric-Ambrym Maillard, Romain Gautron.

Title: Crop management

Duration: 2019–2022

Abstract: We study how reinforcement learning may be used to provide recommendations of practices to small farm holders in under-developped countries. In such countries, agriculture remains mostly a non mechanized activity, dealing with fields of very small surface.

This is a very challenging application for RL: data is scarce, recommendations made to farmers should be of quality: we can not just learn by making millions of bad recommendations to people who use them to live and feed their family. Modeling the problem as an RL is yet an other challenge.

We feel that it is very interesting to challenge RL with such complex tasks. Solving games with RL is nice and fun, but we should assess RL abilities to solve real risky tasks.

This pioneering work is done within Romain Gautron's PhD, in collaboration with CIRAD, the CGIAR, and in relation with the Africa Rising program.

9.2.6. Project CNRS-INSERM REPOS

Participants: Émilie Kaufmann, Clémence Réda [INSERM].

Title: Repositionnement de médicaments basé sur leurs effets transcriptionnels par des approches de réseaux géniques

Type: Appel à projet Santé Numérique

PI: Pr. Andrée Delahaye-Duriez (INSERM, UMR1141)

Duration: 2019

Abstract: Drug repurposing consists in studying molecules already commercialized and find other therapies in which they may be efficient. The quality of therapeutic components is often assessed by their affinity to a given protein, but it can also be assessed in terms of their impact at the transciptomic level. The aim of this project is to develop a method for selecting which drugs could be used for a given disease based on their ability to inverse the transcriptomic signature of a pathological phenotype. We will propose a new method based on algorithms for sequential decision making (bandit algorithms) to adaptively select which drug should be explored, where exploring a drug means performing simulations to propagate the perturbation (using for example gene regulatory networks) and estimate the transcriptomic impact of the perturbation induced by the drug. These simulations will hinge on existing gene expression data that are already available for many drugs, but also on new transcriptomic data generated for a mouse model of a rare disease called the Ondine syndrom.

9.2.7. National Partners

- ENS Paris-Saclay
  - M. Valko collaborated with V. Perchet on structured bandit problem. They co-supervise a PhD student (P. Perrault) together
  - O-A. Maillard collaborates with V. Perchet on automated feature learning. They co-supervise a PhD student (R. Ouhamma) together
  - E. Kaufmann collaborated with V. Perchet and E. Boursier on Multi-Player bandits
- Institut de Mathématiques de Toulouse, then Ecole Normale Supérieure de Lyon

  - E. Kaufmann collaborated with Aurélien Garivier on sequential testing and structured bandit problems
- Centrale-Supélec Rennes:
  - E. Kaufmann co-advises Lilian Besson, who works at CentraleSupélec with Christophe Moy on MAB for cognitive radio and Internet-of-Things communications
- Participation to the Inria Project Lab (IPL) "HPC – Big Data": Started in 2018, this IPL gathers a dozen Inria team-projects, mixing researchers in HPC with researchers in machine learning and data science. SEQUEL contribution in this project is about how we can take advantage of HPC for our computational needs regarding deep learning and deep reinforcement learning, and also how such learning algorithms might be redesigned or re-implemented in order to take advantage of HPC architectures.
- Participation to the Inria Project Lab (IPL) "HYAIAI": Started in 2019, this IPL gathers Magnet and SEQUEL in Lille, Tau in Saclay, Lacodam in Rennes, Orpailleur and Multispeech in Nancy. The goal of this IPL is to study machine learning combining symbolic and numeric approaches, to obtain interpretable AI systems.
- PCIM (École Polytechnique)
  - Ph. Preux collaborates with Tanguy Levent (PhD student) on the control of smartgrids with reinforcement learning
- Defrost (Inria Lille)
  - Ph. Preux collaborates with Pierre Schegg (PhD student) on the control of soft robots with reinforcement learning

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

9.3.1.1. DELTA

Participants: Michal Valko, Émilie Kaufmann, Omar Darwiche Domingues, Pierre Ménard.

Program: CHIST-ERA

Project acronym: DELTA

Project title: Dynamically Evolving Long-Term Autonomy

Duration: October 2017 - December 2021

Coordinator: Anders Jonsson (PI)

Inria Coordinator: Michal Valko

Other partners: UPF Spain, MUL Austria, ULG Belgium

Abstract: Many complex autonomous systems (e.g., electrical distribution networks) repeatedly select actions with the aim of achieving a given objective. Reinforcement learning (RL) offers a powerful framework for acquiring adaptive behaviour in this setting, associating a scalar reward with each action and learning from experience which action to select to maximise long-term reward. Although RL has produced impressive results recently (e.g., achieving human-level play in Atari games and beating the human world champion in the board game Go), most existing solutions only work under strong assumptions: the environment model is stationary, the objective is fixed, and trials end once the objective is met. The aim of this project is to advance the state of the art of fundamental research in lifelong RL by developing several novel RL algorithms that relax the above assumptions. The new algorithms should be robust to environmental changes, both in terms of the observations that the system can make and the actions that the system can perform. Moreover, the algorithms should be able to operate over long periods of time while achieving different objectives. The proposed algorithms will address three key problems related to lifelong RL: planning, exploration, and task decomposition. Planning is the problem of computing an action selection strategy given a (possibly partial) model of the task at hand. Exploration is the problem of selecting actions with the aim of mapping out the environment rather than achieving a particular objective. Task decomposition is the problem of defining different objectives and assigning a separate action selection strategy to each. The algorithms will be evaluated in two realistic scenarios: active network management for electrical distribution networks, and microgrid management. A test protocol will be developed to evaluate each individual algorithm, as well as their combinations.

9.4. International Initiatives

9.4.1. Inria International Partners

- É. Kaufmann visited CWI, Amsterdam for one week in February, working with Wouter Koolen, Rémy Degenne and Rianne De Heide. Pierre Ménard also collaborated with them.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Anders Jonsson, Pompeu Fabra University, Spain ,sabbatical year Sep 2019 – Jul 2020
- Kaige Yang, University College London, UK, Oct 9 & Jan 9 2020
- Rianne de Heide, CWI, The Netherlands, April 23 – August 3, 2019
- Chuan-Zheng Lee, Stanford University, USA, June – October 2019
- Arun Verma, IIT Bombay, June 1 – November 30, 2019

9.5.1.1. Internships

- Alessio Della Libera, from Jul 2019 until Sep 2019

  TD-Gammon, and his github with the gym-backgammon code

SIERRA Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

Alexandre d'Aspremont: IRIS, PSL "Science des données, données de la science".

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

ERC Sequoia Title: Robust algorithms for learning from modern data

Programm: H2020

Type: ERC

Duration: 2017-2022

Coordinator: Inria

Inria contact: Francis Bach

Abstract: Machine learning is needed and used everywhere, from science to industry, with a growing impact on many disciplines. While first successes were due at least in part to simple supervised learning algorithms used primarily as black boxes on medium-scale problems, modern data pose new challenges. Scalability is an important issue of course: with large amounts of data, many current problems far exceed the capabilities of existing algorithms despite sophisticated computing architectures. But beyond this, the core classical model of supervised machine learning, with the usual assumptions of independent and identically distributed data, or well-defined features, outputs and loss functions, has reached its theoretical and practical limits. Given this new setting, existing optimization-based algorithms are not adapted. The main objective of this project is to push the frontiers of supervised machine learning, in terms of (a) scalability to data with massive numbers of observations, features, and tasks, (b) adaptability to modern computing environments, in particular for parallel and distributed processing, (c) provable adaptivity and robustness to problem and hardware specifications, and (d) robustness to non-convexities inherent in machine learning problems. To achieve the expected breakthroughs, we will design a novel generation of learning algorithms amenable to a tight convergence analysis with realistic assumptions and efficient implementations. They will help transition machine learning algorithms towards the same wide-spread robust use as numerical linear algebra libraries. Outcomes of the research described in this proposal will include algorithms that come with strong convergence guarantees and are well-tested on real-life benchmarks coming from computer vision, bioinformatics, audio processing and natural language processing. For both distributed and non-distributed settings, we will release open-source software, adapted to widely available computing platforms.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Sebastian Pokutta from TU & Zuse Institute, Berlin, December 2019.
- Critobal Guzman from Universidad Católica de Chile, July 2019.
- Quentin Berthet from University of Cambridge, from Feb 2019 until Apr 2019.
- Eduard Gorbunov from Moscow Institute of Physics and Technology, Oct 2019.
- Song Mei, from Stanford University, from Sep 2019 until Oct 2019.
- Anant Raj, from M.P.I. Tubingen, from Oct 2019.
- Aadirupa Saha, from Indian Institute of Technology, Bangalore, from Nov 2019

SIMSMART Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

Inter-Labex SEACS: V. Monbet, F. Le Gland, C. Herzet and Thi Tuyet Trang Chau (PhD student) are part of the *inter Labex Cominlabs-Lebesgue-Mer SEACS, http://www.seacs.cominlabs.ueb.eu/fr*, which stands for Stochastic modEl-dAta-Coupled representationS for the analysis, simulation and reconstruction of upper ocean dynamics. This project which concerns mainly Objectives 2 and 3, aims at exploring novel statistical and stochastic methods to address the emulation, reconstruction and forecast of fine-scale upper ocean dynamics.maths-computer-sea science for ocean dynamics.

CMEMS 3DA (2018-2019): C. Herzet is part of the project *CMEMS 3DA* on data assimilation of oceanographic events with non-parametric data assimilation methods. The goal of the project is to demonstrate the relevance of data-driven strategies to improve satellite derived interpolated products and especially the geostrophic surface currents. The project is made in collaboration with IMT Atlantique Brest, Ifremer and the Institue of Geosciences and Environment in Grenoble.

Action Exploratoire – Labex Cominlabs: C. Herzet is part of a project on sparse representations in continuous dictionaries. Partners: R. Gribonval (Inria Rennes PANAMA), A. Drémeau (IMT Atlantique) and P. Tandeo (IMT Atlantique).

7.2. National Initiatives

7.2.1. ANR

ANR BECOSE (2016-2020): Beyond Compressive Sensing: Sparse approximation algorithms for ill-conditioned inverse problems.

Cédric Herzet is part of the BECOSE project. The BECOSE project aims to extend the scope of sparsity techniques much beyond the academic setting of random and well-conditioned dictionaries. In particular, one goal of the project is to step back from the popular L1-convexification of the sparse representation problem and consider more involved nonconvex formulations, both from a methodological and theoretical point of view. The algorithms will be assessed in the context of tomographic Particle Image Velocimetry (PIV), a rapidly growing imaging technique in fluid mechanics that will have strong impact in several industrial sectors including environment, automotive and aeronautical industries.

ANR Melody (2020-2024): Bridging geophysics and MachinE Learning for the modeling, simulation and reconstruction of Ocean DYnamics.

Cédric Herzet is part of the MELODY project. The MELODY project aims to bridge the physical model-driven paradigm underlying ocean/atmosphere science and AI paradigms with a view to developing geophysically-sound learning-based and data-driven representations of geophysical flows accounting for their key features (e.g., chaos, extremes, high-dimensionality).

7.3. European Initiatives

7.3.1. FP7 & H2020 Projects

ERC MsMaths (2015-2019): M. Rousset is part of *ERC MSMaths* on molecular simulation (PI T. Lelièvre). With the development of large-scale computing facilities, simulations of materials at the molecular scale are now performed on a daily basis. The objective of the MSMath ERC project is to develop and study efficient algorithms to simulate such high-dimensional systems over very long, macroscopic times. ERC MsMaths especially focus on the computational issues related to 'metastable' states, that is to say specific molecular configurations that do evolve only on very large time scales. This results in a multi-timescale computational bottleneck that needs to be addressed by specific algorithms.

7.3.2. Collaborations with Major European Organizations

The agency European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) of Darmstadt. The transfer focuses on the estimation of atmospheric 3D winds from the future hyperspectral instrument (IRS on MTG-S, developed by ESA and IASI-NG on Metop-SG developed by CNES).

7.4. International Initiatives

7.4.1. Participation in Other International Programs

ECOS ARGENTINE (2018-2021): V. Monbet has obtained a funding program through the ECOS Sud - MINCyT intiative (http://www.univ-paris13.fr/cofecub-ecos/). The program involves a collaboration with the French-Argentinian Climate Institute (http://www.cima.fcen.uba.ar/UMI/), and focuses on non-parametric, analog methods, combined with data assimilation techniques to reconstruct complex meteorological dynamics (Objective 3).

SPHINX Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- **Project Acronym :** IFSMACS
  Project Title : Fluid-Structure Interaction: Modeling, Analysis, Control and Simulation
  Coordinator: Takéo Takahashi
  Participants: Julien Lequeurre, Alexandre Munnier, Jean-François Scheid, Takéo Takahashi
  Duration : 48 months (starting on October 1st, 2016)
  Other partners: Institut de Mathématiques de Bordeaux, Inria Paris, Institut de Mathématiques de Toulouse
  Abstract: The aim of this project is to analyze systems composed by structures immersed in a fluid. Studies of such systems can be motivated by many applications (motion of the blood in veins, fish locomotion, design of submarines, etc.) but also by the corresponding challenging mathematical problems. Among the important difficulties inherent to these systems, one can quote nonlinearity, coupling, free-boundaries. Our objectives include asymptotic analyses of FSIS, the study of controllability and stabilizability of FSIS, the understanding of locomotion of self-propelled structures and the analyze and development of numerical tools to simulate fluid-structure system.
  URL: http://ifsmacs.iecl.univ-lorraine.fr/
- **Project Acronym:** QUACO
  Project title: QUAntum COntrol: PDE systems and MRI
  Coordinator: Thomas Chambrion
  Duration: 48 months (starting January 1st 2018).
  URL: http://www.iecl.univ-lorraine.fr/~Thomas.Chambrion/QUACO/index.html
  Abstract The aim of the project is the use of geometrical tools for the study and the control of quantum system with application to MRI.
- **Project acronym:** ISDEEC
  Project title: Interaction entre Systèmes Dynamiques, Equations d'Evolution et Contrôle
  Coordinator: Romain Joly
  Participant: Julie Valein
  Other partners: Institut Fourier, Grenoble; Département de Mathématiques d'Orsay
  Duration: 36 months (2017-2020)
  URL: http://isdeec.math.cnrs.fr/
  Abstract The aim of the project is to study the qualitative dynamics of various classes of PDEs and classes of ODEs with special structure. This work program requires expertise in different mathematical domains such as dynamical systems theory, PDE techniques, control theory, geometry, functional analysis... while the current trend in mathematics is for high specialisation. The purpose of this project is to create and extend interactions between experts of these various domains, in order to deepen our understanding of the dynamics of evolution equations and to explore the new challenging questions, which will emerge.

- **Project Acronym:** ODISSE
  Project title: Observer Design for Infinite-dimensional Systems
  Coordinator: Vincent Andrieu
  Local coordinator: Karim Ramdani
  Duration: 48 months (starting on October 1st 2019)
  Participants: Ludovick Gagnon, Karim Ramdani, Julie Valein and Jean-Claude Vivalda.
  Other partners: Laas, Lagepp, Inria-Saclay
  Abstract: This ANR project includes 3 work-packages
  1. Theoretical aspects of observability and identifiability.
  2. From finite dimensional systems to infinite dimensional systems : Infinite-dimensional Luenberger observers, Parametric identification and adaptive estimation algorithm, Infinite-dimensional observers for finite-dimensional systems.
  3. From infinite dimensional systems to finite dimensional systems : discretization, hierarchical reduction.

9.2. International Initiatives

9.2.1. Inria International Labs

9.2.1.1. BEC2HPC

Title: Bose-Einstein Condensates : Computation and HPC simulation

Head: Xavier Antoine

International Partner: Sichuan University, Chengdu (China) - Department of mathematics - Qinglin TANG

Start year: 2019

See also: https://team.inria.fr/bec2hpc/

All members of the associate team are experts in the mathematical modeling and numerical simulation of PDEs related to engineering and physics applications. The first objective of the associate team is to develop efficient high-order numerical methods for computing the stationary states and dynamics of Bose-Einstein Condensates (BEC) modeled by Gross-Pitaevskii Equations (GPEs). A second objective is to implement and validate these new methods in a HPC environment to simulate large scale 2D and 3D problems in quantum physics. Finally, a third objective is to provide a flexible and efficient HPC software to the quantum physics community for simulating realistic problems.

9.2.2. Participation in Other International Programs

9.2.2.1. Réseau Franco-Brésilien de mathématiques

Ludovick Gagnon collaborates with the Universidade Federal da Paraiba and Universidade Federal do Rio de Janeiro funded by the Réseau Franco-Brésilien de mathématiques.

9.2.2.2. Indo-French Center of Applied Mathematics

Title : **Analysis, Control and Homogenization of Complex Systems**

International Partner: TIFR CAM, Bangalore

Heads: Takéo Takahashi (France) and Mythily Ramaswamy (India).

Duration: 2018 - 2021

Scientific Objectives

- Study the well-posedness of models arising from either structure in the fluid or structure on the boundary of the domain containing the fluid.
- Explore Controllability, Optimal Control and Stabilization of such fluid-structure interaction problems.
- Study systems describing fluid flows in a time dependent domain with a rapidly oscillating boundary using Homogenization Theory. The rapid oscillations of the boundary takes into account, the rough character of the boundary and its movements may take into account the displacement of a deformable body into a fluid flow.
- Carry out Finite Element Analysis for such models, including elastic structures as well as rigid ones.

9.3. International Research Visitors

9.3.1. Visits to International Teams

Jean-François Scheid was invited to the "École Supérieure des Sciences et Technologie d'Hammam-Sousse", Tunisia, 30 September–5 October 2019.

9.3.1.1. Research Stays Abroad

Xavier Antoine was invited to the Department of Mathematics, Sichuan University, Chengdu, January 2019 (2 weeks) + August 2019 (4.5 weeks) + November 2019 (3 weeks).

TAU Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- **EPITOME** 2017-2020 (225kEuros), *Efficient rePresentatIon TO structure large-scale satellite iMagEs* (Section 7.5.2).
  Coordinator: Yuliya Tarabalka (Titane team, Inria Sophia-Antipolis)
  Participant: Guillaume Charpiat
- **HUSH** 2020-2023 (348kEuros), *The HUman Supply cHain behind smart technologies*.
  Coordinator: Antonio A. Casilli (Telecom Paris)
  Participant: Paola Tubaro

9.1.2. Others

- **Nutriperso** 2017-2020, 122 kEuros. Personalized recommendations toward healthier eating practices (Section 7.3.2).
  U. Paris-Saclay IRS (*Initiative de Recherche Stratégique*)
  Partners: INRA (coordinator), INSERM, Agro Paristech, Mines Telecom
  Participants: Philippe Caillou, Flora Jay, Michèle Sebag, Paola Tubaro
- **IRS CDS** 2017-2020, 75 kEuros. Personalized recommendations toward healthier eating practices
  U. Paris-Saclay IRS (*Initiative de Recherche Stratégique*)
  Partners: INRA (coordinator), INSERM, Agro Paristech, Mines Telecom
  Participants: Philippe Caillou, Flora Jay, Michèle Sebag, Paola Tubaro
- **PIA Adamme** 2015-2019 (258 kEuros) Machine Learning on a mass-memory architecture.
  Coordinator: Bruno Farcy (Bull SAS)
  Participants: Marc Schoenauer, Guillaume Charpiat, Cécile Germain-Renaud
- **NEXT** 2017-2021 (675 kEuros). Simulation, calibration, and optimization of regional or urban power grids (Section 4.2).
  ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie)
  Coordinator: ARTELYS
  Participants Isabelle Guyon, Marc Schoenauer, Michèle Sebag, Victor Berger (PhD), Herilalaina Rakotoarison (PhD), Berna Bakir Batu (Post-doc)
- **DATAIA Vadore** 2018-2020 (105 kEuros) VAlorizations of Data to imprOve matching in the laboR markEt, with CREST (ENSAE) and Pôle Emploi (Section 7.3.1).
  Coordinator: Michèle Sebag
  Participants: Philippe Caillou, Isabelle Guyon
- **PIA JobAgile** 2018-2021 (379 kEuros) *Evidence-based Recommandation pour l'Emploi et la Formation* (Section 7.3.1).
  Coordinator: Michèle Sebag and Stéphanie Delestre (Qapa)
  Participants: Philippe Caillou, Isabelle Guyon
- **HADACA** 2018-2019 (50 kEuros), within EIT Health, for the organization of challenges toward personalized medicine (Section 7.6).
  Coordinator: Magali Richard (Inria Grenoble)
  Participants: Isabelle Guyon

- **IPL HPC-BigData** 2018-2022 (100 kEuros) High Performance Computing and Big Data (Section 7.5.5)
  Coordinator: Bruno Raffin (Inria Grenoble)
  Participants: Guillaume Charpiat, Loris Felardos (PhD)
- **ScGlass** 2016-2020 (10 M$), "Cracking the Glass problem" international collaboration on cracking the glass problem, funded by the Simons Fundation (NY, NYC, USA).
  Coordinator: 13 PIs around the world (see https://scglass.uchicago.edu/)
  Participants: (alumni, actively collaborating with members) François Landes

9.2. European Initiatives

9.2.1. Collaborations with Major European Organizations

CERN: collaboration with two major CERN experiments (ATLAS and CMS) on the role of machine learning at all stages of the scientific discovery process. C. Germain supervises a CERN-funded PhD.

9.3. International Initiatives

9.3.1. Inria International Labs

IIL CWI-Inria
Associate Team involved in the International Lab:

9.3.1.1. MDG-TAO

Title: Data-driven simulations for Space Weather predictions

International Partner (Institution - Laboratory - Researcher):

CWI (Netherlands) - Multiscale Dynamics Group - Enrico Camporeale

Start year: 2017

See also: http://pages.saclay.inria.fr/cyril.furtlehner/html/mdg-tao.html

We propose an innovative approach to Space Weather modeling: the synergetic use of state-of-the-art simulations with Machine Learning and Data Assimilation techniques, in order to adjust for errors due to non-modeled physical processes, and parameter uncertainties. We envision a truly multidisciplinary collaboration between experts in Computational Science and Data assimilation techniques on one side (CWI), and experts in Machine Learning and Data Mining on the other (Inria). Our research objective is to realistically tackle long-term Space Weather forecasting, which would represent a giant leap in the field. This proposal is extremely timely, since the huge amount of (freely available) space missions data has not yet been systematically exploited in the current computational methods for Space Weather. Thus, we believe that this work will result in cutting-edge results and will open further research topics in space Weather and Computational Plasma Physics.

TOSCA Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- C. Henry is the coordinator of the PAIRE project, a TREMPLIN-COMPLEX project funded by University of Côte d'Azur. The project aims at creating new international and cross-sector collaborations to foster innovative solutions for particle contamination in the environment. This will be achieved by bringing together partners in a consortium to submit a research proposal to the European MSCA-RISE-2019 and MSCA-RISE-2020 calls.
- A. Lejay is a member of the Executive board of LUE Impact digistrust on citizens' trust in the digital world (grant of the i-site, U. Lorraine), since 2018.

8.2. National Initiatives

8.2.1. ANR

- N. Champagnat was member of the ANR NONLOCAL (Phénomènes de propagation et équations non locales), coordinated by F. Hamel (Univ. Aix-Marseille), which ended in October.
- C. Henry is the coordinator of the PACE project, a MRSEI project funded by the ANR to help prepare European projects. As for PAIRE, the project aims at creating new international and cross-sector collaborations to foster innovative solutions for particle contamination in the environment. This will be achieved by bringing together partners in a consortium to submit a research proposal to the European MSCA-RISE-2019 and MSCA-RISE-2020 calls.
- U. Herbach is member of the ANR SinCity (Analyses transcriptomiques sur cellules uniques dont la généalogie est identifiée au cours d'un processus de différentiation), coordinated by O. Gandrillon (ENS Lyon).

8.2.2. GDR

A. Lejay is leader of the GdR Project TRAG on rough paths founded by INSMI in 2019.

8.2.3. ITMO Cancer

N. Champagnat, C. Fritsch and U. Herbach are involved in an ITMO Cancer project (INSERM funding) on "Modeling ctDNA dynamics for detecting targeted therapy resistance" (2017-2020), involving researchers from IECL (Institut Elie Cartan de Lorraine), the Inria teams BIGS and TOSCA, ICL (Institut de Cancérologie de Lorraine), CRAN (Centre de Recherche en Automatique de Nancy) and CHRU Strasbourg (Centre Hospitalier Régional Universitaire). This project is coordinated by N. Champagnat.

8.2.4. PEPS

The project SECURE of C. Fritsch obtained a PEPS I3A (Intelligence Artificielle et Apprentissage Automatique).

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

Program: FP7

Project acronym: HBP

Project title: The Human Brain Project

Duration: April 2018 - Mars 2020 (third part)

Coordinator: EPFL

Other partners: see the webpage of the project.

Tosca contact: Etienne Tanré

Abstract: Understanding the human brain is one of the greatest challenges facing 21st century science. If we can rise to the challenge, we can gain profound insights into what makes us human, develop new treatments for brain diseases and build revolutionary new computing technologies. Today, for the first time, modern ICT has brought these goals within sight. The goal of the Human Brain Project, part of the FET Flagship Programme, is to translate this vision into reality, using ICT as a catalyst for a global collaborative effort to understand the human brain and its diseases and ultimately to emulate its computational capabilities. The Human Brain Project will last ten years and will consist of a ramp-up phase (from month 1 to month 36) and subsequent operational phases. This Grant Agreement covers the ramp-up phase. During this phase the strategic goals of the project will be to design, develop and deploy the first versions of six ICT platforms dedicated to Neuroinformatics, Brain Simulation, High Performance Computing, Medical Informatics, Neuromorphic Computing and Neurorobotics, and create a user community of research groups from within and outside the HBP, set up a European Institute for Theoretical Neuroscience, complete a set of pilot projects providing a first demonstration of the scientific value of the platforms and the Institute, develop the scientific and technological capabilities required by future versions of the platforms, implement a policy of Responsible Innovation, and a programme of transdisciplinary education, and develop a framework for collaboration that links the partners under strong scientific leadership and professional project management, providing a coherent European approach and ensuring effective alignment of regional, national and European research and programmes. The project work plan is organized in the form of thirteen subprojects, each dedicated to a specific area of activity. A significant part of the budget will be used for competitive calls to complement the collective skills of the Consortium with additional expertise.

M. Bossy and C. Henry are involved in the VIMMP H2020 project, started in January 2018. M. Bossy is responsible for the partner Inria. VIMMP is a four years development for a software platform and simulation market place on the topic of complex multiscale CFD simulations.

8.4. International Initiatives

8.4.1. Participation in Other International Programs

Math AmSud SARC

Title: Stochastic and Statistics analysis for Stochastic Differential equations driven by fractional Brownian motion with non regular coefficients.

International Partner (Institution - Laboratory - Researcher):

Universidade Estadual de Campinas (Brasil)

Universidad de Valparaiso (Chile) - CIMFAV – Facultad de Ingenieria

PI: C. Olivera (Brasil), E. Tanré (France), S. Torrès (Chile)

Duration: 2019 - 2020

Start year: 2019

Keywords: Stochastic differential equations, fractional Brownian motion, Malliavin calculus, Bayesian parametric, and nonparametric statistics.

BRN

Title: Biostochastic Research Network

International Partner (Institution - Laboratory - Researcher):

Universidad de Valparaiso (Chile) - CIMFAV – Facultad de Ingenieria - Soledad Torres, Rolando Rebolledo

CNRS, Inria & IECL - Institut Élie Cartan de Lorraine (France) - N. Champagnat, A. Lejay, D. Villemonnais, R. Schott.

Duration: 2018 - 2022

Start year: 2018

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- E. Horton (University of Bath) spent one week in IECL in April to work with D. Villemonais.
- E. Mordecki (U. de la República, Uruguay) spent 3 months in IECL, with an invited professor position (*poste rouge CNRS*).
- H. Olivero Quintos spent one month at Sophia Antipolis.

8.5.1.1. Internships

- Loubna Ben Allal

  subject: processus de Hawkes

  date: sept. 2019 - june 2020

  institution: École des Mines de Nancy
- Wejdene Ben Nasr

  subject: méthodes de signature pour les séries temporelles multi-variées

  date: sept. 2019 - june 2020

  institution: Master IMSD, U. Lorraine.
- Olivier Coudray

  subject: transmission de la longueur de télomères entre générations

  date: apr. 2019 - aug. 2019

  institution: École Polytechnique, Master Mathématiques de l'aléatoire
- Rémi Maréchal

  subject: processus de fragmentation pour les avalanches

  date: sept. 2019 - june 2020

  institution: École des Mines de Nancy
- Seyedafshin Shekarforush

  subject: particles in the environment: the adaptative grid generation problem in particle agglomeration and fragmentation dynamics

  date: apr. 2019 - aug. 2019

  institution: Université Nice Sophia Antipolis

8.5.2. Visits to International Teams

8.5.2.1. Sabbatical programme

D. Villemonais obtained a *délégation CNRS* which ended in August.

TRIPOP Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

The SMART PROTECT project (2019–2022) is a R&D booster project granted by the Région Auvergne Rhône–Alpes. The project is coordinated by Géolithe Innov, a French company specialized in the innovation in Geotechnics. The partners are Géolithe, Irstea and Myotis. The aim of the project is to design and validate a new type of protection structures against rockfall and avalanches. The role of the TRIPOP team is to propose a numerical modeling of the structure and to improve the link between simulations and wireless sensors, which will equip the structure.

8.2. National Initiatives

8.2.1. ANR project Digitslid

B. Brogliato coordinates the ANR project Digitslid (PRC, ANR-18-CE40-0008-01), Differentiateurs et commandes homogenes par modes glissants en temps discret: l'approche implicite. Partners: LS2N (Ecole Centrale de Nantes), Inria Lille Nord Europe (team Non-A-Post), and Tripop. October 2018-September 2021. 12 participants overall (3 post-doc students recruited by the project, 3 Ph.D. students supported by other means). Total financial support by the ANR: 338 362 euros (100 762 for Tripop, 18 months of post-doc to be recruited in 2019).

8.2.2. FUI Modeliscale.

https://team.inria.fr/modeliscale/

The ModeliScale FUI focuses on the modeling, simulation and analysis of large cyber-physical systems. It federates the research activities of several teams, covering a broad spectrum of topics, namely hybrid systems modeling & verification, numerical analysis, programming language design and automatic control. Our research agenda includes the following tracks:

- New compilation techniques for Modelica modelers: structural analysis of multimode DAE (Differential Algebraic Equations) systems, modular compilation, combining state-machines and non-smooth dynamical systems (complementarity dynamical systems and Filippov differential inclusions), contract-based specification of cyber-physical systems requirements, requirements capture using under-/over-determined DAE systems.
- Simulation of large cyber-physical systems: distributed simulation, discretization methods for non-smooth dynamical systems, space-/time-adaptive discretization methods for multimode DAE systems, quantized state solvers (QSS).
- Guaranteed numerics: guaranteed simulation of non-smooth and hybrid dynamical systems, numerical methods preserving invariant properties of hybrid systems, contract-based reasoning methods.

8.2.3. Inria Project Lab (IPL): ModeliScale, Languages and Compilation for Cyber-Physical System Design

https://team.inria.fr/modeliscale/

The project gathers researchers from three Inria teams, and from three other research labs in Grenoble and Paris area.

Table 1. Member of IPL Modeliscale

Name	Team	Inria Center or Laboratory
Vincent Acary	Bipop	Inria Grenoble Rhône Alpes
Bernard Brogliato		
Albert Benveniste	Hycomes Inria Rennes	
Benoît Caillaud		Bretagne Atlantique
Khalil Ghorbal		
Marc Pouzet	Parkas	ENS
Tim Bourke		Inria Paris
Goran Frehse	Tempo	Verimag-univ. Grenoble Alpes
Antoine Girard		L2S-CNRS, Saclay
Eric Goubault	Cosynus	LIX, École Polytechnique, Saclay
Sylvie Putot		

The main objective of ModeliScale is to advance modeling technologies (languages, compile-time analyses, simulation techniques) for CPS combining physical interactions, communication layers and software components. We believe that mastering CPS comprising thousands to millions of components requires radical changes of paradigms. For instance, modeling techniques must be revised, especially when physics is involved. Modeling languages must be enhanced to cope with larger models. This can only be done by combining new compilation techniques (to master the structural complexity of models) with new mathematical tools (new numerical methods, in particular).

ModeliScale gathers a broad scope of experts in programming language design and compilation (reactive synchronous programming), numerical solvers (nonsmooth dynamical systems) and hybrid systems modeling and analysis (guaranteed simulation, verification). The research program is carried out in close cooperation with the Modelica community as well as industrial partners, namely, Dassault Systèmes as a Modelica/FMI tool vendor, and EDF and Engie as end users.

TROPICAL Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- Projet ANR JCJC CAPPS ("Combinatorial Analysis of Polytopes and Polyhedral Subdivisions"), responsable Arnau Padrol (IMJ-PRG, Sorbonne Université). Partenaires : IMJ-PRG (Sorbonne Université), Inria Saclay (Tropical), LIGM (Université Paris-Est Marne-la-Vallée), LIF (Université Aix-Marseille), CERMICS (École Nationale des Ponts et Chaussées), LIX (École Polytechnique).

9.1.2. Labex Hadamard

- Projet du Labex Hadamard, intitulé "ALgebraic Methods in gAmes and optimization ALMA", conjoint avec le PGMO, coordonné par E. Tisgaridas (Inria Paris) et X. Allamigeon, faisant intervenir M. Akian et S. Gaubert.

9.1.3. IRS iCODE (Institut pour le Contrôle et la Décision de l'Idex Paris-Saclay)

- White project "New perspectives in the numerical solution of Hamilton-Jacobi-Bellman partial differential equations", coordinated by M. Akian, including S. Gaubert and members of the EPC Commands (Inria Saclay and École polytechnique), UMA (ENSTA), and LMO (Paris-Sud).

9.1.4. Centre des Hautes Études du Ministère de l'Intérieur

- Project "Optimisation de la performance de centres de traitement d'appels d'urgence en cas d'événements planifiés ou imprévus", coordinated by X. Allamigeon, involving M. Boyet, B. Colin and S. Gaubert.

9.2. International Initiatives

9.2.1. Participation in Other International Programs

- Bilateral projects FACCTS, between the University of Chicago (Statistics) – Lek-Heng Lim– and Ecole polytechnique – Stéphane Gaubert– "Tropical geometry of deep learning".
- Math AmSud Project ARGO, "Algebraic Real Geometry and Optimization", accepted, with CMM (Chile), Univ. Buenos Aires (Argentina), Univ. Fed. Rio and Univ. Fed. Ceara (Brasil), Univ Savoie and CMAP, Ecole polytechnique (France).

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Oliver Lorscheid, IMPA, Rio (on sabattical at MPI, Bonn), one week in June and 3 days in October, joint invitation with CMLS, Ecole polytechnique.
- Louis Rowen, Bar Ilan University, 3 days in March.
- Sergei Sergeev, Birmingham, 1 week in April.
- Grigorio Malajovich, Univ. Federal, Rio, 1 week in August.
- Armando Gutiérrez, Aalto University, 2 days in February.

9.3.1.1. Internships

- Sarah Vannucci, PhD student, University of Salerno, has been invited for 3 months in the team.

9.3.2. Visits to International Teams

- S. Gaubert
  - Univ. Birmingham, Math and Stats Dep, Jan. 2019 (visiting S. Sergeev)
  - Univ. Bar Ilan, Math Dep, June 2019 (visiting L. Rowen)
  - Univ. Baltimore, Math Dep, Oct. 2019 (visiting A. Sagnier)
- B. Tran
  - U. de Hong Kong, March-April 2019 (2 months, visiting Zheng Qu)
- C. Walsh
  - Univ. Kent, School of Mathematics, Statistics and Actuarial Science, 1 week in November (visiting B. Lemmens and M. Roelands).

VALSE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

The team participates in CPER Data programs and projects:

- ControlHub, coordinator A. Polyakov, see the dedicated platform description above
- "ContrATech" subprogram of CPER ELSAT, coordinator J.-M. Foucaut (LMFL)

8.2. National Initiatives

8.2.1. ANR

- Digitslid, coordinator B. Brogliato (Inria, Grenoble)
- Finite4SoS, coordinator W. Perruquetti (École Centrale de Lille)
- WaQMoS, coordinator D. Efimov (Inria, Lille)
- TurboTouch, coordinator G. Casiez (Inria, Lille)

8.2.2. Inria project labs

The team participates in IPL COSY, coordinator E. Cinquemani (Inria, Grenoble).

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

The team is involved in 1 EU project UCoCoS, coordinator W. Michiels (KUL, Belgium).

8.4. International Initiatives

8.4.1. Inria North European associate teams

- WeCare with Uppsala University (Sweden), coordinator R. Ushirobira
- RECoT with IBM Research (Ireland), coordinator A. Polyakov

8.4.2. Inria International Partners

- UNAM (Mexico), L. Fridman and J. Moreno
- ITMO University (Russia), A. Bobtsov and I. Furtat

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- A. Aleksandrov, SPbSU (Russia), from Mar 2019 until Apr 2019
- S. Aranovskiy, École supérieure d'électricité, Jun 2019
- J. Epperlein, IBM Research (Ireland), from Dec 2019
- E. Fridman, Tel Aviv University (Israel), from Jul 2019 until Sep 2019, **Inria invited professor**
- A. Medvedev, Upsalla University (Sweden), from Nov 2019 until Dec 2019
- J. Moreno, UNAM (Mexico), from Dec 2019
- Y. Orlov, CICESE (Mexico), from Dec 2019
- M. Ruderman, University of Agder (Norway), from Dec 2019
- L. Tupak Aguilar Bustos, CICESE (Mexico), from Dec 2019
- J. Zhang, HDU (China), from Aug 2019
- K. Zimenko, ITMO University (Russia), from Sep 2019 until Nov 2019
- S. Zhuk, IBM Research (Ireland), from Dec 2019

8.5.1.1. Internships

- M. Ballesteros Escamilla, Cinvestav (Mexico), until Apr 2019
- D. Cruz Ortiz, Cinvestav (Mexico), until Apr 2019
- J. Franco Jaramillo, Technological Institute of La Laguna (Mexico), from Oct 2019 until Nov 2019
- J. Mendoza Avila, UNAM (Mexico), from Sep 2019 until Dec 2019

ABS Project-Team

6. Partnerships and Cooperations

6.1. Regional Initiatives

– Frédéric Cazals is endowed chair within the 3IA Côte d'Azur (http://3ia.univ-cotedazur.fr/), within the focus area *Computational Biology and Bio-Inspired AI.*

6.2. International Research Visitors

6.2.1. Visits of International Scientists

6.2.1.1. Internships

- Internship of Maria Guramare, Harvard University, Cambridge, Massachusetts. Supervision: Frédéric Cazals and Dorian Mazauric. *Shortest Paths under Constraints Problem with Application for Structural Alignments.*
- Internship of Guilherme Santa Cruz, Polytech Nice. Supervision: Frédéric Cazals and Dorian Mazauric. *New method for assessing protein-phenotype relevance interpolating gene expression and biological networks*.
- Internship of Gabriel Djebbar, École Polytechnique de l'Université Nice Sophia Antipolis. Filière Sciences Informatiques, deuxième année du cursus ingénieur (niveau Master 1). Supervision: Frédéric Havet and Dorian Mazauric. *Graph Coloring Games with application on Algorithmic Geometry.*
- Projet de fin d'études de Youssef Benjelloun et Quentin Sautel, École Polytechnique de l'Université Nice Sophia Antipolis. Filière Mathématiques Appliquées et Modélisation, deuxième année du cursus ingénieur (niveau Master 1). Supervision: Dorian Mazauric. *Algorithmes pour le calcul de motif commun d'un ensemble de conformations d'une protéine.*

AIRSEA Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

C. Prieur is co-leader of work-package 3 of the cross-disciplinary-project Trajectories from Idex Grenoble.

8.2. National Initiatives

8.2.1. ANR

A 4-year contract : ANR COCOA (COmprehensive Coupling approach for the Ocean and the Atmosphere). PI: E. Blayo. (Jan. 2017 - Dec. 2020). Other partners: Laboratoire des Sciences du Climat et de l'Environnement (UMR8212, Gif-sur-Yvette), Laboratoire de Météorologie Dynamique (UMR8539, Paris), Laboratoire d'Océanographie Physique et Spatiale (UMR6523, Brest), Centre National de Recherche Météorologique (UMR3589, Toulouse), Cerfacs (Toulouse). This project aims at revisiting the overall representation of air-sea interactions in coupled ocean-atmosphere models, and particularly in climate models, by coherently considering physical, mathematical, numerical and algorithmic aspects.

A 4-year contract : ANR HEAT (Highly Efficient ATmospheric modelling) http://www.agence-nationale-recherche.fr/?Project=ANR-14-CE23-0010.

A 4-year contract : ANR ADOM (Asynchronous Domain decomposition methods)

A 5-year contract : ANR MELODY (Bridging geophysics and MachinE Learning for the modeling, simulation and reconstruction of Ocean DYnamic)

A 5-year contract with the French Navy (SHOM) on the improvment of the CROCO ocean model http://www.croco-ocean.org.

C. Prieur and E. Arnaud are involved as experts in project High-Tune http://www.agence-nationale-recherche.fr/Projet-ANR-16-CE01-0010 funded by ANR.

8.2.2. Inria Challenge

Sea Uncertainty Representation and Forecast (SURF),

Coord : Airsea (A. Vidard),

Partenaires Inria : Ange, Cardamom, Fluminance, Lemon, Mingus, Defi

Partenaires extérieurs: BRGM, Ifremer, SHOM

8.2.3. Other Initiatives

A. Vidard leads a group of projects gathering multiple partners in France and UK on the topic "Variational Data Assimilation for the NEMO/OPA9 Ocean Model", see 5.3 .

C. Prieur is co-advising the PhD thesis of Henri Mermoz Kouye, ine the framework of the Inria-INRA collaboration.

C. Prieur chaired GdR MASCOT NUM 2010-2017, in which are also involved M. Nodet, E. Blayo, C. Helbert, E. Arnaud, L. Viry, S. Nanty, L. Gilquin. She is still strong involved in the group (co-chair). In particular, she will co-chair next GdR annual meeting in Aussois (May 2020). http://www.gdr-mascotnum.fr/doku.php.

LEFE/GMMC CASIS, Coupled Assimilation Strategies for the Initialisation of an ocean- atmospheric boundary layer System, A. Vidard en collaboration avec Mercator océan

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

H2020 project IMMERSE (Improving Models for Marine EnviRonment SErvices) is funded from 2018-12-01 to 2022-11-30 (Inria contact: Florian Lemarié, coordinator: J. Le Sommer, CNRS). The overarching goal of the project is to ensure that the Copernicus Marine Environment Monitoring Service (CMEMS) will have continuing access to world-class marine modelling tools for its next generation systems while leveraging advances in space and information technologies, therefore allowing it to address the ever-increasing and evolving demands for marine monitoring and prediction in the 2020s and beyond. See also https://cordis.europa.eu/project/rcn/218810/factsheet/fr and https://immerse-ocean.eu/

8.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: C3S

Project acronym: ERGO

Project title: Enabling an Ensemble of Data Assimilation for the Ocean

Duration: Février 2019 - juillet 2021

Coordinator: Arthur Vidard

Other partners: Cerfacs (France), Met Office (U.K.), CMRE (int, Italie)

Abstract: The scope of this contract is to improve ocean data assimilation capabilities at ECMWF, used in both initialization of seasonal forecasts and generation of coupled Earth System reanalyses. In particular it shall focus on i) improving ensemble capabilities in NEMO and NEMOVAR and the use of their information to represent background error statistics; ii) extend NEMOVAR capabilities to allow for multiple resolution in multi-incremental 3D-Var; iii) make better use of ocean surface observations. It shall also involve performing scout experiments and providing relevant diagnostics to evaluate the benefit coming from the proposed developments.

8.3.3. Collaborations with Major European Organizations

Partner: European Center for Medium Range Weather Forecast. Reading (UK)

World leading Numerical Weather Center, that include an ocean analysis section in order to provide ocean initial condition for the coupled ocean atmosphere forecast. They play a significant role in the NEMOVAR project in which we are also partner.

Partner: Met Office (U.K) National British Numerical Weather and Oceanographic service. Exceter (UK).

We do have a strong collaboration with their ocean initialization team through both our NEMO, NEMO-ASSIM and NEMOVAR activities. They also are our partner in the NEMOVAR consortium.

Partner : SAMO board

SAMO board is in charge of the organization of the SAMO (sensitivity analysis of model outputs) conferences, every three years. It is strongly supporter by the Joint Research Center of the European Commission. In 2019, Clémentine Prieur, which is part of this board, as also co-chair of a satellite event on the future of sensitivity analysis. A position paper is under construction, as a synthesis of the discussions hold in Barcelona (autumn 2019).

8.4. International Initiatives

8.4.1. Inria Associate Teams Not Involved in an Inria International Labs

8.4.1.1. UNQUESTIONABLE

Title: UNcertainty QUantification is ESenTIal for OceaNic & Atmospheric flows proBLEms.

International Partner: Massachusetts Institute of Technology (United States) - Aerospace Computational Design Laboratory - Youssef Marzouk

Start year: 2018

See also: https://team.inria.fr/unquestionable/

The ability to understand and predict the behavior of geophysical flows is of greatest importance, due to its strong societal impact. Numerical models are essential to describe the evolution of the system (ocean + atmosphere), and involve a large number of parameters, whose knowledge is sometimes really poor. The reliability of the numerical predictions thus requires a step of parameter identification. The Inria-AIRSEA team has a strong expertise in variational approaches for inverse problems. An alternative is the use of particle filters, whose main advantage is their ability to tackle non-gaussian frameworks. However, particle filters suffer from the curse of dimensionality. The main objective of the collaboration we propose between the Inria-AIRSEA team and the MIT UQ group is the understanding of potential low-dimensional structure underlying geophysical applications, then the exploitation of such structures to extend particle filter to high-dimensional applications.

8.4.2. Inria International Partners

F. Lemarié and L. Debreu collaborate with Hans Burchard and Knut Klingbeil from the Leibniz-Institut für Ostseeforschung in Warnemünde (Germany) [32], [12].

C. Prieur collaborates with Jose R. Leon (Universdad de la república de Uruguay, Montevideo).

C. Prieur collaborates with K. Bertin (CIMFAV, Valparaíso).

F.-X. Le Dimet is a Honorary Professor of the Institut of Mechanics, Ac.Sci. Vietnam.

F.-X. Le Dimet is a Honorary Professor of the Institut of Numerical Mathematics, Russian Ac.Sci.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Alistair Adcroft (Princeton Univ.) visited the team in Jan. 2019

Jose R. León was visiting the team during two weeks. He is working with Clémentine Prieur, in collaboration with Pierre Etoré and Adeline Samson (DATA department of LJK) on UQ for models described by SDE.

Nicholas Kevlahan, from McMaster University (Canada) was a visiting scientist of the AIRSEA team for 10 months in 2018-2019.

Victor Shutyaev, from the Institut of Numerical Mathematics (Moscow, Russian Ac.Sci.) was visiting the team during two weeks to collaborate with F.-X. Le Dimet [17].

ANGE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR MFG (2016-2021)

Participant: Julien Salomon.

Project acronym: MFG

Project title: Mean Field Games

Coordinator: Sébastien Boyaval (LHSV/ENPC)

Funding: 299 160 euros.

Mean field game theory (MFG) is a new and active field of mathematics, which analyses the dynamics of a very large number of agents. Introduced about ten years ago, MFG models have been used in different fields: economics, finance, social sciences, engineering,... MFG theory is at the intersection of mean field theory, mathematical game theory, optimal control, stochastic analysis, variation calculation, partial differential equations and scientific calculation. Drawing on an internationally recognized French team on the subject, the project seeks to obtain major contributions in 4 main directions: the "medium field" aspect (i.e., how to obtain macroscopic models from microscopic models); the analysis of new MFG systems; their numerical analysis; the development of new applications. In this period of rapid expansion of MFG models, the project seeks to foster French leadership in the field and attract new researchers from related fields.

9.1.2. ANR INFAMIE (2015-2019)

Participant: Boris Haspot.

Program: ANR Défi de tous les savoirs (DS10) 2015

Project acronym: INFAMIE

Project title: INhomogeneous Flows : Asymptotic Models and Interfaces Evolution

Coordinator: Raphaël Danchin (Univ. Paris-Est)

Funding: 232 960 euros.

Our project aims at a better mathematical understanding of several models for the evolution of inhomogeneous flows. Through three main lines of research (see below), we will pursue a twofold final objective. First, we want to develop the current theory of regular solutions for several equations for the evolution of fluids, proposing a new approach and developing tools that are likely to be efficient in various areas of PDEs. Second, for a few selected concrete systems that describe flows in the earth environment or in astrophysics, we wish to use this general approach to extract as much information as possible concerning the qualitative behavior of the solutions.

9.1.3. ANR SEDIFLO (2015-2019)

Participants: Emmanuel Audusse, Martin Parisot.

Program: ANR Défi 1 “Gestion sobre des ressources et adaptation au changement climatique” (JCJC)

Project acronym: SEDIFLO

Project title: Modelling and simulation of solid transport in rivers

Coordinator: Sébastien Boyaval (LHSV/ENPC)

Based on recent theoretical and experimental results, this project is aimed at modelling transport of sediments within rivers. It will rely on innovations from the point of view of rheology as well as advanced mathematical tools (asymptotic model reduction, PDE discretisation).

9.1.4. ANR Hyflo-Eflu (2016-2019)

Participants: Jérémy Ledoux, Martin Parisot, Jacques Sainte-Marie, Julien Salomon.

ANR project call: Energies marines renouvelables

Project acronym: Hyflo-Eflu

Project title: Hydroliennes flottantes et énergie fluviale

Coordinator: Julien Salomon

The project is a collaboration between the Inria-team ANGE, specialist of free surface flow and optimisation, and the industrial developers of the turbine, HydroTube Energie. The objective of the project HyFlo-EFlu is to deliver a numerical software able to simulate the dynamic of a floating water turbine in real context. For the academic partner, the main challenge is in the simulation of the floating structure at the scale of the river, and the modelling of the vertical and horisontal axis turbine. For the industrial partner, the objective is the validation of the stability of the structure and the performance in term of energy production.

9.1.5. ANR CHARMS (2016-2020)

Participant: Cindy Guichard.

ANR project call: Transformations et inter-conversions énergétiques

Project acronym: CHARMS

Project title: Modèles de réservoirs quantitatifs pour les systèmes hydrothermaux complexes

Coordinator: Simon Lopez (BRGM)

Funding: 73k euros for LJLL (in 767k euros for the whole project)

CHARMS ANR project is focused on the mathematical methods and software tools dedicated to the simulation of the physical models issued from geothermal engineering. The final objective is the achievement of a highly parallel code, validated on realistic cases.

9.1.6. GdR EGRIN (2017–2021)

Participants: Emmanuel Audusse, Bernard Di Martino, Nicole Goutal, Cindy Guichard, Anne Mangeney, Martin Parisot, Jacques Sainte-Marie.

EGRIN stands for Gravity-driven flows and natural hazards. J. Sainte-Marie is the head of the scientific committee of this CNRS research group and A. Mangeney is a member of the committee. Other members of the team involved in the project are local correspondents. The scientific goals of this project are the modelling, analysis and simulation of complex fluids by means of reduced-complexity models in the framework of geophysical flows.

9.1.7. ANR FireCaster (2017-2020)

Participants: Frédéric Allaire, Vivien Mallet.

ANR project call: DS0104

Project acronym: FireCaster

Project title: Plateforme de prévision incendie et de réponse d'urgence

Coordinator: Jean-Baptiste Filippi (Univ. Corse)

Funding: 442k euros

The goal of the FireCaster project is to prototype a fire decision support system at the national scale to estimate upcoming fire risk (H+24 to H+48) and in case of crisis, to predict fire front position and local pollution (H+1 to H+12).

9.1.8. ANR CENSE (2017-2020)

Participants: Antoine Lesieur, Vivien Mallet.

ANR project call: DS0601

Project acronym: CENSE

Project title: Caractérisation des environnements sonores urbains : vers une approche globale associant données libres, mesures et modélisations

Coordinator: Judicaël Picaut (IFSTTAR)

Funding: 856k euros

The CENSE project aims at proposing a new methodology for the production of more realistic noise maps, based on an assimilation of simulated and measured data through a dense network of low-cost sensors.

9.1.9. ANR RAVEX (2017-2020)

Participant: Anne Mangeney.

ANR project call: DS0106

Project acronym: RAVEX

Project title: Développement d'une approche intégrée pour la réduction des Risques Associés au Volcanisme EXplosif, de la recherche sur l'aléa aux outils de gestion de crise : le cas de la Martinique

Coordinator: Olivier Roche (IRD)

Funding: 619k euros

9.1.10. ANR CINE-PARA (2015-2019)

Participant: Julien Salomon.

ANR project call: DS0708

Project acronym: CINE-PARA

Project title: Méthodes de parallélisation pour cinétiques complexes

Coordinator: Yvon Maday (LJLL)

9.1.11. PGMO Project ORACLE (2019-2021)

Participant: Julien Salomon.

PGMO Call

Project acronym: Oracle

Project title: Optimal Resource Allocation in micro-organisms under Changing Environment

Coordinator: Térence Bayen

9.2. European Initiatives

9.2.1.

Participants: Martin Parisot, Yohan Penel, Jacques Sainte-Marie.

CNRS PICS NHML (2017-2019)

Program: CNRS PICS (projet international de collaboration scientifique)

Project acronym: NHML

Project title: non-hydrostatic multilayer models

Duration: 01/17-12/19

Coordinator: Yohan Penel (Inria)

Other partners: IMUS (Sevilla, Spain)

Other Participants: Enrique Fernández-Nieto (Sevilla), Tomas Morales de Luna (Cordoba)

Funding: 12k euros

Abstract: This collaboration aims at designing a hierarchy of multilayer models with a non-hydrostatic pressure as a discretisation along the vertical axis of the Euler equations. The hierarchy relies on the degree of approximation of the variables discretised with a Discontinuous Galerkin method for the vertical direction. These innovative models will imply a theoretical study and the development of numerical tools in dimensions 1 and 2 before the modelling of other physical phenomena (viscosity effects, ...).

9.3. International Initiatives

9.3.1. Inria International Partners

Three long-term collaborations with foreign colleagues have to be mentioned:

- **Spain** - A collaboration with spanish researchers has been initiated in 2016 to derive accurate models and effecient algorithms for free surface flows including non-hydrostatic effects.
- **Germany** A collaboration with researchers from the University of Constance is in progress about domain decomposition and identifaction algorithms (G. Ciaramella, S. Volkwein). The internship (Masterarbeit) of S. Buchwald has been co-supervised by J. Salomon.
- **Hong-Kong, Switzerland** A collaboration with F. Kwok and M. Gander on time parallelization for assimilation algorithm is in progress. A first paper has been submitted in october.

9.4. International Research Visitors

- Y. Penel made two two-week stay (March, October) at the university of Sevilla (Spain) to collaborate with E. Fernández-Nieto.
- M. Parisot spent two months (October, November) at the university of Aachen (Germany) to collaborate with S. Noelle.

9.4.1. Visits of International Scientists

- G. Ciaramella (Constance University) visited J. Salomon (20.05-23.05) to work on algorithms related to design of experiments and identification.
- F. Kwok (Baptist University, Hong-Kong) visited J. Salomon (8.07-11.07) to work on algorithms related to time parallelization for identification.

ARAMIS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Health Data Hub

Participant: Stanley Durrleman.

Project acronym: Precise-PD-HDH

Project title: Modélisation et prédiction de la progression de la maladie de Parkinson

Duration: 1 year (pilot project)

Coordinator: Jean-Christophe Corvol

Other partners: Inserm, réseau NS-PARK, ICM

9.1.2. ANR

9.1.2.1. ANR-NIH-NSF CANDT

Participant: Fabrizio de Vico Fallani [Correspondant].

Project acronym: CANDT

Project title: Advancing neuroscientific discovery and training by lowering the barrier of entry to network neuroscience via open science

Duration: Oct 2019 - Sep 2023

Amount: 137k€

Coordinator: Fabrizio De Vico Fallani

Other partners: Indiana Univ., US; UPenn, US

Abstract: This project will use open science methods and cloud-computing, effectively lowering the barrier of entry to network neuroscience and increase the widespread availability of well-maintained and reproducible network neuroscience tools. We will use the platform brainlife.io as a digital marketplace for network neuroscience analysis methods; network neuroscience tools and software will be packaged into self-contained, standardized, reproducible Apps, shared with and modified by a burgeoning community of users, and seamlessly integrated into existing brainlife.io processing and analysis pipelines. This approach will engage both experts in network science, scientists from other domains, and users of the proposed methods. In addition, it will ensure correct implementation, a high level of reproducibility, and maximal reusability of network neuroscience methods. As a requirement, Apps will also be accompanied by links to primary sources, in-depth tutorials, and documentation, and worked-through examples, highlighting their correct usage and offering solutions for mitigating possible pitfalls. This proposed research lowers the barrier of entry to network neuroscience, standardizes the software sharing process, and provides a cloud-based repository of expertly-maintained network neuroscientific tools and software that is made available to the broader neuroscientific community.

9.1.2.2. ANR-NIH-NSF NETBCI

Participants: Fabrizio de Vico Fallani [Correspondant], Mario Chavez, Denis Schwartz.

Project acronym: NETBCI

Project title: Modeling and predicting brain-computer interface learning from dynamic networks

Duration: Avr 2016 - Avr 2020

Amount: 322k€

Coordinator: Fabrizio De Vico Fallani

Other partners: Complex system group, UPenn, USA

Abstract: This project will bring together expertise in computational and experimental neuroscience, signal processing and network science, statistics, modeling and simulation, to establish innovative methods to model and analyze temporally dynamic brain networks, and to apply these tools to develop predictive models of brain-computer interface (BCI) skill acquisition that can be used to improve performance. Leveraging experimental data and interdisciplinary theoretical techniques, this project will characterize brain networks at multiple temporal and spatial scales, and will develop models to predict the ability to control the BCI as well as methods to engineer BCI frameworks for adapting to neural plasticity. This project will enable a comprehensive understanding of the neural mechanisms of BCI learning, and will foster the design of viable BCI frameworks that improve usability and performance.

9.1.2.3. ANR-NIH-NSF HIPLAY7

Participants: Olivier Colliot [Correspondant], Marie Chupin, Stanley Durrleman, Anne Bertrand.

Project acronym: HIPLAY7

Project title: Hippocampal layers: advanced computational anatomy using very high resolution MRI at 7 Tesla in humans

Duration: Jan 2017 - Jan 2020

Amount: 770k€

Coordinator: Olivier Colliot and Pierre-François Van de Moortele

Other partners: University of Minnesota, Neurospin

Abstract: The overall goal of this proposal is to develop a coherent mathematical framework for computational anatomy of the internal structures of the hippocampus based on cutting edge MRI acquisition techniques at 7 Tesla. These mathematical and computational approaches are expected to significantly advance the field of computational anatomy of the human brain, breaking down the millimeter barrier of conventional brain morphometry and providing a coherent analysis framework for anatomical data at ultra-high spatial resolution.

9.1.2.4. ANR PREV-DEMALS

Participants: Olivier Colliot [Correspondant], Marie Chupin, Stanley Durrleman, Anne Bertrand.

Project acronym: PREV-DEMALS

Project title: Predict to prevent frontotemporal lobar degeneration (FTLD) and amyotrophic lateral sclerosis (ALS)

Duration: Avr 2015 - Avr 2019

Amount: 487k€

Coordinator: Isabelle Le Ber

Other partners: ICM, AP-HP, CHR de Lille, CHU Limoges, CHU Rouen, Laboratory of Biomedical Imaging

Abstract: The project focuses on C9ORF72, the most frequent genetic form of frontotemporal lobar degeneration (FTLD) and amyotrophic lateral sclerosis (ALS). Since 2006, major discoveries have helped elucidate the pathological bases and linked FTLD and ALS: 1) TDP-43 aggregates in neurons and 2) C9ORF72 mutations in both disorders. Two major pathological subtypes are now defined in FTLD, FTLD-TDP and FTLD-TAU. C9ORF72 mutations (associated to FTLD-TDP) are the most frequent genetic causes of FTLD (15%), FTLD-ALS (65%) and ALS (40%). No curative treatment actually exists, but therapeutics emerged against tau aggregation. The objectives of the project are to develop appropriate cognitive, brain imaging markers and peripheral biomarkers of the early phase of FTLD, to follow disease progression and to guide future targeted therapeutic trials. To address this questions, we will conduct a multimodal study (cognition, brain structural MRI, brain metabolism - FDG-PET) in C9ORF72 families. The cohort will be followed at 3-time points (M0, M18, M36). Longitudinal analyses will aim at characterizing the trajectory of decline across time. Brain structural changes will be evaluated by 1) morphometric analysis to assess global brain atrophy, cortical thickness and study of the cortical sulci; 2) functional connectivity analysis of resting-state MR data; 3) structural connectivity analysis of diffusion-weighted MRI. Brain metabolism will be evaluated with FDG-PET. We will use the most recent RNA sequencing technology to detect gene expression and RNA splicing alterations in lymphocytes of patients and presymptomatic carriers. The discovery of new markers involved in FTLD will have practical consequences for early and accurate diagnosis of FLD and ALS disease.

9.1.2.5. ANR IVMRS

Participants: Anne Bertrand [Correspondant], Alexandra Petiet, Mathieu Santin, Francesca Branzoli, Benoit Delatour, Marc Sanson.

Project acronym: IVMRS

Project title: Implantable miniaturized probe for In-vivo Magnetic Resonance Spectroscopy: Application to Murine models of Alzheimer's disease and Gliomas.

Duration: Oct 2016 - Oct 2020

Amount: 633k€

Coordinator: Luc Hebrard

Other partners: ICube - Unistra, Strasbourg; ISA Laboratory, Lyon; NYU School of Medicine, NY, USA.

Abstract: During the development of new therapeutics against brain diseases, the pre-clinical phase, i.e. the validation of treatment delivery, safety and efficacy in animal models of the disease, represents a crucial step. Magnetic Resonance Imaging (MRI) is a method of particular interest at this stage, as it provides non-invasive surrogate endpoints that can help selecting appropriate candidates during the process of drug development. Single Voxel Magnetic Resonance Spectroscopy (SVS) provides non-invasive, in-vivo quantitative measurements of brain metabolites, which reflects functional changes at the cellular and subcellular levels, and can be repeated longitudinally. As high-field MRI has become the benchmark in preclinical research on animal models, it appears possible to investigate the cerebral metabolomics changes in animals, and to use it as a surrogate marker in preclinical therapeutic trials. However, the number of relevant metabolites is much higher than the low number of measurable metabolites with conventional in-vivo high-field SVS. Moreover, considering also the subtle changes of these metabolites at the early stage of the disease, the use of conventional high-field SVS in preclinical studies remains strongly limited. The high volume of the Voxel-of-Interest (VOI), ranging from 10 to 30mm3, which is required to have a usable signal in conventional SVS, and the inherent variability of longitudinal SVS measurement due to the variable position of the VOI in the successive experiments, remain the two major issues when looking during time for small changes in metabolic concentrations and metabolites ratios in a specific small region of the animal brain. The IvMRS project aims at filling this gap by developing the first chronic implantable MRS micro-probe, minimally invasive, exhibiting very high signal sensitivity, and sharp spectral peaks, from sub-millimetric VOI. Such a probe will allow detecting a much higher number of metabolites than conventional in-vivo SVS. The probe will work at frequencies ranging from 300MHz to 500MHz in ultra-high field Magnetic Resonance Imaging scanners, 7T and 11.7T. It will embed a specific micro-coil antenna, a low-noise signal conditioning circuit designed in CMOS microelectronics technology, as well as an accurate on-chip positioning sensor. It will be dedicated to the study of changes in brain metabolite markers of two major diseases, Alzheimer's disease and cerebral gliomas, and to the assessment of effective therapeutic strategies.

9.1.3. Inria Project Labs

9.1.3.1. IPL Neuromarkers

Participants: Stanley Durrleman [Correspondant], Olivier Colliot [Correspondant], Fabrizio de Vico Fallani, Anne Bertrand, Stéphane Epelbaum.

Project acronym: Neuromarkers

Project title: Design of imaging biomarkers of neurodegenerative diseases for clinical trials and study of their genetic associations

Duration: 2017-2021

Coordinators: Stanley Durrleman and Olivier Colliot

Other partners: Inria GENSCALE, Inria BONSAI, Inria DYLISS, Inria XPOP, ICM, IHU/ICM iConics

Abstract: The Inria Project Lab Neuromarkers aims to develop new statistical and computational approaches to integrate multimodal imaging and omics data and to demonstrate their potential to identify early alterations and predict progression of neurodegenerative diseases. To tackle this challenge, the project brings together multidisciplinary expertise from Inria and ICM (Brain and Spine Institute) in the fields of statistical learning, brain imaging, bioinformatics, knowledge modeling, genomics and neurodegenerative diseases.

9.1.4. IHU

9.1.4.1. General program

Participants: Olivier Colliot, Stanley Durrleman, Didier Dormont, Ninon Burgos, Stéphane Epelbaum, Fabrizio de Vico Fallani.

Project acronym: IHU-A-ICM

Project title: Institute of Translational Neuroscience

Founded in 2011

General Director: Bertrand Fontaine

The IHU-A-ICM program was selected, in 2011, in a highly competitive national call for projects. A 10-year, 55M€ program, has been implemented by a recently created foundation for scientific cooperation. Based on the clinical and scientific strenghts of the ICM and the hospital Department of Nervous System Diseases, it mainly supports neuroscience research, but is also invested in improving care and teaching. ARAMIS is strongly involved in the IHU-A-ICM project, in particular in WP6 (neuroimaging and electrophysiology), WP7 (biostatistics), WP2 (Alzheimer) and WP5 (epilepsy). We have started collaborations with the new bioinformatics/biostatistics platform (IHU WP7, head: Ivan Moszer), in particular through a joint project on the integration of imaging and genomics data.

9.1.4.2. ICM-Internal Research projects

Participants: Anne Bertrand [Correspondant], Takoua Kaaouana, Benoit Delatour, Alexandra Petiet, Olivier Colliot, Arnaud Marcoux.

Project title: The Histo-MRI project: targeting MR signature of tauopathy from micro- to macroscopy

Started in 2014

Coordinator: Anne Bertrand

Identifying morphological MR signatures of brain diseases usually follows a top-down process, which starts by describing a pattern of MR signal changes in patients, hypothesizes an underlying pathological mechanism, and confirms this mechanism by correlating the observed MR signal changes with histological lesions on post-mortem examination. This top-down process, relevant for large, centimetric brain lesions, becomes inappropriate when targeting the MR signal intensity changes associated with microscopic lesions. Our project aims at developing an MR biomarker of NFT using a new bottom-up approach. We will start by identifying the MR signal changes associated with the presence of NFT at the level of the histological slice, and utilize these findings to develop a method of NFT quantification on clinical, millimetric 3D MR images. To achieve this goal, we will develop and implement a 11.7T histological coil dedicated to the scanning of histological slices, which allows both ultra-high resolution MR imaging (up to 33 microns in-plane) and perfect co-registration with histological staining, performed subsequently on the same slice. This method has the potential to provide a novel biomarker of tauopathy that could not have been identified using the usual top-down approach. It also envisions the possibility to describe and understand new MRI contrasts in other neurodegenerative diseases associated with microscopic deposition of various proteins.

9.1.4.3. ICM BBT Program - project PredictICD

Participants: Olivier Colliot [Correspondant], Jean-Christophe Corvol [Correspondant], Johann Faouzi.

Project title: Predict impulse control disorders in Parkinson's disease (PREDICT-ICD)

Started in 2018

Coordinators: Olivier Colliot and Jean-Christophe Corvol (ICM)

In Parkinson's disease (PD), the therapeutic strategy is based on the dopamine replacement therapy. Although available since the 1960s', it is only relatively recently that behavioral disorders associated with these drugs have been described. Gathered under the term of "behavioral addiction", they include impulse control disorders (ICDs), dopamine dysregulation syndrome (DDS), and punding. Interestingly, whereas addiction to L-dopa itself occurs quasi exclusively with L-dopa, ICDs appear electively under dopamine agonist (DA) therapy. The objectives of this project are: i) to elucidate the genetic basis of DA induced ICDs in PD patients from several international cohorts; ii) to develop and validate a machine learning model to predict the occurrence of ICDs from the combination of clinical and genetic data.

9.1.4.4. ICM BBT Program - project DYNAMO

Participants: Stanley Durrleman [Correspondant], Harald Hampel [Correspondant], Sabrina Fontanella, Simone Lista, Olivier Colliot, Stephanie Allassonniere, Jean-Baptiste Schiratti, Bruno Dubois, Hovagim Bakardjian, Remi Genthon, Enrica Cavedo, Katrine Rojkowa.

Project title: Dynamic models of disease progression across Alzheimer's disease stages informed by multimodal neuroimaging and biological data

Started in 2016

Coordinator: Stanley Durrleman and Harald Hampel

Other partners: Institut de la Mémoire et de la maladie d'Alzheimer

The estimation of data-driven models of disease progression for neurodegenerative diseases, including Alzheimer's disease (AD), is crucial to confirm, refine and extend the current hypothetical models. The estimation of such quantitative models from longitudinal data sets is notably difficult because of the lack of principled methodological frameworks for the analysis of spatiotemporal data.

The project builds on an innovative mathematical, statistical, and computational framework to automatically align the dynamics and the direction of individual trajectories of the evolving pathology, and then to infer a normative scenario of disease progression across different disease stages. The estimated scenario will combine spatiotemporal maps of lesion propagation, such as maps of amyloid deposition or cortical atrophy, and global measurements such as levels of CSF biomarkers. It will be possible to estimate not only a normative scenario but also the inter-individual variability in the values, dynamics and direction of both topographical and pathophysiological biomarkers changes during the course of the disease.

The application of this technology to publicly available and in-house longitudinal data sets of individuals from the asymptomatic at risk to the prodromal and dementia stages will yield new insights into the pathophysiology of AD from the preclinical to the AD dementia stages. This quantitative data-driven approach will be exploited to assess and refine the current qualitative hypothetical models of AD progression. Notably, it will complement these models with typical pathways of lesion propagation in the brain during disease progression. It will also highlight the effect of the known risk factors of AD such as apolipoprotein E genotype on the disease progression profile.

The project will open up the concrete possibility to derive a computer-aided diagnosis, staging, and prognosis tool for a better recruitment of patients in clinical studies and to assist clinicians in the diagnosis and the monitoring of both disease progression and treatment efficacy.

9.1.4.5. ICM BBT Program - project SEMAPHORE

Participants: Stanley Durrleman [Correspondant], Stéphane Lehéricy [Correspondant], Jean-Christophe Corvol, Marie Vidailhet, Raphael Couronné, Safia Said.

Project title: Personalized progression model of Parkinson’s disease

Started in 2018

Coordinator: Stanley Durrleman and Stéphane Lehéricy

Other partners: Neurology and Neuro-radiology departments, Pitié-Salpêtrière Hospital, AP-HP

The aim of this project is to build a personalizable model of Parkinson’s disease (PD) progression integrating the complex dynamical interplay between phenotypic, imaging, genetic and metabolic alterations. We will identify and validate markers for monitoring of progression of brain damage in early and prodromal PD and identify conversion markers in subjects at risk of PD (idiopathic rapid eye movement sleep behavior disorders iRBD, PD- related mutation carriers). We will describe the appearance, characterize clinical phenotypes of PD, and identify modifier genes of disease phenotype. To this aim, we will relie on a novel statistical learning method using Bayesian non-linear mixed-effects model allowing to combine and realign short term sequence data to estimate a long-term scenario of disease progression. This method is able to estimate individual stages of disease progression and to analyze automatically non-linear spatiotemporal patterns of data change. It estimates both a group-average scenario of PD progression as well as the inter-individual variability of this model in terms of age at onset, pace of disease progression and variability in the spatiotemporal trajectory of data changes. We will analyse the effect of genetic variants in the modulation of these non-linear progression patterns, and assess the statistical power of the individual parameters encoding for these patterns. The method will be applied to two sets of longitudinal data from the local prospective NUCLEIPARK (60 PD patients, 20 patients with iRBD, 60 controls) and ICEBERG studies (200 early idiopathic PD, 50 iRBD, 30 GBA and LRRK2 PD-related mutation carriers, 50 controls). Examinations included clinical, biological, and neurophysiological data, and multimodal 3T MRI, DATScan, and skin and salivary gland biopsies. The models of PD progression for each category of subjects will be released to the community, as well as the software for reproducibility purposes.

9.1.4.6. ICM BBT Program - project ATTACK

Participants: Fabrizio de Vico Fallani [Correspondant], Charlotte Rosso [Correspondant], Marie-Constance Corsi, Laurent Hugueville.

Project title: ATTACK Brain Network Models Of Motor Recovery After Stroke

Started in 2018

Coordinator: Fabrizio De Vico Fallani, Charlotte Rosso

Other partners: Neurology and Stroke departments, Pitié-Salpêtrière Hospital, AP-HP

Like in other connected systems, studying the structure of the interactions between different brain regions has profound implications in the comprehension of emergent complex phenomena as, for example, the capability of the human brain to functionally reorganize after cerebrovascular "attacks" or stroke. This dynamic skill, which is known in neuroscience as neural plasticity, is not only interesting from a network science perspective, but it also plays a crucial role in determining the motor/cognitive recovery of patients who survive a stroke. As a critical innovation, this project proposes to develop a systematic and rigorous approach based on neuroimaging techniques, signal processing, and network science for the modeling and analysis of temporally dynamic neural processes that characterize motor recovery after stroke. To achieve these goals, this project is organized around the following objectives: i) acquiring a comprehensive longitudinal dataset of brain and behavioral/clinical data after stroke, ii) developing new analytic tools to characterize and generate temporally dynamic brain networks, iii) building network-based models of motor recovery after stroke, accounting for individual patients. These objectives involve an intensive gathering of heterogeneous mass data, their processing, the subsequent outcome interpretation and statistical simulation, as well as the development of longitudinal models and network-based diagnostics of the patient's motor recovery progress. Results will be first characterized from pure network-theoretic and neuroscience perspectives, so as to highlight fundamental research challenges, and then validated to clarify the importance and the applicability to the clinical scenario. Our results will unveil multiscale properties of dynamic brain networks and identify predictive neuromarkers for motor recovery after stroke. This project has a two-fold impact on the society. On the one hand, it will provide new methods and robust tools to properly characterize and model temporally dynamic networks in neuroscience. On the other hand, it will provide longitudinal models of motor recovery in stroke patients that can potentially unveil the neural substrate that underpins rehabilitation, improve prognosis, and eventually lower cost of hospitalization time. From a broader perspective this interdisciplinary project proposes a transformative approach to analyze large-scale neural systems.

9.1.5. 3IA Institutes - PRAIRIE

Participants: Olivier Colliot, Stanley Durrleman, Ninon Burgos.

Project acronym: PRAIRIE

Project title: Paris Artificial Intelligence Research Institute

Founded in 2019

Director: Isabelle Ryl

Website: https://prairie-institute.fr/

PRAIRIE is one of the four selected French Institutes of AI. It was selected within a call for creation of interdisciplinary AI research institutes (or “3IAs” for “Instituts Interdisciplinaires d'Intelligence Artificielle”), as part of the national French initiative on Artificial Intelligence (AI). PRAIRIE aspires to become within five years a world leader in AI research and higher education, with an undeniable impact on economy and technology at the French, European and global levels. ARAMIS team members N. Burgos, O. Colliot and S. Durrleman hold a chair at PRAIRIE.

9.1.6. National Networks

- GdR Statistics and Medicine - http://gdr-stat-sante.math.cnrs.fr/spip/
- GdR (MaDICS) Masses de Données, Informations et Connaissances en Sciences Big Data - Data ScienceStatistics and Medicine - http://www.madics.fr/reseaux/
- F. De Vico Fallani participated to the GdR (HANDICAP) in the framework of the future strategy of Inria
- F. De Vico Fallani was founding member of the CORTICO national network for brain-computer interfaces

9.1.7. Other National Programs

9.1.7.1. Fondation Vaincre Alzheimer

Participants: Olivier Colliot, Vincent Henry, Martin Hoffman-Apitius.

Project title: Integrative multiscale knowledge model of Alzheimer's disease pathophysiology

2019-2020

Amount: 100K€

Coordinator: Olivier Colliot

Other partners: Frauhofer SCAI (Germany)

Abstract: Alzheimer's disease (AD) pathophysiology is still imperfectly understood. In particular, we currently lack an integrative view of the disease to interconnect knowledge about the molecular, cellular, clinical and systems levels that remain scattered. Computational knowledge models have the potential to provide such an integrative view. The aim of this project is to provide a multiscale knowledge model of AD pathophysiology by aggregating existing heterogeneous resources (disease maps, ontologies, databases) using Semantic Web standards. The resulting model and associated software tools will be made publicly available to the scientific community.

9.1.7.2. France Parkinson

Participants: Jean-Christophe Corvol, Olivier Colliot, Stanley Durrleman.

Project title: PRECISE-PD - From pathophysiology to precision medicine for Parkinson's disease

2019-2024

Amount: 3M€

Coordinator: Jean-Christophe Corvol

Other partners: Inserm CIC-1436, Inserm CIC-P1421, Inserm U1171, Université de Bordeaux (IMN), University of Glasgow, University of Calgary,

Abstract: Parkinson's disease (PD) is a complex neurodegenerative disease characterized by the progression of motor and non-motor symptoms resulting from the spreading of the disease into dopaminergic and non-dopaminergic areas. Clinical trials have failed to demonstrate efficacy to slow PD progression because the relationships between progression profiles and their underlying molecular mechanisms remain to be identified. The objective of PRECISE-PD is to propose a mechanismsbased progression model of PD by combining genetic and longitudinal clinical data from a large cohort of patients. We will implement a biobank to the NS-PARK/FCRIN cohort collecting motor and non-motor symptoms from >22,000 PD patients followed in the 24 expert centers in France. Genomic data will be generated by using a microarray platform developed for neurodegenerative diseases studies, and brain imaging will be obtained from a subgroup of patients. Computational and machine learning approaches will be developed to address the challenges of analyzing the high dimensionality and the mixture of data necessary to move beyond empirical stratification of patients. Replication will be performed in independent cohorts, and biological validation will combine biomarkers and preclinical research. PRECISE-PD is an unpreceded opportunity to open the path to the new era of precision and personalized medicine for PD.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. H2020 - Project EuroPOND

Participants: Olivier Colliot, Stanley Durrleman, Manon Ansart, Igor Koval, Alexandre Bône.

Project acronym: EuroPOND

Project title: Data-driven models for Progression Of Neurological Disease

Duration: Jan 2016 - Dec 2019

Amount: 6M€

Coordinator: Daniel Alexander

Other partners: University College London (UK), EMC Rotterdam (The Netherlands), VUMC (The Netherlands), Fate Bene Fratelli (Italy), Carol Besta Institute (Italy), Université de Genève (Switzerland), Icometrix (Belgium)

Abstract: EuroPOND will develop a data-driven statistical and computational modeling framework for neurological disease progression. This will enable major advances in differential and personalized diagnosis, prognosis, monitoring, and treatment and care decisions, positioning Europe as world leaders in one of the biggest societal challenges of 21st century healthcare. The inherent complexity of neurological disease, the overlap of symptoms and pathologies, and the high comorbidity rate suggests a systems medicine approach, which matches the specific challenge of this call. We take a uniquely holistic approach that, in the spirit of systems medicine, integrates a variety of clinical and biomedical research data including risk factors, biomarkers, and interactions. Our consortium has a multidisciplinary balance of essential expertise in mathematical/statistical/computational modelling; clinical, biomedical and epidemiological expertise; and access to a diverse range of datasets for sporadic and well-phenotyped disease types.The project will devise and implement, as open-source software tools, advanced statistical and computational techniques for reconstructing long-term temporal evolution of disease markers from cross-sectional or short-term longitudinal data. We will apply the techniques to generate new and uniquely detailed pictures of a range of important diseases. This will support the development of new evidence-based treatments in Europe through deeper disease understanding, better patient stratification for clinical trials, and improved accuracy of diagnosis and prognosis. For example, Alzheimer's disease alone costs European citizens around €200B every year in care and loss of productivity. No disease modifying treatments are yet available. Clinical trials repeatedly fail because disease heterogeneity prevents bulk response. Our models enable fine stratification into phenotypes enabling more focussed analysis to identify subgroups that respond to putative treatments.

9.2.1.2. H2020 - Project VirtualBrainCloud

Participant: Stanley Durrleman.

Project acronym: TVBCloud

Project title: Personalized Recommendations for Neurodegenerative Disease

Duration: Jan 2019 - Dec 2022

Amount: 15 M€

Coordinator: Petra Ritter

Other partners: Charite Berlin, Université Aix Marseille, Fraunhofer Gesellschaft, University of Oxford, Forschungzentrum Juelich, Institut du Cerveau et de la Moëlle épinière, Inria, Fundacio institut de bioenginyeria de catalunya, Helsingin yliopisto, Universita degli studi di genova, Universidad complutense de Madrid, Codebox Computer-Dienste, Codemart, Eodyne Systems, Universität Wien, TP21, Alzheimer Europe

Abstract: The annual worldwide cost of Alzheimer's dementia was 777.81 billion Euro in 2015. This number will rise to 7.41 trillion Euro in 2050. Early diagnosis would save up to $7.9 trillion in medical and care costs by 2050 in the US alone. However, the emergent pathology is highly variable across people, necehighly variable across people, necessitating individualized diagnostics and interventions. The VirtualBrainCloud addresses this by bridging the gap between computational neuroscience and subcellular systems biology, integrating both research streams into a unifying computational model that supports personalized diagnostics and treatments in NDD. TheVirtualBrainCloud not only integrates existing software tools, it also merges the efforts of two big EU initiatives, namely The Virtual Brain large scale simulation platform of the EU Flagship Human Brain Project and IMI-EPAD initiative (European prevention of Alzheimer's dementia consortium). VirtualBrainCloud will develop and validate a decision support system that provides access to high quality multi-disciplinary data for clinical practice. The result will be a cloud-based brain simulation platform to support personalized diagnostics and treatments in NDD. The EU PRACE (Partnership for Advanced Computing in Europe) initiative, will provide the required computing infrastructure. TheVirtualBrainCloud will develop robust solutions for legal and ethical matters by interacting with EU projects such as European Open Science Cloud (EOSC), 'cloud4health', Alzheimer's Europe patient organizations and ELIXIR, an organization that manages and safeguards EU research data. Our software developers have already produced highly successful brain simulation and clinical decision support tools. The resulting software will be a cloud based computational modeling system that is tailored to the individual, and bridges multiple scales to identify key mechanisms that predict NDD progression and serves as Precision Decision Support System.

9.2.1.3. FET Flagship - Human Brain Project

Participants: Olivier Colliot, Stanley Durrleman.

Project acronym: HBP

Project title: Human Brain Project

Sub-project: SP8 - Medical Informatics Platform

Duration: 2016-

Abstract: The Human Brain Project (HBP) is a European Commission Future and Emerging Technologies Flagship. The HBP aims to put in place a cutting-edge, ICT-based scientific Research Infrastructure for brain research, cognitive neuroscience and brain-inspired computing. The Project promotes collaboration across the globe, and is committed to driving forward European industry. Our team is involved in the Subproject SP8 (Medical Informatics Platform). The Medical Informatics Platform (MIP) is an innovative data management system that gives researchers the means to access and analyse large amounts of anonymized clinical neuroscience data. Within that framework, we will develop and implement a method to construct disease progression models from longitudinal biomarkers. The method will use statistical learning techniques to infer a long-term disease progression model from multiple short term data from a series of individuals. The model will account for variability in age at disease onset, pace of disease progression and trajectories of biomarkers changes across individuals in the observed population.

9.2.1.4. ERC - LEASP

Participant: Stanley Durrleman.

Project acronym: LEASP

Project title: Learning Spatiotemporal Patterns in Longitudinal Image Data Sets of the Aging Brain

Duration: 2016-2021

Abstract: Time-series of multimodal medical images offer a unique opportunity to track anatomical and functional alterations of the brain in aging individuals. A collection of such time series for several individuals forms a longitudinal data set, each data being a rich iconic-geometric representation of the brain anatomy and function. These data are already extraordinary complex and variable across individuals. Taking the temporal component into account further adds difficulty, in that each individual follows a different trajectory of changes, and at a different pace. Furthermore, a disease is here a progressive departure from an otherwise normal scenario of aging, so that one could not think of normal and pathologic brain aging as distinct categories, as in the standard case-control paradigm.

Bio-statisticians lack a suitable methodological framework to exhibit from these data the typical trajectories and dynamics of brain alterations, and the effects of a disease on these trajectories, thus limiting the investigation of essential clinical questions. To change this situation, we propose to construct virtual dynamical models of brain aging by learning typical spatiotemporal patterns of alterations propagation from longitudinal iconic-geometric data sets.

By including concepts of the Riemannian geometry into Bayesian mixed effect models, the project will introduce general principles to average complex individual trajectories of iconic-geometric changes and align the pace at which these trajectories are followed. It will estimate a set of elementary spatiotemporal patterns, which combine to yield a personal aging scenario for each individual. Disease-specific patterns will be detected with an increasing likelihood.

This new generation of statistical and computational tools will unveil clusters of patients sharing similar lesion propagation profiles, paving the way to design more specific treatments, and care patients when treatments have the highest chance of success.

9.3. International Initiatives

9.3.1. Informal International Partners

- O. Colliot has an enduring collaboration with the Center for Magnetic Resonance Research, University of Minnesota, USA (P-F Van de Moortele, T. Henry).
- S. Durrleman and O. Colliot have a collaboration with the Center for Medical Image Computing (CMIC) at University College London (UCL), London, UK (D. Alexander, H. Zhang).
- F. De Vico Fallani has a collaboration with Penn University, US (Prof. D. Bassett) and Queen Mary University London, UK (Prof. Vito Latora).

9.4. International Research Visitors

9.4.1. Visits of International Scientists

We hosted Prof Bruno Jedynak from Portland State University (USA) in June and July 2019.

ATHENA Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ADT

8.1.1.1. ADT BCI-Browser

Participants: Théodore Papadopoulo, Maureen Clerc.

Duration: 1 year

Most often, BCI techniques are demonstrated in simple toy applications made. The only "few" real BCI applications are specific developments and are not used much as they lack of functionality, maintenance, ... The goal of this development contract is to demonstrate a new approach to BCI, in which BCI interactions are integrated in existing applications. Ideally, the original software is not modified and not even recompiled. It is modified by providing either modified GUI libraries or providing extensions as plugins. As a proof of concept, we aim at modifying C++/Qt applications with a focus on web browsing, by redefining some of its basic interactions (mouse clicks, keyboard, ...) using some BCI components. In this manner, it might be possible to drive standard and state-of-the-art application using BCI and at a limited maintenance cost.

This contract is part of the AMDT initiative.

8.1.1.2. ADT OpenMEEG

Participants: Théodore Papadopoulo, Maureen Clerc, Kostiantyn Maksymenko, Alexandre Gramfort [PARIETAL], Joan Massich [PARIETAL].

Duration: *24 months.*

The OpenMEEG ADT aims at improving OpenMEEG along 3 main directions:

1. Offer a user interface for the creation and verification of head models most importantly for a simpler management of non-nested head models.
2. Improve the Python interface (extension and reliability). This will also be useful to develop new research axes (in connection with point 3).
3. Enrich the available operators and refactor the code to offer new possibilities in OpenMEEG and reduce the cost of maintenance.

In addition to the expected gains in code maintenance, these improvements will allow a number of new – more sophisticated – applications as well as open OpenMEEG to a larger audience with a simplified interface for classical use-cases.

This contract is part of the AMDT initiative.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. ERC AdG CoBCoM

Program: H2020-EU.1.1. (ERC-ADG-2015 - ERC Advanced Grant)

Project acronym: CoBCoM - **ID:** 694665

Project title: *Computational Brain Connectivity Mapping*

Start date: 2016-09-01, End date: 2021-08-31

P.I. : R. Deriche

Partners: ATHENA project-team

Abstract:

One third of the burden of all the diseases in Europe is due to problems caused by diseases affecting brain. Although exceptional progress has been obtained for exploring it during the past decades, **the brain is still terra-incognita** and calls for specific research efforts to better understand its architecture and functioning.

COBCOM is our response to this great challenge of modern science with the overall goal to **develop a joint Dynamical Structural-Functional Brain Connectivity Network** (DSF-BCN) solidly grounded on advanced and integrated methods for diffusion Magnetic Resonance Imaging (dMRI) and Electro & Magneto-Encephalography (EEG & MEG).

To take up this grand challenge and achieve new frontiers for brain connectivity mapping, we will develop a new generation of computational models and methods for identifying and characterizing the structural and functional connectivities that will be at the heart of the DSF-BCN. Our strategy is to break with the tradition to incrementally and separately contributing to structure or function and develop **a global approach involving strong interactions between structural and functional connectivities.** To solve the limited view of the brain provided just by one imaging modality, our models will be developed under a rigorous computational framework integrating complementary non invasive imaging modalities: dMRI, EEG and MEG.

COBCOM will push far forward the state-of-the-art in these modalities, developing **innovative models and ground-breaking processing tools** to provide in-fine a joint DSF-BCN solidly grounded on a detailed mapping of the brain connectivity, both in space and time.

Capitalizing on the strengths of dMRI, MEG & EEG methodologies and building on the **bio-physical and mathematical foundations** of our new generation of computational models, COBCOM will be applied to high-impact diseases, and its **ground-breaking computational nature and added clinical value** will open new perspectives in neuroimaging.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Declared Inria International Partners

- Sherbrooke University, CA (M. Descoteaux)
- CMRR, University of Minnesota, USA (C. Lenglet)
- Verona University, It (G. Menegaz)
- Department of CISE, the University of Florida, Gainesville, USA (B. C. Vemuri)
- Centre for Medical Image Computing (CMIC), Dept. Computer Science, UCL, UK (D. Alexander)
- SBIA, University of Pennsylvania Medical School, USA (R. Verma).
- EEMagine company on EEG/MEG hardware.

8.3.2. Participation in Other International Programs

- University Houari Boumedienne (USTHB, Algiers) (L. Boumghar) and University of Boumerdes, (D. Cherifi), Algeria.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Pr Gloria Menegaz, Department of Computer Science, University of Verona (March 23 - Sept 20, 2019)

8.4.1.1. Internships

- Imogen Den otter-Moore - Queen's University, Kingston, Canada, From early May to late July, 2019
- Federica Cruciani - Department of Computer Science, University of Verona (March 1 - June 30, 2019)
- Enes Albay - Ph.D. student in Computer Engineering (Cont.), Istanbul Technical University, From Nov. 4, 2019 to Oct. 3, 2020.

BEAGLE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- CPER LECO++: Parallel HPC architectures evolve and the calculation codes are naturally bound to vary over time. Indeed, the architectures change every 2-3 years while the lifespan of a scientific code is much longer (at least 10 years). Knowing how to control the impacts of these changes in order to automatically adapt the digital simulation codes to maintain a high level of performance is a necessity to guarantee a certain sustainability of the developed code. Currently, these variations are manually managed by programmers which require a high level of expertise as well as time.

  A collaboration between the AVALON teams from LIP and BEAGLE from LIRIS on this subject involved one master trainees this year (funding from Federation Informatique de Lyon – PMSISEE project). More specifically, BEAGLE is interested in designing AEVOL a high performance parallel code for simulating the evolution of a population of bacteria. The different parts of the code have been adapted to the hardware characteristics of current architectures (multicore, vector computing, etc.) for which certain operations have several implementations (CPU or vector) or several parallel variants. Designing the assembly of the right versions and choosing the right parameters remains a difficult problem. In this issue, the AVALON team brings its expertise in the development and exploitation of component models, in parallel programming models and in the expertise of executive supports for HPC.

  A PhD thesis between Avalon and Beagle (Laurent Turpin) linked to the CPER LECO++ project (coordinator: T. Gautier, AVALON) has started with the aim of studying the robustness of computer codes on modern parallel architectures and their evolution. Thus, the targeted hardware is that being acquired through the LECO++ project (ARM machine, massively multi-GPU (10)).

  The work of this thesis aims to study the methods and approaches allowing to contribute to a solution to the problems of composition, choice of parameters and efficient execution on a parallel architecture in HPC. The problem addressed in the thesis concerns the portability of the performance of a parallel application for managing code variants and variations at runtime. The solutions that will be studied will be those at the interface between a programming model and its exploitation by executive support. In order to exploit the performance of a class of machines in a portable manner, the candidate will propose the necessary adaptations, whether to the existing component-based programming model (typically Comet) and to executive support (OpenMP type or an executive engine with task base). A major constraint of this work is the performance at execution: the evaluation will be based on an experimental methodology with AEVol as target application. The target hardware is that of an HPC computing node of tomorrow: a multi-core server coupled with a large number of hardware accelerators - GPUs - allowing to have a significant computing density (approximately from 30 to 128 TFlops double precision for 4 to 16 GPUs).

8.2. National Initiatives

8.2.1. ANR

- Evoluthon (2019-2022): Artificial Life as a benchmark for evolutionary studies, a 4-year project leaded by E Tannier with 2 partners, Beale Inria and Le Cocon, LBBE.
- Dopaciumcity (2014-2018): Dopamine modulation of calcium influx underlying synaptic plasticity, a 4-year project funded by a grant from the ANR-NSF-NIH Call for French-US Projects in Computational Neuroscience. With L. Venance, College de France, CIRB, CNRS/UMR 7241 - INSERM U1050, Paris, France and K Blackwell, Krasnow Institute of Advanced Studies, George Mason University, Fairfax, VA, USA. Supervisor: L Venance (for France) and K.L. Blackwell (for US). Participants: H Berry, I Prokin, A Foncelle

- Dallish (2016-2020): Data Assimilation and Lattice LIght SHeet imaging for endocytosis/exocytosis pathway modeling in the whole cell, Call AAPG ANR 2016. With C. Kervrann (Inria Rennes), J. Salamero (Institute Curie, Paris), B. Laroche (INRA, Jouy-en-Josas). Participants: H. Berry.
- Storiz (2018-2020): Horizontal transfers as documents from extinct or unknown species. Call ANR JCJC 2018. Leaded by Damien de Vienne (LBBE, Lyon) Participant: Eric Tannier
- LncEvoSys (2017-2019): An evolutionary systems approach to understand long non-coding RNA functionality, Call ANR JCJC 2017. Leaded by Anamaria Necsulea (LBBE, Lyon). Participant: Eric Tannier

8.2.2. Inria

- Naviscope (Inria Project Lab, 2018-2022): image-guided Navigation and VIsualization of large data sets in live cell imaging and microSCOPy. Nowadays, the detection and visualization of important localized events and process in multidimensional and multi-valued images, especially in cell and tissue imaging, is tedious and inefficient. Specialized scientists can miss key events due to complexity of the data and the lack of computer guidance. In Naviscope we develop original and cutting-edge visualization and navigation methods to assist scientists, enabling semi-automatic analysis, manipulation, and investigation of temporal series of multi-valued volumetric images, with a strong focus on live cell imaging and microscopy application domains. We build Naviscope upon the strength of scientific visualization and machine learning methods in order to provide systems capable to assist the scientist to obtain a better understanding of massive amounts of information. Such systems will be able to recognize and highlight the most informative regions of the dataset by reducing the amount of information displayed and guiding the observer attention. Head: C. Kervrann (Serpico), other EPIs: Aviz, Beagle, Hybrid, Morpheme, Mosaic, Parietal, and MaIage (INRA unit).
- Action Exploratoire "Community Garden Book": IPBES's recent report on declining biodiversity calls for generalization of agroecological, productive, biodiversity and environmental friendly methods, oriented towards participatory action research. This exploratory action is a proposal to develop tools from open science, evolution science and algorithmics for the co-construction and use of an agroecological network of interactions between groups, species, varieties found in fields and gardens.
- Action Exploratoire ExODE: In biology, the vast majority of systems can be modeled as ordinary differential equations (ODEs). Modeling more finely biological objects leads to increase the number of equations. Simulating ever larger systems also leads to increasing the number of equations. Therefore, we observe a large increase in the size of the ODE systems to be solved. A major lock is the limitation of ODE numerical resolution so ware (ODE solver) to a few thousand equations due to prohibitive calculation time. The AEx ExODE tackles this lock via 1) the introduction of new numerical methods that will take advantage of the mixed precision that mixes several floating number precisions within numerical methods, 2) the adaptation of these new methods for next generation highly hierarchical and heterogeneous computers composed of a large number of CPUs and GPUs. For the past year, a new approach to Deep Learning has been proposed to replace the Recurrent Neural Network (RNN) with ODE systems. The numerical and parallel methods of ExODE will be evaluated and adapted in this framework in order to improve the performance and accuracy of these new approaches.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Declared Inria International Partners

- Beagle is a member of the CNRS Laboratoire International Associé “EvoAct” (Evolution in Action). Other members of EvoAct are the TIMC-IMAG (Grenoble) and the Beacon Center (Michigan State University, USA).

8.3.1.2. Informal International Partners

- Collaboration with Alexander Fleischmann at Brown University (USA) on neuro-evo-devo.
- Collaboration with Cedric Chauve, SFU, Vancouver (Canada) on phylogeny and rearrangements.
- Collaboration with Tom Williams, Bristol (UK) on phylogeny.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- We welcomed Leonardo Trujillo (Venezuela) as a visiting professor from January 2019 to July 2019. Leonardo Trujillo worked on the innovation dynamics in evolution using NK Fitness-Landscapes.
- Corrado Cali, BESE Division, KAUST University, Saudi Arabia, 1 week in november

8.4.1.1. Internships

- Barbara Genocchi (PhD candidate, Tampere University of Technology, Tampere, Finland) visited us for 16 days (Sept 9 - Sept 24).

BIGS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- Lorraine Université d'Excellence LUE, Impact Project GEENAGE (Functional **G**enomic, **E**pigenomic and **EN**vironment interplay to imptact the understanding, diagnosis and management of healthy and pathological **AGE**ing). Anne Gégout-Petit, Lionel Lenôtre, Emma Horton.

9.2. National Initiatives

- FHU CARTAGE (Fédération Hospitalo Universitaire Cardial and ARTerial AGEing ; leader : Pr Athanase Benetos), Jean-Marie Monnez, Benoît Lalloué, Anne Gégout-Petit.
- RHU Fight HF (Fighting Heart Failure ; leader : Pr Patrick Rossignol), located at the University Hospital of Nancy, Jean-Marie Monnez, Benoît Lalloué.
- Project "Handle your heart", team responsible for the creation of a drug prescription support software for the treatment of heart failure, head: Jean-Marie Monnez
- A. Gégout-Petit, N. Sahki, S. Mézières are involved in the learning aspect of the clinical protocol "EOLEVAL" with Assistance Publique des Hopitaux de Paris (APHP)
- "ITMO Physics, mathematics applied to Cancer" (2017-2019): "Modeling ctDNA dynamics for detecting targeted therapy", Funding organisms: ITMO Cancer, ITMO Technologies pour la santé de l'alliance nationale pour les sciences de la vie et de la santé (AVIESAN), INCa, Leader: N. Champagnat (Inria TOSCA), Participants: A. Gégout-Petit, A. Muller-Gueudin, P. Vallois.
- PEPS AMIES (2019-2020), Etude Biométrique en foetopathologie et développement de l'enfant, Collaboration between Institut Elie Cartan and the CRESS INSERM, S. Ferrigno.
- Modular, multivalent and multiplexed tools for dual molecular imaging (2017-2020), Funding organism: ANR, Leader: B Kuhnast (CEA). Participant: T. Bastogne.
- Sophie Mézières belongs to GDR 720 ISIS, Funding organism: CNRS, leader: Laure Blanc-Féraud.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

Juhyun Park from Bath University spent a week in Nancy in June 2019 to work on tests for paired distributions in the framework of functional analysis with Anne Gégout-Petit.

BIOCORE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. National programmes

- **ANR-Phycover:** The overall objective of the PHYCOVER project (2014-2018) is to identify a modular wastewater treatment process for the production of biogas. The method combines three modules. First, a high-rate algal pond is dedicated to the treatment of municipal wastewater. Then, an anaerobic digester capable of co-digesting biomass products (and others organic matter resources) to significantly reduce biological and chemical contaminants while producing a sustainable energy as biogas is analysed. A final module transforms the residual carbon, nitrogen and phosphorus into high-value microalgae dedicated to aquaculture and green chemistry.
- **ITE-OPALE:** The goal of the Institut de la Transition Énergétique - OPALE project (2016-2019) is to increase the lipid content of microalgae by specific selection pressure. The project relies on the strain already selected during the Facteur 4 project, whose productivity was 4 times higher than the wild type. We expect to still increase strain performances up to 10 times the productivity of the wild type. This project was unexpectedly arrested by the funding agency on April 2019.
- **ADEME Phytorecolt:** The goal of this project (2017-2019) is to develop an automated and optimized procedure for microalgae harvesting. A project coordinated by H. Bonnefond.
- **ANR-ICycle:** This project (2016-2020) aims at understanding the communication pathways between the cell division cycle and the circadian clock, using mathematical modeling and control theory to construct and implement two coupled synthetic biological oscillators. Project coordinated by M. Chaves.
- **ANR - Maximic:** The goal of the project (2017-2021) is to design and implement control strategies in a bacterium for producing at maximal rate a high value product. It is coordinated by H. de Jong (IBIS Grenoble), and involves members of Biocore and McTao.
- **Plan Cancer - Imodrez:** The objective of this project (2018-2021) is to understand cancer drug response heterogeneity using tumor single-cell dynamics and developing mathematical models and computational approaches. A project coordinated by J. Roux (IRCAN) and funded by Inserm - Plan Cancer.
- **SIGNALIFE:** Biocore is part of this Labex (scientific cluster of excellence) whose objective is to build a network for innovation on Signal Transduction Pathways in life Sciences, and is hosted by the University of Nice Sophia Antipolis.
- **UMT FIORIMED:** FioriMed is a Mixed Technology Unit created in January 2015 to strengthen the production and dissemination of innovation to the benefit of ornamental horticulture. Horticultural greenhouses are seen as a "laboratory" for the actual implementation of agroecology concepts with the possibility of generic outcomes being transfered to other production systems. The main partners of UMT FioriMed are ASTREDHOR (National Institute of Horticulture) and the ISA Joint Research Unit of INRA-CNRS-Univ. Nice.
- **EcoPhyto - CeraTIS Corse:** “Territorial management of the Mediterranean fruit fly in Corsica by the Sterile Insect Technique” (2020-2022). This project is based on a pilot field experiment of sterile male releases and it integrates population dynamics and socio-economic approaches.
- **EcoPhyto - INTERLUDE:** “Territorial innovations to reduce phytoparmaceutical products for the sustainable production of vegetable crops” (2020-2022). BIOCORE members participate in a case study that focuses on the agroecological management of soil pests and pathogens in Provence.

9.1.2. Inria funding

- **Inria Project Lab, Algae** *in silico***:** (2014-2019) The Algae in silico Inria Project Lab, funded by Inria and coordinated by O. Bernard, focuses on the expertise and knowledge of biologists, applied mathematicians and computer scientists to propose an innovative numerical model of microalgal culturing devices. The latest developments in metabolic modeling, hydrodynamic modeling and process control are joined to propose a new generation of advanced simulators in a realistic outdoor environment. The project gathers 5 Inria project teams and 3 external teams.
- **Inria Project Lab, Cosy:** (2017-...) This proposal aims at exploiting the potential of state-of-art biological modeling, control techniques, synthetic biology and experimental equipment to achieve a paradigm shift in control of microbial communities. We will investigate, design, build and apply an automated computer-driven feedback system for control of synthetic microbial communities, not just accounting for but rather leveraging population heterogeneity in the optimal accomplishment of a population-level task. The development of methodologies of general applicability will be driven by and applied to two different applications closely connected with real-world problems in the biomedical and biotechnological industry. The consortium is composed of the four Inria project-teams IBIS, BIOCORE, COMMANDS, VALSE, INBIO, as well as the external partners BIOP (Université Grenoble Alpes, including members of IBIS), MaIAge (INRA), and YoukLAB (TU Delft).

9.1.3. INRA funding

- **MoGeR:** “From knowledge to modeling: towards a user-friendly simulation tool to test crop resistance management scenarios in the Phoma-oilseed rape case study”, INRA Metaprogramme SMaCH, 2017–2019. This is a follow-up of the K-Masstec project, which focused on sustainable strategies for the deployment of genetic resistance in the field, based on molecular knowledge on avirulence genes.
- **ABCD:** INRA SPE is funding the project ABCD "Augmentative Biological Control; optimizing natural ennemies Deployment" (2017-2019) in which Biocore is a partner with INRA Sophia Antipolis.
- **IMMUnE:** INRA SPE is funding the project IMMUnE "Immunité et Modélisation Mathématique pour Unifier l’Epidémiologie" (2019-2021), headed by F. Hamelin (Agrocampus Ouest), in which BIOCORE is a partner.

9.1.4. Networks

- **ModStatSAP:** The objective of this INRA network is to federate researchers in applied mathematics and statistics and to promote mathematical and statistical modeling studies in crop and animal health. S. Touzeau is a member of the scientific committee.
- **Seminar:** BIOCORE organizes a regular seminar “Modeling and control of ecosystems” at the station zoologique of Villefranche-sur-Mer, at INRA-ISA or at Inria.

9.2. European Initiatives

9.2.1. Collaborations in European Programs, Except FP7 & H2020

Program: **PHC-Pessoa** Partenariat Hubert Curien with Portugal, managed by Campus France

Project acronym: **LTSB**

Project title: Logic Tools for Systems Biology

Duration: 01/2019 - 12/2019

Coordinator: M. Chaves

Other partners: M.A. Martins, University of Aveiro

Abstract: This project aims at developing Boolean, piecewise linear and other hybrid tools for analysis of biological networks.

9.2.2. Collaborations with Major European Organizations

Imperial college, Department of Chemical engineering (UK),

Modelling and optimization of microalgal based processes.

University of Padova, Italy.

Modelling and control of microalgal production at industrial scale.

9.3. International Initiatives

9.3.1. Inria International Labs

Inria Chile
Associate Team involved in the International Lab:

9.3.1.1. GREENCORE

Title: Modelling and control for energy producing bioprocesses

International Partners (Institution - Laboratory - Researcher):

PUCV (Chile) - Escuela de Ingenieria Bioquimica (EIB) - David Jeison

UTFSM (Chile) - Departamento de Matematica - Pedro Gajardo

Univ. Chile (Chile) - Centro de modelacion matematica - Hector Ramirez

Inria coordinator: O. Bernard

Start year: 2014

See also: https://team.inria.fr/eagreencore/

The worldwide increasing energy needs together with the ongoing demand for CO2 neutral fuels represent a renewed strong driving force for the production of energy derived from biological resources. In this scenario, the culture of oleaginous microalgae for biofuel and the anaerobic digestion to turn wastes into methane may offer an appealing solution. The main objective of our proposal is to join our expertise and tools, regarding these bioprocesses, in order to implement models and control strategies aiming to manage and finally optimize these key bioprocesses of industrial importance. By joining our expertise and experimental set-up, we want to demonstrate that closed loop control laws can significantly increase the productivity, ensure the bioprocess stability and decrease the environmental footprint of these systems. This project gathers experts in control theory and optimization (BIOCORE, UTFSM) together with experts in bioprocesses (PUCV and CMM) and software development.

International Laboratory for Research in Computer Science and Applied Mathematics
Associate Team involved in the International Lab:

9.3.1.2. EPITAG

Title: Epidemiological Modelling and Control for Tropical Agriculture

International Partner (Institution - Laboratory - Researcher):

Université de Douala (Cameroon) - Département de Mathématique et Informatique - Samuel Bowong

Inria coordinator: S. Touzeau

Start year: 2017

See also: https://team.inria.fr/epitag/

EPITAG gathers French and Cameroonian researchers, with a background in dynamical systems and control and with an interest in crop diseases. Crop pests and pathogens are responsible for considerable yield losses and represent a threat to food security. Their control is hence a major issue, especially in Cameroon, where agriculture is an important sector in terms of revenues and employment. To help design efficient strategies for integrated pest management, mathematical models are particularly relevant. Our main objective is to study the epidemiology and management of tropical crop diseases, with a focus on Cameroon and Sub-Saharan Africa. Our approach consists in developing and analysing dynamical models describing plant-parasite interactions, in order to better understand, predict and control the evolution of damages in crops. To ensure the relevance of our models, field experts and stakeholders need to be closely associated. We will focus on pest and pathogens that affect major staple food and cash crops, such as cocoa plant mirids, plantain and banana plant-parasitic nematodes, coffee berry borers, coffee leaf rust, maize stalk borers, cabbage diamondback moths, papaya mealybugs, etc. To tackle these issues, we jointly supervise master and PhD students.

9.3.2. Inria International Partners

- NTNU (Norwegian University of Science and Technology), Trondheim, Norway. The project involves turning wastes into bioenergy with anaerobic digestion. O. Bernard spent a one year sabbatical at NTNU in the Enersene group working on renewable energy.

9.3.3. Participation in Other International Programs

- Univ. Ben Gurion : Microalgal Biotechnology Lab (Israel), Member of the ESSEM COST Action ES1408 European network for algal-bioproducts (EUALGAE). Modelling of photosynthesis.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Daniel Figueiredo, University of Aveiro, Portugal, 02-06 Sep. 2019. Visit in the context of PHC-Pessoa project to work on the development of logical tools for systems biology.

Israël Tankam Chedjou, University of Yaoundé 1, Cameroon, Feb.-Jun. 2019. Visit in the context of the EPITAG associate team.

Yves Fotso Fotso, University of Dschang, Cameroon, Mar.-Jul. 2019. Visit in the context of the EPITAG associate team.

Clotilde Djuikem, University of Douala, Cameroon, Mar.-Jul. 2019. Visit in the context of the EPITAG associate team.

9.4.2. Visits to International Teams

9.4.2.1. Sabbatical programme

O. Bernard spent a one year sabbatical at NTNU (Norwegian University of Science and Technology), Trondheim, Norway. He worked on a project to turn wastes into bioenergy with anaerobic digestion.

9.5. Project-team seminar

BIOCORE organized a 3-day seminar in September at Peyresq (Alpes-de-Haute-Provence). On this occasion, every member of the project-team presented his/her recent results and brainstorming sessions were organized.

BIOVISION Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. Trajectory

Title: Encoding and predicting motion trajectories in early visual networks

Programme: ANR

Duration: October 2015 - September 2020

Coordinator: Invibe Team, Institut des Neurosciences de la Timone, Frédéric Chavane,

Partners:

Institut de Neurosciences de la Timone (CNRS and Aix-Marseille Université, France)

Institut de la Vision (IdV), Paris, France

Universidad Tecnico Federico Santa María (Electronics Engineering Department, Valparaíso, Chile)

Inria contact: Bruno Cessac

Global motion processing is a major computational task of biological visual systems. When an object moves across the visual field, the sequence of visited positions is strongly correlated in space and time, forming a trajectory. These correlated images generate a sequence of local activation of the feed-forward stream. Local properties such as position, direction and orientation can be extracted at each time step by a feed-forward cascade of linear filters and static non-linearities. However such local, piecewise, analysis ignores the recent history of motion and faces several difficulties, such as systematic delays, ambiguous information processing (e.g., aperture and correspondence problems) high sensitivity to noise and segmentation problems when several objects are present. Indeed, two main aspects of visual processing have been largely ignored by the dominant, classical feed-forward scheme. First, natural inputs are often ambiguous, dynamic and non-stationary as, e.g., objects moving along complex trajectories. To process them, the visual system must segment them from the scene, estimate their position and direction over time and predict their future location and velocity. Second, each of these processing steps, from the retina to the highest cortical areas, is implemented by an intricate interplay of feed-forward, feedback and horizontal interactions. Thus, at each stage, a moving object will not only be processed locally, but also generate a lateral propagation of information. Despite decades of motion processing research, it is still unclear how the early visual system processes motion trajectories. We, among others, have proposed that anisotropic diffusion of motion information in retinotopic maps can contribute resolving many of these difficulties. Under this perspective, motion integration, anticipation and prediction would be jointly achieved through the interactions between feed-forward, lateral and feedback propagations within a common spatial reference frame, the retinotopic maps. Addressing this question is particularly challenging, as it requires to probe these sequences of events at multi-scale (from individual cells to large networks) and multiple stages (retina, primary visual cortex (V1)). “TRAJECTORY” proposes such an integrated approach. Using state-of-the-art micro- and mesoscopic recording techniques combined with modeling approaches, we aim at dissecting, for the first time, the population responses at two key stages of visual motion encoding: the retina and V1. Preliminary experiments and previous computational studies demonstrate the feasibility of our work. We plan three coordinated physiology and modeling work-packages aimed to explore two crucial early visual stages in order to answer the following questions: How is a translating bar represented and encoded within a hierarchy of visual networks and for which condition does it elicit anticipatory responses? How is visual processing shaped by the recent history of motion along a more or less predictable trajectory? How much processing happens in V1 as opposed to simply reflecting transformations occurring already in the retina? The project is timely because partners master new tools such as multi-electrode arrays and voltage-sensitive dye imaging for investigating the dynamics of neuronal populations covering a large segment of the motion trajectory, both in retina and V1. Second, it is strategic: motion trajectories are a fundamental aspect of visual processing that is also a technological obstacle in computer vision and neuroprostheses design. Third, this project is unique by proposing to jointly investigate retinal and V1 levels within a single experimental and theoretical framework. Lastly, it is mature being grounded on (i) preliminary data paving the way of the three different aims and (ii) a history of strong interactions between the different groups that have decided to join their efforts.

9.2. European Initiatives

9.2.1. Collaborations in European Programs, Except FP7 & H2020

- Program: Leverhulme Trust
- Project acronym:
- Project title: A novel approach to functional classification of retinal ganglion cells
- Duration: 2017-2020
- Coordinator: Evelyne Sernagor, Institute of Neuroscience (ION), Newcastle, UK
- Inria contact: Bruno Cessac
- Other partners:

  Melissa Bateson Institute of Neuroscience (ION), Newcastle, UK

  Matthias Hennig Institute for Adaptive and Neural Computation (ANC, School of Informatics University of Edinburgh, UK)

  Gerrit HilgenInstitute of Neuroscience (ION), Newcastle, UK
- Abstract: Vision begins with photoreceptors converting light from different parts of the visual scene into electrical signals, compressing our visual world into a parsimonious code of impulses at the retinal output level, the retinal ganglion cells (RGCs). This information is sent to the brain via only $\approx$1m RGCs (45,000 in mouse). Amazingly, the brain can recreate images from interpreting these "barcodes" or trains of impulses. This ability is partly due to the astonishing functional diversity of RGCs, each interpreting a different feature of the visual scene. It is all these parallel streams of information that impart the complexity of visual scenes to our brain visual areas. At present, at least 30 RGC subtypes have been identified. Classification is typically based on common anatomical features, or on basic functions (e.g. whether cells respond to the onset or offset of the light, or whether they are sensitive to motion direction) and it has recently progressed to include molecular markers. Recent studies have successfully characterised common physiological properties between RGCs sharing gene expression, suggesting that their molecular signature may indeed be a good indicator of function. However, according to mouse genetics repositories (e.g., the Allen Brain Project) many genes are expressed in subpopulations of RGCs for which we have no phenotype yet. Genes that are expressed in most RGCs probably do not reflect specific functional populations, but some other genes are expressed only in sparse RGC groups. Each gene-specific class exhibits a distinct spatial mosaic pattern across the retina, suggesting that the cells belong to a common group. Many classes, even sparse, exhibit asymmetric distributions across the retina, e.g., with larger numbers on the ventral or dorsal side, suggesting specific roles in ecological vision, e.g., specialised in detecting moving objects in the sky (ventral) or on the ground (dorsal).

  We propose to develop a multidisciplinary approach to functionally phenotype new RGC subclasses sharing gene expression. Rather than inferring knowledge about the entire population from studying individual cells, we will take a global approach based on large-scale, high-density pan-retinal recordings, pharmacogenetics (allowing us to selectively silence defined cell populations at will) and high-resolution imaging combined with computational approaches and behaviour. This novel approach necessitates collaboration between retinal neurophysiologists, animal behaviour specialists (Newcastle) and modellers (Inria) who specialise in visual processing and have sophisticated mathematical tools and software to handle and interpret the encoding of visual information at the pan-retinal level.

9.3. International Initiatives

9.3.1. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

9.3.1.1. MAGMA

Title: Modelling And understandinG Motion Anticipation in the retina

International Partner (Institution - Laboratory - Researcher):

Universidad Técnica Federico Santa Marı´a, Valparaiso (Chile) - Department of Electric Engineering - Maria-José Escobar

Start year: 2019

See also: https://team.inria.fr/biovision/associated-team-magma/.

Motion processing represents a fundamental visual computation ruling many visuomotor features such as motion anticipation which compensates the transmission delays between retina and cortex, and is fundamental for survival. We want to strengthen an existing collaborative network between the Universidad de Valparaiso in Chile and the Biovision team, gathering together skills related with physiological recording in the retina, data analysis numerical platforms and theoretical tools to implement functional and biophysical models aiming at understanding the mechanisms underlying anticipatory response and the predictive coding observed in the mammalian retina, with a special emphasis on the role of lateral connectivity (amacrine cells and gap junctions).

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Helene Schreyer (University of Göttingen, Germany)

Dr Cyril Eleftheriou (IIT, Genova)

R. Cofré (Universidad Valparaíso, Chile).

9.4.1.1. Internships

- **September-November 2019 (M1).** Ignacio Ampuero, Université de Valparaiso.
- **March-August 2019 (M1).** Min-Toan Nguyen, Cycle Ingénieur Polytechnicien 3A. (co-direction with A. Muzy (I3S) et P. Reynaud-Bourret (LJAD)).
- **March-May 2019 (M1)** Safia Mensor, Master Mod4NeuCog (co-direction with A. Guyon (IPMC)) [35].
- **March-May 2019 (M1) et September 2019 - February 2020 (M2)** Simone Ebert, Master Mod4NeuCog (Co-direction with O. Marre Institut de la Vision (IdV), Paris, France et R. Veltz (Mathneuro)).
- **March-August 2019 (M2)** Téva Andreoletti, ENSEA Cergy.

CAMIN Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- Occitanie Region finances half of the PhD thesis salary of Lucie William.
- Occitanie Region gave a grant to CAMIN for the PhD thesis of XinYue Lu (PILE-CIFRE) - 10.000 euros.

8.2. National Initiatives

- Inria ADT STIMBIO

  Participants : Christine Azevedo, Daniel Simon, Ronan Le Guillou, Benoît Sijobert.

  A 1-year engineer (R. LeGuillou) was funded by Inria ADT on the development of an architecture dedicated to FES-cycling platform.
- I-SITE MUSE COMPANIES AND CAMPUS grant - SPINSTIM project

  Collaboration with academic local partners (CHU, IES) and NEURINNOV company on the spinal stimulation for bladder and bowel functions restoration. This is linked to an ongoing collaboration with Oslo University (Norway).
- LABEX NUMEV - MEDITAPARK project Collaboration with Montpellier Hospital (Neurology service) and the Montpellier Mindfulness Center to analyze the impact of meditation on upper limb tremor.
- EDF Foundation - CYCLOSEF project

  Collaboration with La Châtaigneraie Hospital on FES-assisted cycling. Financial support for a study on FES-cycling training method and performance otimization on individuals with complete spinal cord injury.
- I-SITE MUSE - EXPLORE

  Support for the visit of Henrique Resende (UFMG, Brazil) and Emersion Fachin (UNB, Brazil) as guest researchers from December to February 2019. Completed with a LIRMM laboratory financial aid.
- I-SITE MUSE - EXPLORE

  Support for the visit of François Bonnetblanc at the Karolinska institute Hospital, Neurosurgery and Neurology Department
- ANR Grasp-It (2019-2023) - Leader LORIA, Nancy.

8.3. European Initiatives

8.3.1. Collaborations with Major European Organizations

CAMIN team is leader of a EIT Health project "AGILIS" on Grasping rehabilitation in individuals with quadriplegia (http://www.lirmm.fr/camin/agilis-project/).

8.4. International Initiatives

8.4.1. Inria Associate Teams Not Involved in an Inria International Labs

8.4.1.1. CACAO

Title: Lower limb electrical stimulation for function restoration

International Partner (Institution - Laboratory - Researcher):

UNB (Brazil) Physiology Faculty - FACHIN-MARTINS Emerson

Start year: 2019

See also: https://team.inria.fr/cacao/

The CACAO team has developed an expertise in the application of electrical stimulation for assisting seat-to-seat transfers and pedaling for people with paraplegia. The team shared a unique experience in 2016 by participating in the first Cybathlon techno-sports games with a Brazilian driver and a French driver in the assisted bicycle race. The team wishes to continue the work by optimizing the quality of pedaling to participate in the Cybathlon 2020 and extending the technique for the rehabilitation of patients with hemiplegia in a rehabilitation context.

8.4.1.2. Informal International Partners

We have an ongoing informal collaboration with Andrew Murray (DIMLAB, Dayton University) on the design of complex mechanisms in the context of cycling (trike design) and grasping (orthosis design).

8.5. International Research Visitors

Henrique Resende (UFMG, Brazil) and Emerson Fachin (UNB, Brazil) spent 3 months in CAMIN team from December 2018 to February 2019 to work on FES-cycling project (I-SITE MUSE Explore program and LIRMM support).

8.5.1. Internships

Camilo Silva is achieving a 6-months ERASMUS internship in the team on motion recognition using Deep Learning techniques.

CAPSID Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. CPER – IT2MP

Participants: Marie-Dominique Devignes [contact person], Malika Smaïl-Tabbone, David Ritchie.

Project title: *Innovations Technologiques, Modélisation et Médecine Personnalisée*; PI: Faiez Zannad, Université de Lorraine (Inserm-CHU-UL). Value: 14.4 M€ ("SMEC" platform – Simulation, Modélisation, Extraction de Connaissances – coordinated by Capsid and Orpailleur teams for Inria Nancy – Grand Est, with IECL and CHRU Nancy: 860 k€, approx); Duration: 2015–2020. Description: The IT2MP project encompasses four interdisciplinary platforms that support several scientific pôles of the university whose research involves human health. The SMEC platform supports research projects ranging from molecular modeling and dynamical simulation to biological data mining and patient cohort studies.

8.1.2. LUE-FEDER – CITRAM

Participants: Marie-Dominique Devignes [contact person], Isaure Chauvot de Beauchêne, Bernard Maigret, Philippe Noel, Dominique Mias-Lucquin, Antoine Moniot, David Ritchie.

Project title: *Conception d'Inhibiteurs du Transfert de Résistances aux agents Anti-Microbiens: bio-ingénierie assistée par des approches virtuelles et numériques, et appliquée à une relaxase d'élément conjugatif intégratif*; PI: N. Leblond, Université de Lorraine (DynAMic, UMR 1128); Other partners: Chris Chipot, CNRS (LPCT, UMR 7565); Value: 200 k€ (Capsid: 80 k€); Duration: 2017–2018. Description: This project follows on from the 2016 PEPS project "MODEL-ICE". The aim is to investigate protein-protein interactions required for initiating the transfer of an ICE (Integrated Conjugative Element) from one bacterial cell to another one, and to develop small-molecule inhibitors of these interactions.

8.1.3. IMPACT GeenAge

Participant: Marie-Dominique Devignes [contact person].

The IMPACT project GeenAge (Lorraine Université d'Excellence) is composed of four axes dedicated to research in high-throughput molecular biology. The Capsid team is involved in a transversal axis for numerical sciences. In the frame of this project, Marie-Dominique Devignes co-supervises with Amedeo Napoli a post-doc hired by the Orpailleur team. She is also responsible with Thierry Bastogne (CRAN) and Anne Gegout-Petit (IECL) for creating a Center of Competencies in Artificial Intelligence and Health.

8.2. National Initiatives

8.2.1. FEDER – SB-Server

Participants: Marie-Dominique Devignes [contact person], Bernard Maigret, Isaure Chauvot de Beauchêne, Sabeur Aridhi, David Ritchie.

Project title: *Structural bioinformatics server*; PI: David Ritchie, Capsid (Inria Nancy – Grand Est); Value: 24 k€; Duration: 2015–2020. Description: This funding provides a small high performance computing server for structural bioinformatics research at the Inria Nancy – Grand Est centre.

8.2.2. ANR

8.2.2.1. FIGHT-HF

Participants: Marie-Dominique Devignes [contact person], Malika Smaïl-Tabbone [contact person], Emmanuel Bresso, Bernard Maigret, Sabeur Aridhi, Kévin Dalleau, Claire Lacomblez, Gabin Personeni, Philippe Noel, David Ritchie.

Project title: *Combattre l'insuffisance cardiaque : Projet de Recherche Hospitalo-Universitaire FIGHT-HF*; PI: Patrick Rossignol, Université de Lorraine (FHU-Cartage); Value: 9 m€ (Capsid and Orpailleur: 450 k€, approx); Duration: 2015–2020. Description: This "Investissements d'Avenir" project aims to discover novel mechanisms for heart failure and to propose decision support for precision medicine. The project has been granted € 9M, and involves many participants from Nancy University Hospital's Federation "CARTAGE". Marie-Dominique Devignes and Malika Smaïl-Tabbone are coordinating a work-package dedicated to network-based science, decision support and drug discovery for this project.

8.2.2.2. IFB

Participants: Marie-Dominique Devignes [contact person], Sabeur Aridhi, Isaure Chauvot de Beauchêne, David Ritchie.

Project title: *Institut Français de Bioinformatique*; PI: Claudine Médigue and Jacques van Helden (CNRS UMS 3601); Value: 20 M€ (Capsid: 126 k€); Duration: 2014–2021. Description: The Capsid team is a research node of the IFB (Institut Français de Bioinformatique), the French national network of bioinformatics platforms (http://www.france-bioinformatique.fr). The principal aim is to make bioinformatics skills and resources more accessible to French biology laboratories. Marie-Dominique Devignes is coordinating with Alban Gaignard the Interoperability task in the Integrative Bioinformatics Workpackage.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. H2020 ITN RNAct

Participants: Isaure Chauvot de Beauchêne [contact person], Marie-Dominique Devignes, Malika Smaïl-Tabbone, Hrishikesh Dhondge, Anna Kravchenko, David Ritchie.

Program: H2020 Innovative Training Network

Project acronym:RNAct

Project title: Enabling proteins with RNA recognition motifs for synthetic biology and bio-analytics

Duration: octobre 2018 - octobre 2022

Coordinator: Wim Vranken (Vrije University Bruxelles, Belgium)

Other partners: Loria, CNRS (France), Helmholtz Center Munich (Germany), Conseio Superior de Investigaciones Cientificas, Instituto de Biologia Molecular y Celular de Plantas (Spain), Ridgeview instruments AB (Sweden), Giotto Biotech Srl (Italy), Dynamic Biosensors GmbH (Germany).

Abstract: This project aims at designing new proteins with "RNA recognition motifs (RRM)" that target a specific RNA, for exploitation in synthetic biology and bio-analytics. It combines approaches from sequence-based and structure-based computational biology with experimental biophysics, molecular biology and systemic biology. Our scientific participation regards the creation and usage of a large database on RRMs for KDD, and the development of RNA-protein docking methods.

URL: http://rnact.eu

8.3.2. Informal European Partners

EBI: European Bioinformatics Institute, Maria Martin team (UK). We are working with the EBI team to validate and improve our graph-based approaches for protein function annotation.

ELIXIR: 3D-bioinfo Community. We participated in the creation of the new ELIXIR 3D-bioinfo community. ELIXIR Communities enable the participation of communities of practice in different areas of the life sciences in the activities of ELIXIR. The goal is to underpin the evolution of data, tools, interoperability, compute and training infrastructures for European life science informatics (see https://www.elixir-europe.org/use-cases). ELIXIR supports its formally recognised Communities by providing funding for workshops and short collaborative projects associated with the Community. More specifically, Isaure Chauvot de Beauchene is member of the sub-section "Tools to describe, analyze, annotate, and predict nucleic acid structures" of this community.

ELIXIR: Interoperability Platform Marie-Dominique Devignes is collaborating with the ELIXIR Interoperability Platform aa a member of the IFB (the ELIXIR French Node: ELIXIR FR). She co-ordinates and reviews projects in the field of FAIR data, Data Management Plans and Recommended Interoperability Resources (RIR).

8.4. International Initiatives

8.4.1. TempoGraphs

Project: Analyzing big data with temporal graphs and machine learning. Application to urban traffic analysis and protein function annotation.

Participants: Sabeur Aridhi (PI), Marie-Dominique Devignes, Malika Smaïl-Tabbone, Bishnu Sarker, Wissem Inoubli, Dave Ritchie.

Partners: LORIA/Inria NGE, Federal University of Ceará (UFC).

Value: 20 k€.

Duration: 2017–2020.

Description: This project aims to investigate and propose solutions for both urban traffic-related problems and protein annotation problems. In the case of urban traffic analysis, problems such as traffic speed prediction, travel time prediction, traffic congestion identification and nearest neighbors identification will be tackled. In the case of protein annotation problem, protein graphs and/or protein–protein interaction (PPI) networks will be modeled using dynamic time-dependent graph representations.

8.4.2. Inria Associate Teams Not Involved in an Inria International Labs

Project: FlexMol. Algorithms for Multiscale Macromolecular Flexibility:

Participants: Maria-Elisa Ruiz-Echartea, Dave Ritchie, Isaure Chauvot de Beauchêne.

Partners: Nano-D, ChaconLab team, Rocasolano Institute of Physical Chemistry (IQFR-CSIC), Madrid, Spain, as non-beneficiary associated lab.

Description: Developing representations of molecular flexibility at different scales, for the 3D modeling of multi-molecular assemblies.

8.4.3. Informal International Partners

Project: Characterization, expression and molecular modeling ofTRR1 and ALS3 proteins of Candida spp., as a strategy to obtain new drugs with action on yeasts involved in nosocomial infections. Participant: Bernard Maigret. Partner: State University of Maringá, Brasil. Publication: [14], [18].

Project: Fusarium graminearum target selection. Participant: Bernard Maigret. Partner: Embrapa Recursos Geneticos e Biotecnologia, Brasil. Publication: [13].

Project:The thermal shock HSP90 protein as a target for new drugs against paracoccidioidomicose. Participant: Bernard Maigret. Partner: Brasília University, Brasil.

Project:Protein-protein interactions for the development of new drugs. Participant: Bernard Maigret. Partner: Federal University of Goias, Brasil.

CARMEN Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

The project "Cardiac Arrhythmia Localization Methods," granted by the Région Nouvelle-Aquitaine, with matching from funds held by our clinical collaboraters H. Cochet and P. Jaïs, has started. The purpose of this project is to develop a tool that can predict the exit site of an arrhythmia with moderate accuracy (1 cm) in an absolute sense, with respect to the anatomy of the heart in situ, and with a resolution of about 2 mm in a relative sense, with respect to a nearby pacing site. This tool must fulfill the following criteria:

- it uses only data that are already recorded in the cathlab by other systems: ECG data and electroanatomical mapping data;
- it must work in nearly real-time; catheter displacement advice must be available within 5 seconds after a paced beat;
- it must work automatically, requiring the operator only to indicate which ECG data correspond to the target arrhythmia; and
- it must be safe and easy to operate.

We will in the first place test a number of proposed methods using synthetic data, produced with our realistic models of cardiac electrophysiology and accurate geometric models of different patients. This in-silico testing phase will answer a number of important practical questions. Subsequently we will use offline clinical data, and within 2 years we aim to build a clinical prototype that can be tested (without interfering in the procedure) in the cathlab. In order to work real-time we will initially use very simple methods. However, the clinical prototype and the collectoin of synthetic data that we created will later serve also as a platform to test also more sophisticated inverse methods.

8.2. National Initiatives

8.2.1. ANR EXACARD

We started a collaboration with the STORM team at Inria Bordeaux Sud-Ouest to work on further scaling of the Propag code, to push the limit from about 10^4 to 10^6 parallel processors. A proposal for this project was funded this year by ANR. It allows a postdoc to be employed for 2 years.

8.2.2. ANR MITOCARD

The MITOCARD project (Electrophysiology of Cardiac Mitochondria), coordinated by S. Arbault (Université de Bordeaux, ISM), was granted by the ANR in July 2017. The objective of MITOCARD is to improve understanding of cardiac physiology by integrating the mitochondrial properties of cell signaling in the comprehensive view of cardiac energetics and rhythm pathologies. It was recently demonstrated that in the heart, in striking contrast with skeletal muscle, a parallel activation by calcium of mitochondria and myofibrils occurs during contraction, which indicates that mitochondria actively participate in Ca2+ signaling in the cardiomyocyte. We hypothesize that the mitochondrial permeability transition pore (mPTP), by rhythmically depolarizing inner mitochondrial membrane, plays a crucial role in mitochondrial Ca2+ regulation and, as a result, of cardiomyocyte Ca2+ homeostasis. Moreover, mitochondrial reactive oxygen species (ROS) may play a key role in the regulation of the mPTP by sensing mitochondrial energetics balance. Consequently, a deeper understanding of mitochondrial electrophysiology is mandatory to decipher their exact role in the heart's excitation-contraction coupling processes. However, this is currently prevented by the absence of adequate methodological tools (lack of sensitivity or selectivity, time resolution, averaged responses of numerous biological entities). The MITOCARD project will solve that issue by developing analytical tools and biophysical approaches to monitor kinetically and quantitatively the Ca2+ handling by isolated mitochondria in the cardiomyocyte.

MITOCARD is a multi-disciplinary project involving 4 partners of different scientific fields: the CARMEN team as well as

ISM, the largest chemistry laboratory of the Université de Bordeaux, where the necessary measurement methods will be developed;

Liryc, where mitochondria are studied at all levels of integration from the isolated mitochondrion to the intact heart; and

LAAS, the MiCrosystèmes d'Analyse (MICA) group at the Laboratory of Analysis and Architecture of Systems, which develops the biological microsensors for this project.

The project will

- develop chips integrating 4 different electrochemical microsensors to monitor in real-time key mitochondrial signaling parameters: Ca2+, membrane potential, quinone reduction status, O2 consumption, and ROS production;
- develop microwell arrays integrating ring nanoelectrodes to trap single mitochondria within micrometric chambers and measure locally by combined fluorescence microscopy and electrochemical techniques intra- (by fluorescence) and extra-mitochondrial (electrochemistry) metabolites; and
- develop a mathematical model of mitochondrial Ca2+ and ROS handling built on existing knowledge, new hypotheses, and the measured data.

The model may serve both to assess biological assumptions on the role of mitochondria in Ca2+ signaling and to integrate pathological data and provide clues for their global understanding.

8.2.3. GENCI

GENCI (*grand équipement national de calcul intensif*) is the agency that grants access to all national high-performance resources for scientific purposes in France. GENCI projects have to be renewed yearly. Our project renewal *Interaction between tissue structure and ion-channel function in cardiac arrhythmia*, submitted in September 2018, has been granted 8 million core-hours on the three major systems Irene, Occigen, and Turing. This compute time is primarily destined for our research into the interaction between ionic and structural heart disease in atrial fibrillation, Brugada syndrome, and early repolarisation syndrome [7] [71], and for new HPC developments [72].

8.2.4. PHRCN Multi-centric project

This project has been accepted for funding in December 2019. N Zemzemi is partner of the project and Prof. Emmanuel Cuny (PU-PH CHU de Bordeaux) is the Principal investigator. It is entitled "Deep brain stimulation for Parkinson disease: Probabilistic STN Targeting under general anaesthesia without microelectrode recordings (MER) vs current surgical procedure." It will start in 2020 and end in 2023.

8.2.5. BOUM project on ECGi

This project is coordinated by 2 PhD students (A. Karoui and O. Bouhamama) and 1 postdoc (M. Diallo), and is funded by the French applied and industrial math society (SMAI). It consists in organizing a national workshop on ECGI.

8.2.6. Inria Ciescard project

This project entitled "Combiner des Information Electriques et Structurelles pour aider les cardiologues à mieux Cibler la thérApie caRDiaque" funds an engineer for 2 years to develop some plugins in the software platform Music. The PI is N. Zemzemi.

8.2.7. Inria project OptimDBS

This project is designed to develop a software for the prediction of the optimal Deep stimulation targets based on machine learning techniques. It is funded by Inria as part of the ATT program. The PI is N. Zemzemi

8.3. Transfert

Together with Prof. Emmanuel Cuny and the help of AST (Aquitaine Science Transfert) and Inria Startup Studio, we are working on the creation of a startup company based on the software OptimDBS, and an associated the submitted patent. We follow the Founders 101 program of Inria to help us with the business, marketing, and management parts. The associated patent entitled Méthode de détermination d’une cible cérébrale stéréotaxique has been submitted to INPI by N. Zemzemi, J. Engelhardt, and E. Cuny under the number 71959FR. Our Software is currently used for the treatment of Essential Trauma in a Phase I clinical study at the CHU de Bordeaux and CHU de Lyon. A new PHRC-National multi-centric project has been accepted in December 2019 (see above, funded projects). This project is led by Emmanuel Cuny and aims at assessing the efficiency of our solution in the treatment of Parkinson Disease. The OptimDBS software will be used by 11 medical centers in France.

8.4. European Initiatives

8.4.1. Collaborations in European Programs, Except FP7 & H2020

Program:MSCA-ITN

Project title: "Personalized Therapies for Atrial Fibrillation. A Translational Approach."

Start Feb 2020 - End 2024

Coordinator: for UB/Liyrc: N. Zemzemi, PI: M. Guillem (University of Valencia, Spain)

8.4.2. Collaborations with Major European Organizations

BCAM (Basque Center for Applied Mathematics), Bilbao, Spain: L. Gerardo-Giorda.

We develop surrogate models of Radiofrequency Catheter Ablation for machine learning purposes, with the ambition to provide real-time estimations of lesion depths to clinicians (M. Leguèbe, Y. Coudière).

8.5. International Initiatives

8.5.1. Inria International Labs

International Laboratory for Research in Computer Science and Applied Mathematics

Associate Team involved in the International Lab:

8.5.1.1. EPICARD

Title: inversE Problems In CARDiac electrophysiology

International Partner (Institution - Laboratory - Researcher):

ENIT (Tunisia) - Department of Intelligence Science and Technology - Mourad Bellassoued

Start year: 2018

See also: https://team.inria.fr/carmen/epicard/

Model personalization is a very challenging question in the numerical modeling community, especially for medical applications like cardiac electrophysiology. Our main idea is to adapt the input data like model parameters and boundary conditions of the electrophysiological measurements. There are two mathematical problems raising from this challenge. The first issue is the identifiability of the parameters and the sensitivity of the identification problem to the measured data. The question is: For given measurements, could we prove that there exist a set of parameters that allows to fit these measurements? The second issue is, how can we estimate parameters, when they are identifiable,? Our idea is to provide a theoretical analysis for the identification of each of the parameters and to construct suitable numerical methods to estimate them.

8.5.1.2. Informal International Partners

Y. Coudière works with the group of Prof. Y. Bourgault from the Department of Mathematics and Statistics of the University of Ottawa (Canada). Some results on the numerical analysis of time-stepping methods from C. Douanla’s PhD were carried out together, as well as some theoretical results on parameter identification in the PhD of A. Gérard.

M. Potse works with the group of Prof. U. Schotten at Maastricht University (The Netherlands) and the Center for Computational Medicine in Cardiology at the *Università della Svizzera italiana* (Lugano, Switzerland) on simulation studies of atrial fibrillation [60]. The Maastricht group was partially funded by the FP7 project EUTRAF and our simulations were supported by GENCI (section 8.2.3).

N. Zemzemi works with Cesare Corrado at King's College London on the development of new eikonal models allowing conduction velocity adaptation [55].

Mostafa Bendahmane works with Kenneth H. Karlsen at university of Oslo (Norway) on the stochastic bidomain model in electrocardiology [46].

8.6. International Research Visitors

8.6.1. Visits of International Scientists

- Yassine Abidi, Ecole Nationale d'Ingénieurs de Tunis, Jun 2019,
- Abir Amri, Tunis El Manar University, from May 2019 until Jun 2019,
- Veronica Anaya, Universidad Nacional Autonoma de Mexico, from Jun 2019 until Jul 2019
- Yves Bourgault, University of Ottawa, Jun 2019
- Elmahdi Erraji, Cadi Ayyad University, Jun 2019
- Moncef Mahjoub, Tunis El Manar University, from Oct 2019 until Nov 2019

CASTOR Project-Team

5. Partnerships and Cooperations

5.1. National Initiatives

5.1.1. ANR Sistem

Member of the ANR SISTEM, Oct. 2019 - Sept. 2023 coordinated by the M2P2 Institute of Aix-Marseille Univ. "SImulations with high-order schemes of tranSport and TurbulencE in tokaMak" programme Modeles numeriques 2019

- Participants: Francesca Rapetti, Blaise Faugeras, Didier Auroux, Jacques Blum, Cédric Boulbe

Contact: F. Rapetti

5.2. European Initiatives

5.2.1. FP7 & H2020 Projects

EuroFusion Consortium

CASTOR participates to the following EuroFusion consortium projects :

EUROfusion WPCD (Working Package Code Development):

- EWE-2: Enabling Workflow Exploitation Area - Enabling the exploitation of the equilibrium reconstruction and MHD stability workflow (participation)
- WDEV-2: Workflow Development Area - Free boundary equilibrium and feedback control (participation and coordination)

EuroFusion Enabling Research CfP-AWP19-ENR-01, Strengthening the non-linear MHD code JOREK for application to key questions of the fusion roadmap.

EUROfusion WPSA(Work Package JT-60SA) 2018-2010

5.3. International Initiatives

5.3.1. Informal International Partners

The team collaborates with TUC (Technical University of Crete, Prof. Argyris Delis) on the modelling of acoustic streaming phenomena. In this framework, Argyris Delis has visited the Castor team in November 2019.

COFFEE Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

The team is involved in the IDEX project UCA-JEDI.

7.2. National Initiatives

7.2.1. ANR

- ANR CHARMS (Quantitative Reservoir Models for Complex Hydrothermal Systems), Roland Masson and Konstantin Brenner: december 2016 - december 2020, partners BRGM (leader), LJAD-Inria, Storengy, MdS, LJLL.
- ANR JCJC PRECIS (Effect of a shock wave on a structure with contact using mesh refinement and parallelism), Laurent Monasse: april 2018 - april 2021, partners Inria (leader), Ecole des Ponts, CEA, Université Paris-Est.

7.2.2. National and European networks

- GdR MANU.

  The research group MANU has activities centered around scientific computing, design of new numerical schemes and mathematical modelling (upscaling, homogenization, sensitivity studies, inverse problems,...). Its goal is to coordinate research in this area, as well as to promote the emergence of focused groups around specific projects
- S. Junca is involved in GdR 3437 DYNOLIN “Dynamique non linéaire” and GdR MecaWave.
- LJAD-Inria and BRGM are the French partners of the Norvergian, German French project InSPiRE "International Open Source Simulation Software Partnership in Research and Education” which has just been accepted by the Research Council of Norway with the code ComPASS as one of the softwares of this project together with Dune, Dumux and OPM.

7.3. International Initiatives

7.3.1. Inria Associate Teams Not Involved in an Inria International Labs

7.3.1.1. HDTHM

Title: Mathematical and numerical methods for thermo-hydro-mechanical models in porous media with discontinuities

International Partner (Institution - Laboratory - Researcher):

Monash University (Australia) - School of Mathematics - Jérome Droniou

Start year: 2019

See also: https://math.unice.fr/~massonr/HDTHM/HDTHM.html

The objective of this project is to extend a recent successful joint work between the two project leaders into a tight collaboration between the Monash and the Coffee teams involving several permanent members and students. The present project focuses on challenging directions of research related to the numerical simulation of thermo-hydro-mechanical models in fractured porous media that take advantage of the complementarity of both teams’ expertise as well as of the recent arrival of Laurent Monasse in the Coffee team. It is an opportunity to extend our collaborations with the Coffee team industrial partners in geosciences as well as to submit in common a research project to the Australian Research Council toward the end of the project.

7.3.2. Inria International Partners

The team has many interactions abroad: UFRJ, Ut Austin, India, Geneva, ICL,...

7.3.3. Participation in Other International Programs

Coffee is member of the Interdisciplinary Union of Porous Media Research at the University of Stuttgart (NUPUS).

Principal areas of research cooperation to be pursued under this program include free flow and porous medla flow interaction, fracture and fluid flow interactlon, fluid-solid phase change interaction, and simulation methods and tools.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

The team has welcomed Paulo Amorim, from UFRJ, for research on the modeling of self-organization in f population dynamics, Corrado Mascia, from La Sapienza, on the analysis of hyperbolic systems and Martin Gander, from Univ. Geneva, for research on domain decomposition methods.

COMMEDIA Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. ANR Project "IFSMACS"

Participants: Muriel Boulakia, Céline Grandmont [local coordinator].

Period: 2015-2019.
The objective of this project, coordinated by Takéo Takahashi (Inria Nancy Grand-Est), is the mathematical analysis of systems involving structures immersed in a fluid. This includes the asymptotic analysis, the study of the controllability and stabilization of fluid-structure interaction systems, the understanding of the motion of self-propelled structures and the analysis and development of numerical methods to simulate fluid-structure systems.

9.1.1.2. ANR Project "ADAPT"

Participants: Maria Fuente-Ruiz, Damiano Lombardi [coordinator], Olga Mula.

Period: 2018-2022.
Adaptive Dynamical Approximations by Parallel Tensor methods. The main goal of the ANR is to investigate the numerical approximation of the solution of high-dimensional problems. In particular, the applications that motivate this study are the Uncertainty Quantification and the Kinetic theory. The main objective is to construct in an adaptive way parsimonious discretisations starting from arbitrarily chosen separated discretisations.

DRACULA Project-Team

6. Partnerships and Cooperations

6.1. Regional Initiatives

- The Région ARA project INGERENCE dedicated to "INferring GEne REgulatory NEtworks from single CEll Data to improve vaccine design", 2018-2021.
  Participants: Olivier Gandrillon, Fabien Crauste [Coordinator].

6.2. National Initiatives

6.2.1. ANR

- ANR SinCity "Single cell transcriptomics on genealogically identified differentiating cells" (https://anr.fr/Projet-ANR-17-CE12-0031), 2017-2020.
  Participant: Olivier Gandrillon [Coordinator].
- Olivier Gandrillon participates in the ANR MEMOIRE (head Jacqueline Marvel) dedicated to "MultiscalE MOdeling of CD8 T cell Immune REsponses", 2018-2021.

6.2.2. Other projects

- Thomas Lepoutre is a member of the ERC MESOPROBIO (head Vincent Calvez) dedicated to "Mesoscopic models for propagation in biology", 2015-2020: (http://vcalvez.perso.math.cnrs.fr/mesoprobio.html).

6.3. European Initiatives

6.3.1. FP7 & H2020 Projects

- Olivier Gandrillon and Alexey Koshkin participate in the EU RTN network COSMIC (head Antpoine van Kampen) dedicated to "Combatting disorders of adaptive immunity with systems medicine", 2018-2021, https://cosmic-h2020.eu

6.4. International Initiatives

6.4.1. Inria Associate Teams Not Involved in an Inria International Labs

6.4.1.1. MathModelingHematopoiesis

Title: Mathematical modeling of hematopoietic stem cell dynamics in normal and pathological hematopoiesis with optimal control for drug therapy

International Partner (Institution - Laboratory - Researcher):

Presidency University, Kolkata (India) - Subhas Khajanchi

Start year: 2019

The project proposes to develop and analyse new mathematical models of Hematopoietic Stem Cell population dynamics in normal and pathological hematopoiesis. Two important questions will be explored in this project: i) the biological data concerning the hematopoiesis process evolves constantly, and new understanding modifies the established mathematical models, ii) modeling constraints us to simplify the complicated biological scenarios, which moving away from the reality, but enabling us to reach a certain comprehension of the hematopoiesis process.

The project will shed new light on the different physiological mechanisms that converge toward the continuous regeneration of blood cells, for example: the behavior of hematopoietic stem cells under stress conditions, the understanding of deregulation of erythropoiesis under drug treatments (this can lead to lack of red blood cells (anemia), or a surplus of red blood cells (erythrocytoses)), the appearance of oscillations in patients with Chronic Myeloid Leukemia (CML); Or, the overproduction of blasts in patients with Acute Myeloid Leukemia (AML)). The effect of the immune system and drug therapy in the presence of CML or AML will be included in the model and optimal control method will also be used.

6.4.2. Participation in Other International Programs

6.4.2.1. Indo-French Center of Applied Mathematics

Title: Mathematical modeling of hematopoiesis process in application to chronic and acute myelogenous leukemia

International Partner (Institution - Laboratory - Researcher):

Department of Mathematics - Presidency University, Kolkata (India) - Subhas Khajanchi

Duration: 2018 - 2021

Start year: 2018

6.5. International Research Visitors

6.5.1. Visits of International Scientists

Jairo Gomes da Silva, PhD student at Institute of Biosciences, São Paulo State University (UNESP), Botucatu, Brazil, visiting the team for 6 months (from September 2019 to February 2020).

6.5.2. Visits to International Teams

Paul Lemarre is visiting University of California, Merced, USA, in 2019-2020.

DYLISS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. MoDaL (Brittany and Pays de la Loire regions)

Participant: Olivier Dameron.

The MoDaL project is a federated project funded by BioGenOuest (Région Bretagne-Pays de la Loire) project involving scientists and engineers from IRISA/inria rennes (Genouest, Empenn, Dyliss) and the Institut du Thorax lab in Nantes. The project aims to decompartmentalize the resources dedicated to biomedical imaging and genetics. MoDaL focuses on i) establishing an inventory of the actors and infrastructures available at the inter-regional level, ii) proposing technological demonstrators that address the management, analysis and reuse of multi-infrastructure data (in-vivo, in-vitro and genomic imaging).

2019-2020. Total grant (hosted in the Empenn team): 100,000€.

9.1.2. PhenoMiR (European Maritime and Fisheries Fund)

Participant: Emmanuelle Becker.

The PhenoMiR project is a collaboration between Fishes Physiology and Genomics Laboratory (LPGP - INRAE), eight other laboratories of the INRAE, and the Dyliss team. Its objective is first (i) to settle the first complete repository of microRNAs for the trout, exploring different physiological and breeding conditions, and then (ii) to study the potentiality of some micro-RNAs to act as bio-markers of trout breeding and development condition. The Dyliss team is responsible for the design and development of the analysis pipeline of the genomics data, including the search of potential bio-markers.

2019-2022. Total grant: 495,000€. Dyliss grant: 33,000€.

9.1.3. UBIQUITIN

Participant: Emmanuelle Becker.

The Ubiquitin project is a collaboration between G. Rabut's team at the Institute of Developmental Biology of Rennes and the Dyliss team. It was funded as a cross-disciplinary emerging project by the University of Rennes 1.

G. Rabut's team is developing a new method to detect weak affinity protein-protein interactions based on protein complemantation with Luciferase. However the method may generate a very noisy signal depending on the *in-vivo* concentration of the partners. In the Ubiquitin project, we developped a R workflow to separate the signal from the noise in the experiments. As an application, this allowed us to decipher the intricate interplay between E2 and E3 enzymes during ubiquitination process in Yeast. This work was done during a master 2 internship. We are now continuing the project in two directions : (i) comparing the interactions identified with previously known databases, using web semantic technologies and ontologies describing protein interaction detection methods, and (ii) using formal classification to understand the structural properties of E2 and E3 that lead to their interactions. 2019-2020. Total grant: 7,000€. Dyliss grant: 4,200€.

9.1.4. Ph.D. fundings from Université, Inria Rennes and Inserm

The team benefits from PhD. theses fundings by Univ. Rennes (L. Bourneuf, 2016-2019 – H. Talibart, 2017-2020 – N. Guillaudeux, 2018-2021), by Inria (A. Belcour, 2019-2022 – V. Kmetzsch, 2019–2022), by Inserm (M. Louarn, 2017-2020, Inria-Inserm PhD Grant program), and by our collaborators from IRSET (M. Conan, 2017-2020 – P. Vignet, 2018-2020, O. Dennler, 2019–2022).

9.2. National Initiatives

9.2.1. IDEALG (ANR/PIA-Biotechnology and Bioresource)

Participant: Méziane Aite.

The project gathers 18 partners from Station Biologique de Roscoff (coordinator), CNRS, IFREMER, UEB, UBO, UBS, ENSCR, University of Nantes, INRA, AgroCampus, and the industrial field in order to foster biotechnology applications within the seaweed field. Dyliss is co-leader of the WP related to the establishment of a virtual platform for integrating omics studies on seaweed and the integrative analysis of seaweed metabolism. Major objectives are the building of brown algae metabolic maps, metabolic flux analysis and the selection of symbiotic bacteria for brown algae. We will also contribute to the prediction of specific enzymes (sulfatases and haloacid dehalogenase) [More details]. 2012–20. Total grant: 11M€. Dyliss grant: 534k€.

9.2.2. TGFSysBio (ITMO Cancer)

Participant: Olivier Dameron.

Partners are INSERM (coordinator) (IRSET, Univ. Rennes 1) CNRS (Dyliss team) and Inria (Antique, Paris). The TGFSYSBIO project aims at developing the first model of extracellular and intracellular TGF-beta system by combining a ruled-based modelling approach (kappa) and a Petri net modelling approach (cadbiom). 2015–18, extended in 2019. Total grant: 418k€. Dyliss grant: 129k€.

9.2.3. Programs funded by Inria

9.2.3.1. IPL Neuromarkers

Participant: Emmanuelle Becker.

This project involves mainly the Inria teams Aramis (coordinator) Dyliss, Genscale and Bonsai. The project aims at identifying the main markers of neurodegenerative pathologies through the production and the integration of imaging and bioinformatics data. Dyliss is in charge of facilitating the interoperability of imaging and bioinformatics data. In 2019 V. Kmetzsch started his PhD (supervized by E. Becker from Dyliss and O. Colliot from Aramis). 2017–20.

9.2.3.2. Askomics (ADT)

Participant: Olivier Dameron.

AskOmics [url] is a visual SPARQL query interface supporting both intuitive data integration and querying while avoiding the user to face most of the technical difficulties underlying RDF and SPARQL. The underlying motivation is that even though Linked (Open) Data now provide the infrastructure for accessing large corpora of data and knowledge, life science end-users seldom use them, nor contribute back their data to the LOD cloud by lack of technical expertise. AskOmics aims at bridging the gap between end users and the LOD cloud. 2018–2020.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

- Program: Polish National Science Center
- Project acronym: NCN 2016/21/B/ST6/02158
- Project title: Grammatical inference methods in classification of amyloidogenic proteins
- Duration: January 2017 - January 2020
- Coordinator: Olgierd Unold, Politechnika Wroclawska
- Other partners: Politechnika Wroclawska (Polland)
- Abstract: The objective is to develop the methods for induction of context-free and probabilistic grammars to describe a language matching amyloidogenic protein sequences.

9.3.2. Collaborations with Major European Organizations

Partner: Potsdam (Germany)

Title: Modeling combinatorial and hybrid optmization problems with Answer Set Programming

9.4. International Initiatives

9.4.1. Informal International Partners

We have a cooperation with Univ. of Chile (MATHomics, A. Maass) on methods for the identification of biomarkers and software for biochip design. It aims at combining automatic reasoning on biological sequences and networks with probabilistic approaches to manage, explore and integrate large sets of heterogeneous omics data into networks of interactions allowing to produce biomarkers, with a main application to biomining bacteria. The program is co-funded by Inria and CORFO-chile from 2012 to 2016. In this context, Integrative-BioChile was an Associate Team between Dyliss and the Laboratory of Bioinformatics and Mathematics of the Genome hosted at Univ. of Chile funded from 2011 to 2016. The collaboration is now supported by Chilean programs.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- **Niger:** Oumarou Abdou-Arbi (University of Maradi)

9.5.1.1. Research Stays Abroad

- **Germany:** Maël Conan visited the Zentrum für Bioinformatik at Hamburg University with Prof. Johannes Kirchmair for 2 months. During this stay, he learned how to predict metabolism sites using the tool developped in Pr. Kirchmair unit (FAME2/FAME3) and initiated the development of a new method to predict xenobiotics metabolism.
- **Germany:** Clémence Frioux visited the lab of Oliver Ebenoh (Heidelberg) for one week.

EMPENN Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Défis scientifiques 2019 of University of Rennes 1: Compensating analytic variability for a better use of open data (2019, 6500€).

Participant: Camille Maumet.

In neuroimaging, open data are now well developed with hundred of thousands of images available for the research community. However, those data are still mainly studied in isolation, limiting the potential for new discoveries. Here we focus our efforts on developing neuroinformatics standards and algorithms that will support publication and combination of open datasets.

9.1.2. Region Bretagne: project VARANASI

Participants: Christian Barillot, Camille Maumet, Xavier Rolland.

Thanks to the development of open science practices, more and more public datasets are available to the research community. In the field of brain imaging, these data, combined, bring a critical increase in sample size, necessary to build robust models of the typical and atypical brain. However, in order to build valid inferences on these data, we need to take into account their heterogeneity. Variability can arise due to multiple factors such as: differences in imaging instruments, in acquisitions protocols and even, in post-processing pipelines. In particular, the expansion of open source machine learning workflows creates a multitude of possible outputs out of the same dataset. The variations induced by this methodological plurality can be reFerréd to as ‘analytic variability’ which will be the focus of the thesis funded in half by region Bretagne. The thesis of Xavier Rolland (2018-2021) will address two challenges: 1) How to combine neuroimaging data generated by different analysis pipelines? 2) How to publish neuroimages with an adequate level of metadata to enable their reuse? Methodological developments will combine machine learning techniques with methods from knowledge representation.

9.2. National Initiatives

9.2.1. Projet Fondation de France: PERINE: 99k€ (33 k€ for IRM acquisition and 22 k€ for image analysis) for 2011-2021

Participants: Élise Bannier, Isabelle Corouge, Julie Coloigner, Maia Proisy, Jean-Christophe Ferré, Christian Barillot.

The PELAGIE cohort evaluates the effect of prenatal exposure to neurotoxicants on child development. Following previous studies, the PERINE study focuses on the assessment of brain developement at 10-12 years old using MRI (ASL, Diffusion imaging, Working memory as well as motor inhibition BOLD fMRI together with neuropsychological tests). A total of 101 children were included. A PhD of Anne-Claire Binter was defended in December 2019 linking epidemiology with functional imaging during a GoNoGo task and neuropsychological scores. This work is done in collaboration with Fabienne Pele´ and Ce´cile Chevrier (IRSET).

9.2.2. Fondation de l’Avenir: EPMR-MA

Participants: Pierre-Yves Jonin, Élise Bannier, Christian Barillot, Quentin Duché.

Recognition memory refers to our ability to discriminate between previously experienced vs. unexperienced stimuli. It is impaired very early in the course of Alzheimer's Disease (AD), both regarding behavioural performance and related brain activity. When the memoranda is associated or with existing knowledge, subsequent memory increases in healthy subjects. Moreover, existing knowledge related to prior exposures may alter the brain network underlying successful memory formation. While much is known regarding the brain substrates of recognition memory in early AD, little is known about the impact of prior exposure. Yet, this factor could both enhance memory formation in patients, and highlight a pattern of memory impairments and related brain activity that might accurately discriminates between early AD, before dementia, and healthy aging. The present task-based fMRI study aims at assessing the influence of prior exposures on recognition memory and its neural underpinnings in patients with Mild Cognitive Impairment due to AD. Inclusions were performed between 2016 and 2017 and data analysis is ongoing.

9.2.3. Projet Fondation de France: Connectivity of the amygdala in depression: (PI: M.-L. Paillère Martinot, Paris Descartes University), €200k for 2018-2021

Participants: Christian Barillot, Olivier Commowick, Emmanuel Caruyer, Julie Coloigner.

The onset of depression in teenagers and young adults increases the risk to develop a drug-resistant depression in the adulthood. This project aims at evaluating the role of early changes in the microstructure and connectivity of the amygdala. Using a cohort of drug-resistant patients (N=30), non drug-resistant patients (N=30) and controls (N=30), the aim is to identify imaging biomarkers of the pathology and to compare these with emotional and cognitive phenotypes in this population, searching for early differences in the development of the amygdala connectivity.

9.2.4. CNRS-Inserm Défi Santé numérique – AAP 2019: Imagerie Multimodale de l'Amygdale limbiquE pour le pronostic de la Dépression (IMpAirED): 19k€ for 2019

Participants: Julie Coloigner, Olivier Commowick, Élise Bannier, Emmanuel Caruyer, Christian Barillot.

This grant is an extension of the Projet Fondation de France: Connectivity of the amygdala in depression.

In order to identify early features of this depression disease, the aim of this project is to develop multimodal modeling of the limb amygdala and its network from MR imaging combining activation and rest functional imaging and MR brain microstructure imaging quantitative (diffusion and relaxometry). The development of this model will allow us to define three imaging biotypes corresponding to depressed adult patients responding to antidepressant treatments, depressed resistant patients and controls. These multimodal imaging biomarkers will be used to stratifie a large longitudinal cohort of young adults into three sub-groupsgroups, in order to retrospectively identify early differences in development trajectories of amygdala.

Inclusions of the patients will begin in early 2020.

9.2.5. ANR "MAIA", generic projects program: €150k for 2016-2019 (PI: F. Rousseau, IMT Atlantique, Brest)

Participants: Maia Proisy, Pierre Maurel, Antoine Legouhy, Olivier Commowick, Isabelle Corouge, Jean-Christophe Ferré, Christian Barillot.

Each year in France, 55 000 children are born prematurely, i.e., before the 37th week of gestation. Long-term studies of the outcome of prematurely born infants have clearly documented that the majority of such infants may have significant motor, cognitive, and behavioral deficits.

However, there is a limited understanding of the nature of the cerebral abnormality underlying these adverse neurologic outcomes. In this context, the emergence of new modalities of 3D functional MRI, e.g., Arterial Spin Labeling (ASL), or optical imaging technologies, e.g., Near InfraRed Spectroscopy (NIRS), brings new perspectives for extracting cognitive information, via metabolic activity measures. Other classical techniques devoted to cerebral signal measurement, such as ElectroEncephaloGraphy (EEG), provide cognitive information at the cortical level. Each of these various non-invasive imaging technologies brings substantial and specific information for the understanding of newborn brain development.

This project is developing innovative approaches for multi-image / multi-signal analysis, in order to improve neurodevelopment understanding methods. From a fundamental point of view, mathematics and computer science have to be considered in association with imaging physics and medicine, to deal with open issues of signal and image analysis from heterogeneous data (image, signal), considered in the multiphysics contexts related to data acquisition (magnetic, optic, electric signals) and biophysics modeling of the newborn brain. A sustained synergy between all these scientific domains is then necessary.

Finally, the sine qua non condition to reach a better understanding of the coupled morphological cognitive development of premature newborns, is the development of effective software tools, and their distribution to the whole medical community. The very target of this project is the design of such software tools for medical image / signal analysis, actually operational in clinical routine, and freely available. Academic researchers and industrial partners are working in close collaboration to reach that ambitious goal.

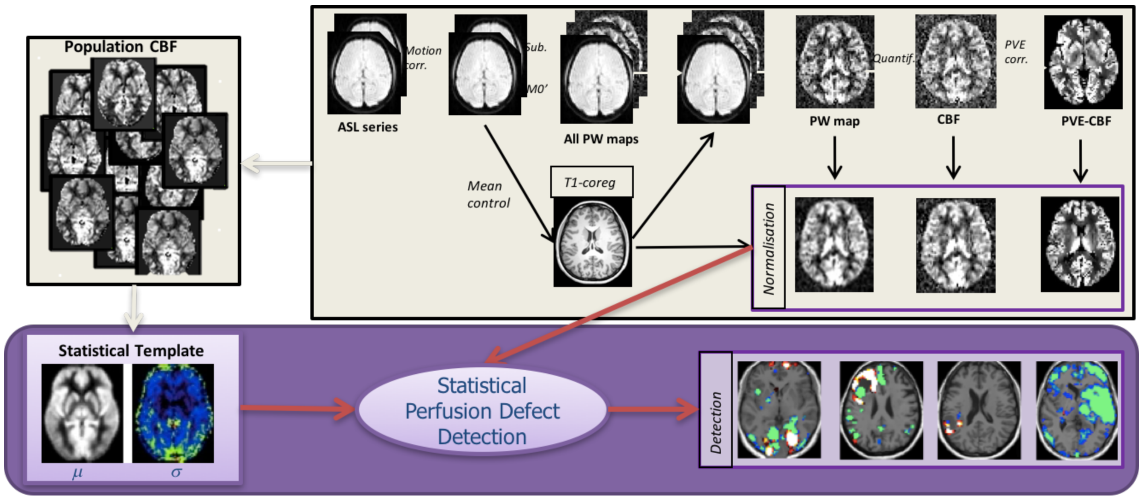


Figure 2. Processing workflow for quantification of Arterial Spin Labelling Cerebral Blood Flow with detection of abnormal perfusion

9.2.6. Fondation pour la recherche médicale (FRM) - Project Hybrid EEG/IRM Neurofeedback for rehabilitation of brain pathologies: 370k€ (2017-2021)

Participants: Élise Bannier, Isabelle Bonan, Isabelle Corouge, Jean-Christophe Ferré, Jean-Yves Gauvrit, Pierre Maurel, Mathis Fleury, Giulia Lioi, Christian Barillot.

The goal of this project is to make full use of neurofeedback (NF) paradigm in the context of brain rehabilitation. The major breakthrough will come from the coupling associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to "optimize" the neurofeedback protocol. We propose to combine advanced instrumental devices (Hybrid EEG and MRI platforms), with new hybrid Brain computer interface (BCI) paradigms and new computational models to provide novel therapeutic and neuro-rehabilitation paradigms in some of the major mental and neurological disorders of the developmental and the aging brain (stroke, language disorders, Mood Depressive Disorder (MDD), . . .). Though the concept of using neurofeedback paradigms for brain therapy has somehow been experimented recently (mostly through case studies), performing neurofeedback through simultaneous fMRI and EEG has almost never been done before so far (two teams in the world including us within the HEMISFER CominLabs project). This project will be conducted through a very complementary set of competences over the different involved teams: Empenn U1228, HYBRID and PANAMA Teams from Inria/Irisa Rennes and EA 4712 team from University of Rennes I.

9.2.7. PHRC EMISEP: Evaluation of early spinal cord injury and late physical disability in Relapsing Remitting Multiple Sclerosis: €200k for 2016-2019

Participants: Élise Bannier, Christian Barillot, Emmanuel Caruyer, Benoit Combès, Olivier Commowick, Gilles Edan, Jean-Christophe Ferré, Haykel Snoussi.

Multiple Sclerosis (MS) is the most frequent acquired neurological disease affecting young adults (1 over 1000 inhabitants in France) and leading to impairment. Early and well adapted treatment is essential for patients presenting aggressive forms of MS. This PHRC (Programme hospitalier de recherche clinique) project focuses on physical impairment and especially on the ability to walk. Several studies, whether epidemiologic or based on brain MRI, have shown that several factors are likely to announce aggressive development of the disease, such as age, number of focal lesions on baseline MRI, clinical activity. However, these factors only partially explain physical impairment progression, preventing their use at the individual level. Spinal cord is often affected in MS, as demonstrated in postmortem or imaging studies. Yet, early radiological depiction of spinal cord lesions is not always correlated with clinical symptoms. Preliminary data, on reduced number of patients, and only investigating the cervical spinal cord, have shown that diffuse spinal cord injury, observed via diffusion or magnetisation transfer imaging, would be correlated with physical impairment as evaluated by the (EDSS) Expanded Disability Status Scale score. Besides, the role of early spinal cord affection (first two years) in the evolution of physical impairment remains unknown.

In this project, we propose to address these different issues and perform a longitudinal study on Relapsing Remitting Multiple Sclerosis (RRMS) patients, recruited in the first year of the disease. Our goal is to show that diffuse and focal lesions detected spinal cord MRI in the first two years can be used to predict disease evolution and physical impairment at 5 years. Twelve centers are involved in the study to include 80 patients.

To date, all subjects have been included. Haykel Snoussi defended his PhD Thesis on diffusion imaging in the spinal cord starting with distortion correction.

B. Combe`s started as a post-doc in November 2016 to process the EMISEP imaging data, starting with morphological data processing (registration, segmentation) and magnetization transfer data processing.

9.2.8. MS-TRACTS (ARSEP and COREC funding): Estimating the impact of multiple sclerosis lesions in motor and proprioceptive tracts, from the brain to the thoracic spinal cord, on their functions, assessed from clinical tests and electrophysiological measurements: 45k€ (2019-2021).

Participants: Élise Bannier, Benoit Combès.

Previous studies, whether epidemiologic or based on brain MRI, have shown that several factors were likely to announce aggressive development of the disease, such as age, clinical relapses, number of focal lesions on baseline MRI. However, these factors only partially explain physical disability progression, preventing their use at the individual level. The access to advanced brain and cord MR images, the development of associated processing tools combined. We hypothesize that a fine assessment of damage on specific networks, from the brain to the thoracic cord, offers a relevant biomarker of disability progression in MS. Such damage assessments must take into account both lesion location, assessed on structural brain and cord MR images and lesion severity, assessed using quantitative MR images. We propose to test this hypothesis by combining assessments of lesion location and severity on corticospinal and proprioceptive tracts from the brain to the thoracic cord with clinical and electrophysiological measurements. This study includes two French centers (Rennes, Marseille) and includes a total of 60 patients. The expected outcome is to obtain early biomarkers of physical impairment evolution in RRMS patients, first treated with immunomodulatory treatment. The long-term goal is to provide the clinician with biomarkers able to anticipate therapeutic decisions and support the switch to alternative more aggressive treatment.

9.2.9. PIA projects

9.2.9.1. The HEMISFER Project: (€400k for 2017-2019)

Participants: Élise Bannier, Isabelle Bonan, Isabelle Corouge, Claire Cury, Jean-Christophe Ferré, Jean-Yves Gauvrit, Pierre Maurel, Christian Barillot.

The HEMISFER project ("Hybrid Eeg-MrI and Simultaneous neuro-FEedback for brain Rehabilitation") is conducted at Inria Rennes with the support of the Labex "CominLabs" [0]. The goal of HEMISFER is to make full use of the neurofeedback paradigm in the context of rehabilitation and psychiatric disorders. The major breakthrough will come from the use of a coupling model associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to "enhance" the neurofeedback protocol. We combine advanced instrumental devices (Hybrid EEG and MRI platforms), with new man-machine interface paradigms (Brain computer interface and serious gaming) and new computational models (source separation, sparse representations and machine learning) to provide novel therapeutic and neuro-rehabilitation paradigms in some of the major neurological and psychiatric disorders of the developmental and the aging brain (stroke, attention-deficit disorder, language disorders, treatment-resistant mood disorders, etc.). This project involves with the HYBRID and PANAMA Teams from Inria Rennes, the EA 4712 team from University of Rennes I and the ATHENA team from Inria Sophia-Antipolis. This work benefits from the research 3T MRI and MRI-compatible EEG systems provided by the NeurInfo in-vivo neuroimaging platform on which these new research protocols aree set up. A budget of 500K€ is provided by CominLabs to support this project (through experimental designs, PhDs, post-docs and expert engineers).

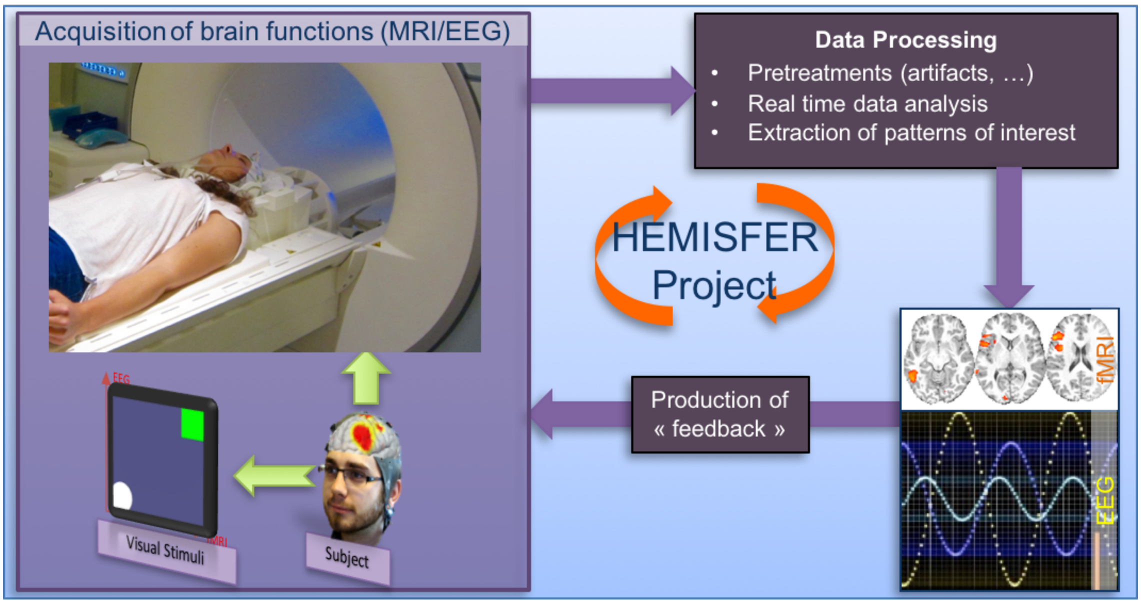


Figure 3. Principle of the Hemisfer project.

9.2.9.2. France Life Imaging (FLI): 2012-2023, €2000k (phase 1) + €1200k (phase 2)

Participants: Christian Barillot, Olivier Commowick.

[0] https://iww.inria.fr/cominlabs-newsletter/april-2013-four-projects-selected/#hemisfer

France Life Imaging (FLI) is a large-scale research infrastructure project to establish a coordinated and harmonized network of biomedical imaging in France. This project was selected by the call “Investissements d’Avenir - Infrastructure en Biologie et Santé”. One node of this project is the node Information Analysis and Management (IAM), a transversal node built by a consortium of teams that contribute to the construction of a network for data storage and information processing. Instead of building yet other dedicated facilities, the IAM node use already existing data storage and information processing facilities (LaTIM Brest; CREATIS Lyon; CIC-IT Nancy; Empenn U1228 Inria Rennes; CATI CEA Saclay; ICube Strasbourg) that increase their capacities for the FLI infrastructure. Inter-connections and access to services are achieved through a dedicated software platform that is developed based on the expertise gained through successful existing developments. The IAM node has several goals. It is building a versatile facility for data management that inter-connects the data production sites and data processing for which state-of-the-art solutions, hardware and software, are available to infrastructure users. Modular solutions are preferred to accommodate the large variety of modalities acquisitions, scientific problems, data size, and to be adapted for future challenges. Second, it offers the latest development that are made available to image processing research teams. The team Empenn fulfills multiple roles in this nation-wide project. Christian Barillot is the chair of the node IAM, Olivier Commowick is participating in the working group workflow and image processing and Michael Kain is the technical manager. Apart from the team members, software solutions like MedInria and Shanoir are part of the software platform.

9.2.9.3. OFSEP: €175k for 2017-2019

Participants: Élise Bannier, Christian Barillot, Olivier Commowick, Gilles Edan, Jean-Christophe Ferré, Francesca Galassi.

The French Observatory of Multiple Sclerosis (OFSEP) is one of ten projects selected in January 2011 in response to the call for proposal in the “Investissements d’Avenir - Cohorts 2010” program launched by the French Government. It allows support from the National Agency for Research (ANR) of approximately 10 million € for 10 years. It is coordinated by the Department of Neurology at the Neurological Hospital Pierre Wertheimer in Lyon (Professor Christian Confavreux), and it is supported by the EDMUS Foundation against multiple sclerosis, the University Claude Bernard Lyon 1 and the Hospices Civils de Lyon. OFSEP is based on a network of neurologists and radiologists distributed throughout the French territory and linked to 61 centers. OFSEP national cohort includes more than 50,000 people with Multiple Sclerosis, approximately half of the patients residing in France. The generalization of longitudinal monitoring and systematic association of clinical data and neuroimaging data is one of the objectives of OFSEP in order to improve the quality, efficiency and safety of care and promote clinical, basic and translational research in MS. For the concern of data management, the Shanoir platform of Inria has been retained to manage the imaging data of the National OFSEP cohort in multiple sclerosis.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. OpenAire-Connect

Participants: Christian Barillot, Camille Maumet, Xavier Rolland.

Project title: **OpenAire-Connect**

Partners: PI: CNR, Italy; Athena Research And Innovation Center In Information Communication & Knowledge Technologies, Greece; Uniwersytet Warszawski, Poland; JISC LBG, UK; Universitaet Bremen, Germany; Universidade Do Minho, Portugal; CNRS (Empenn, Creatis), France; Universita Di Firenze, Italy; Institut De Recherche Pour Le Developpement (IRD), France; European Organization For Nuclear Research (CERN), Switzerland; International Center For Research On The Environment And The Economy, Greece

Budget: 2M € (120k€ for CNRS)

The OpenAire-Connect H2020 project introduces and implements the concept of Open Science as a Service (OSaaS) on top of the existing OpenAIRE infrastructure, delivering out-of-the-box, on-demand deployable tools. OpenAIRE-Connect adopts an end-user driven approach (via the involvement of five prominent research communities), and enriches the portfolio of OpenAIRE infrastructure production services with a Research Community Dashboard Service and a Catch-All Notification Broker Service. The first offers publishing, interlinking, packaging functionalities to enable them to share and re-use their research artifacts (introducing methods, e.g., data, software, protocols). This effort, supported by the harvesting and mining “intelligence” of the OpenAIRE infrastructure, provides communities with the content and tools they need to effectively evaluate and reproduce science. OpenAIRE-Connect combines dissemination and training with OpenAIRE’s powerful NOAD network engaging research communities and content providers in adopting such services. These combined actions bring immediate and long-term benefits to scholarly communication stakeholders by affecting the way research results are disseminated, exchanged, evaluated, and re-used. In this project Empenn is acting, through CNRS, as the French coordinator to develop the link with the Neuroimaging research community. This is performed in the context of the FLI-IAM national infrastructure.

9.3.1.2. EIT-Health

Participant: Christian Barillot.

EIT Health aims to promote entrepreneurship and develop innovations in healthy living and active ageing, providing Europe with new opportunities and resources. EIT Health will enable citizens to lead healthier and more productive lives by delivering products, services and concepts that will improve quality of life and contribute to the sustainability of healthcare across Europe. EIT Health is a strong, diverse and balanced partnership of best-in-class organisations in education, research, technology, business creation and corporate and social innovation. EIT Health intends to foster cooperation and unlock Europe’s innovation and growth potential – developing and retaining the best talents, creating high-quality jobs and boosting the global competitiveness of European industry. Empenn is involved in this project through the Inserm and Inria institutions. Christian Barillot is representing Inria as one expert in the dedicated WG “Healthy Brain”. Empenn is also concerned by the WG “big data”.

9.4. International Initiatives

9.4.1. Inria International Labs

9.4.1.1. MMINCARAV

EPFL-Inria

Associate Team involved in the International Lab:

Title: Multimodal Microstructure-Informed Neuronal Connectivity: Acquisition, Reconstruction, Analysis and Validation

International Partner (Institution - Laboratory - Researcher):

Ecole Polytechnique Fédérale de Lausanne (Switzerland) - Laboratoire de Traitement du Signal 5 - Jean-Philippe Thiran

Start year: 2019

See also: https://team.inria.fr/empenn/research/mmincarav-inria-epfl/

Participants: Emmanuel Caruyer, Olivier Commowick, Julie Coloigner, Élise Bannier and Christian Barillot.

The objectives of this associate team will be to address new scientific challenges related to the use of multimodal magnetic resonance imaging (MRI) to derive microstructure indices and apply them to the measure of brain connectivity. We will focus on 4 aspects of this: first we will develop novel sampling techniques, with the objective to reduce acquisition time for the accurate reconstruction of microstructure indices using diffusion MRI; next we will propose joint T2 relaxometry and diffusion models for the description of microstructure, to take advantage of the complementarity of both modalities in the estimation of microstructure indices; in continuation, we will propose new statistical and network analysis methods using the microstructure-informed connectome, and evaluate its potential to reduce bias and false positives; last we will develop a realistic simulation tool combining a fine macroscopic description of fiber bundles, with a fast and realistic simulator at the mesoscopic scale developed by LTS5.

9.4.1.2. Other projects

Participants: Pierre Maurel, Christian Barillot, Claire Cury.

Gundishapur Program (Partenariat Hubert Curien franco-iranien)

This project is a collaboration between the Empenn team and the Institute of medical science and technologies (Shahid Beheshti university, Iran).

Combining EEG (Electroencephalogram) and fMRI (functional Magnetic Resonance Imaging) shows great promise in helping scientists to better understand the complex function of the brain. It can also be used in understanding the brain dysfunctions or specific behaviors. The integration of these two modalities can provide a good spatio-temporal resolution of the neuronal activities, and therefore, it can bring a good insight on the brain function. EEG is the recording of the electrical activity of the brain through scalp surface electrodes. We are already working in this area through the HEMISFER project, whose goal is to make full use of neurofeedback paradigm by using a coupling model associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) and Electro-encephalography (EEG) to “enhance” the neurofeedback protocol. A former member of our team, Dr. Noorzadeh, has already worked on a part of this project, and is now in IMSAT (Iran). He is our main contact for this collaboration.

This project works on the integration methods, in order to first acquire the simultaneous data of high quality with the minimum possible artifacts, and also on biomedical applications in this regard. One of these applications is the source localization using the multi-modal data. Identifying neuronal sources in both high spatial and temporal resolution can open up a bright way to understand lots of diseases, among which epilepsy is the main one. The epileptic seizures or the inter-ictal discharges are nowadays only detected by EEG, but the origin of the activity is only inferred in terms of brain lobes. This spatial precision can be augmented and the method can be used in the precise detection of the focal points of epilepsy for the pre-surgical evaluations.

9.4.1.3. Informal International Collaborations

- Emmanuel Caruyer collaborates with Alice Bates, research fellow at Australian National University, Canberra, on "Dimensionality sampling for B-tensor encoding in diffusion MRI".
- Camille Maumet collaborates with Prof. Thomas Nichols and his group, NISOx at the Oxford Big Data Institute, with Prof. Jean-Baptiste Poline and his group at McGill University, with Prof. Satrajit Ghosh and his group at MIT, with Dr David Keator at UCI Irvine, with Dr. Karl Helmer at MGH, with Dr Tristan Glatard and his group at Concordia University and with international members of the INCF on neuroimaging data sharing.
- Julie Coloigner collaborates with Prof. Natasha Leporé and Dr. John Wood, Children’s hospital Los Angeles, University Southern California.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- David Kennedy, Professor at University of Massachusetts Medical School, US visited the team on Feb 27 and gave a talk on Repronim: a center for reproducible neuroimaging.

- Natasha Leporé, Professor at Children's hospital Los Angeles, University of Southern California, US visited the team on April 4-5. She gave a talk on "Understanding pediatric brain anatomy through MRI".
- Jan Petr, Researcher at the HZDR in Dresden visited the team in March 1st, 2019 and give a talk on "Processing ASL data with ExploreASL - technical improvement and clinical applications".

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Corentin Vallée visited Brainnetome center, Institute of Automation, Chinese Academy of Science, Beijing from June 1, 2019 to July 31, 2019; he was awarded a grant for international mobility from the MathSTIC doctoral school.

EPIONE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- Marco Lorenzi is principal investigator of the project Big Data for Brain Research, funded during 2017-20 by the Départment des Alpes Maritimes.
- Marco Lorenzi is principal investigator of the project MetaImaGen, funded by Idex Jedi UCA (2018-2020, 37k€).
- Maxime Sermesant is principal investigator of the project "The Digital Heart" and the innovation action "Digital Heart Phantom" with General Electrics, funded by Idex UCA Jedi. These projects gather the local cardiac research in academia, clinics and industry.
- Hervé Delingette is the principal investigator of the LungMark project funded by Idex Jedi UCA (2018-2021).
- Hervé Delingette is the principal investigator of the CIMPLE project, funded by Idex Jedi UCA (2018-2021), the region PACA and Oticon Medical. The region PACA and Oticon Medical are co-funding the Phd of Zihao Wang.
- N. Ayache and P. Robert are principal investigators of the project MNC3 (Médecine Numérique, Cerveau, Cognition, Comportement) funded by Idex Jedi UCA (2017-2021, 450k€). M. Lorenzi (Inria) actively participates to the supervision of this project with the help of V. Manera (ICP).

8.2. National Initiatives

8.2.1. Consulting for Industry

- Marco Lorenzi is a scientific consultant for the company MyDataModels (Sophia Antipolis), and for the company Flexper (Sophia Antipolis.)
- Maxime Sermesant is a scientific consultant for the company inHEART (Bordeaux)
- Nicholas Ayache is a scientific consultant for the company Mauna Kea Technologies (Paris).

8.2.2. Institute 3IA Côte d'Azur

The 3IA Côte d'Azurhttp://univ-cotedazur.fr/institutes/3IA/home is one of the four "Interdisciplinary Institutes of Artificial Intelligence" that were created in France in 2019. Its ambition is to create an innovative ecosystem that is influential at the local, national and international levels, and a focal point of excellence for research, education and the world of AI.

Epione is heavily involved in this institute since its 5 permanents researchers (N. Ayache, H. Delingette, M. Lorenzi, M. Sermesant and X.Pennec) are chair holders in this institute, and N. Ayache is its scientific director.

8.2.3. Collaboration with national hospitals

The Epione-project team collaborates with the following 3 French IHU (University Hospital Institute): the IHU-Strasbourg (Pr J. Marescaux and L. Soler) on image-guided surgery, the IHU-Bordeaux (Pr M. Haïssaguere and Pr P. Jaïs) on cardiac imaging and modeling and the IHU-Pitié Salpétrière (Dr. O. Colliot and S. Durrleman) on neuroimaging.

We also have long term collaborations with the CHU Nice and Centre Antoine Lacassagne in Nice.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. ERC ECSTATIC

Title: Electrostructural Tomography – Towards Multiparametric Imaging of Cardiac Electrical Disorders

Programm: H2020

Type: ERC

Duration: 2017 - 2022

Coordinator: U. Bordeaux

Inria contact: Maxime Sermesant

Cardiac electrical diseases are directly responsible for sudden cardiac death, heart failure and stroke. They result from a complex interplay between myocardial electrical activation and structural heterogeneity. Current diagnostic strategy based on separate electrocardiographic and imaging assessment is unable to grasp both these aspects. Improvements in personalized diagnostics are urgently needed as existing curative or preventive therapies (catheter ablation, multisite pacing, and implantable defibrillators) cannot be offered until patients are correctly recognized.

ECSTATIC aims at achieving a major advance in the way cardiac electrical diseases are characterized and thus diagnosed and treated, through the development of a novel non-invasive modality (Electrostructural Tomography), combining magnetic resonance imaging (MRI) and non-invasive cardiac mapping (NIM) technologies.

The approach will consist of: (1) hybridising NIM and MRI technologies to enable the joint acquisition of magnetic resonance images of the heart and torso and of a large array of body surface potentials within a single environment; (2) personalising the inverse problem of electrocardiography based on MRI characteristics within the heart and torso, to enable accurate reconstruction of cardiac electrophysiological maps from body surface potentials within the 3D cardiac tissue; and (3) developing a novel disease characterisation framework based on registered non-invasive imaging and electrophysiological data, and propose novel diagnostic and prognostic markers.

This project will dramatically impact the tailored management of cardiac electrical disorders, with applications for diagnosis, risk stratification/patient selection and guidance of pacing and catheter ablation therapies. It will bridge two medical fields (cardiac electrophysiology and imaging), thereby creating a new research area and a novel semiology with the potential to modify the existing classification of cardiac electrical diseases.

8.3.1.2. ERC G-statistics

Title: Biophysical Modeling and Analysis of Dynamic Medical Images

Programme: FP7

Type: ERC

Period: 2018-2023

Coordinator: Inria

PI: Xavier Pennec

G-Statistics aims at exploring the foundations of statistics on non-linear spaces with applications in the Life Siences. Invariance under gauge transformation groups provides the natural structure explaining the laws of physics. In life sciences, new mathematical tools are needed to estimate approximate invariance and establish general but approximate laws. Rephrasing Poincaré: a geometry cannot be more true than another, it may just be more convenient, and statisticians must find the most convenient one for their data. At the crossing of geometry and statistics, G-Statistics aims at grounding the mathematical foundations of geometric statistics and to exemplify their impact on selected applications in the life sciences.

So far, mainly Riemannian manifolds and negatively curved metric spaces have been studied. Other geometric structures like quotient spaces, stratified spaces or affine connection spaces naturally arise in applications. G-Statistics will explore ways to unify statistical estimation theories, explaining how the statistical estimations diverges from the Euclidean case in the presence of curvature, singularities, stratification. Beyond classical manifolds, particular emphasis will be put on flags of subspaces in manifolds as they appear to be natural mathematical object to encode hierarchically embedded approximation spaces.

In order to establish geometric statistics as an effective discipline, G-Statistics will propose new mathematical structures and characterizations of their properties. It will also implement novel generic algorithms and illustrate the impact of some of their efficient specializations on selected applications in life sciences. Surveying the manifolds of anatomical shapes and forecasting their evolution from databases of medical images is a key problem in computational anatomy requiring dimension reduction in non-linear spaces and Lie groups. By inventing radically new principled estimations methods, we aim at illustrating the power of the methodology and strengthening the "unreasonable effectiveness of mathematics" for life sciences.

8.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: ERA CoSysMed

Project acronym: SysAFib

Project title: Systems medicine for diagnosis and stratification of atrial fibrillation

Duration: Mai 2016 - Mai 2019

Coordinator: Simula, Norway

Inria contact: Maxime Sermesant

Other partners: Inria, Helmholtz Zentrum München, Oslo University Hospital, Maastricht University, CardioCentro Ticino/CCMC

Abstract: Atrial fibrillation (AF) sharply increases the risk of stroke and is associated with a number of other severe complications, including heart failure. The SysAFib project aims to combine advanced data analysis and computer simulations with classical clinical approaches to create a decision support tool for treating AF. Diverse data sources, such as the individual patient's medical history, clinical measurements and genetic data will be combined into a single tool for optimizing and personalizing AF therapy. SysAFib's ultimate goal is to deliver the right treatment to the right patient at the right time, stopping AF in its tracks and ending the need for repeat invasive procedures.

8.4. International Initiatives

8.4.1. Inria International Labs

Inria@SiliconValley

Associate Team involved in the International Lab:

8.4.1.1. GeomStats

Title: Geometric Statistics in Computational Anatomy: Non-linear Subspace Learning Beyond the Riemannian Structure

International Partner (Institution - Laboratory - Researcher):

Stanford (United States) - Department of Statistics - Susan Holmes

Start year: 2018

See also: http://www-sop.inria.fr/asclepios/projects/GeomStats/

The scientific goal of the associated team is to develop the field of geometric statistics with key applications in computational anatomy. Computational anatomy is an emerging discipline at the interface of geometry, statistics, image analysis and medicine that aims at analysing and modelling the biological variability of the organs shapes at the population level. An important application in neuroimaging is the spatial normalization of subjects that is necessary to compare anatomies and functions through images in populations with different clinical conditions. Following the developments of the last 3 years of the associated team GeomStat, the new research directions have been broken into three axes. The first axis aims at continuing the progresses in theoretical and applied Geometric statistics, with a first theme studying the impact of curvature on the estimation with a finite sample, and a second axis extending the current work on Barycentric Subspace Analysis (BSA), notably with algorithms. The second axis aims at developing a hierarchical atlas of the brain anatomy based on the stratification of the space of image orbits under diffeomorphisms. The third axis explores three important applications of low-dimensional subspace learning in manifolds using BSA in neuroscience: the approximation of EEG signals for brain-computer interfaces (BCI); the acceleration and robustification of Tensor Distribution Functions (TDF) estimation in diffusion images; and the efficient inference in spaces of rank-deficient symmetric matrices for imaging-genetics from multi-centric databases.

8.4.2. Inria Associate Teams Not Involved in an Inria International Labs

8.4.2.1. PERSOCARDIOLEARN

Title: Personalization of Cardiac Models using Experimental Data and Machine Learning

International Partner (Institution - Laboratory - Researcher):

University of Toronto (Canada) - Sunnybrook Research Institute - Mihaela Pop

Start year: 2017

See also: https://team.inria.fr/asclepios/research/associated-team-persocardiolearn/

Multi-scale computer modelling is a powerful tool that could be used to simulate in silico cardiac electrical activity and biomechanical function of individual heart. Imaging and 3D heart models built from images can help us understand the basis of structurally-diseased hearts at organ level and to predict in silico the changes in electro-mechanical function as a consequence of muscle remodelling in pathologic state (e.g. chronic infarction, a major cause of death). We hypothesize that MRI-based predictive models can help us identify new opportunities to intervene or to predict the outcome of ablation therapy, which currently has low clinical success. However, these predictive models need to be validated and thoroughly tested in preclinical experiments prior to their integration into the clinical stage. Hence, the next logical step for our joint Inria-SB efforts is to expand our experimental-theoretical framework and to personalize fast 3D heart models from in vivo MR-EP data. This translational step involves numerous challenging tasks from the modelling perspective since the in vivo imaging and physiological signals are rather noisy and obtained at a poor spatial resolution, potentially leading to erroneous customization of mathematical model parameters. However, this collaboration employs a rare combination of experiments and modelling specialists. Moreover, the originality of the proposed approach is to build upon machine-learning techniques rather than on data assimilation methods that are more explored in the literature but have inherent limitations (robustness to noise, local minima…).

8.4.3. Inria International Partners

8.4.3.1. Informal International Partners

8.4.3.1.1. University College London (UCL), London, UK

Marco Lorenzi is collaborator of the Translational Imaging Group of UCL, and with the UCL Institute od Ophtalmology. His collaboration is around the topic of spatio-temporal analysis of medical images, with special focus on brain imaging analysis and biomarker development. He is also collaborating with the “Progression Over Neurodegenerative Disorders” (POND) group (Prof. Daniel Alexander) for developing new computational models and techniques for learning characteristic patterns of disease progression using large longitudinal clinical data sets, with special focus on dementias.

8.4.3.1.2. Imaging Genetics Center (IGC), University of Southern California (USC), CA, USA

Marco Lorenzi is currently collaborator of IGC for the investigation of the complex relationship between brain atrophy and genetics in Alzheimer's disease, in particular for demonstrating the effectiveness of multivariate statistical models in providing a meaningful description of the relationship between genotype and brain phenotype.

8.4.3.1.3. St Thomas' Hospital, King's College London, United Kingdom

Maxime Sermesant is a visiting lecturer in the Division of Imaging Sciences and Biomedical Engineering, St Thomas' Hospital, King's College London lead by Pr Reza Razavi. The XMR facility within this hospital is a unique opportunity to validate and exploit the cardiovascular modelling work.

8.4.3.1.4. Other International Hospitals

Collaborations with several other European hospitals have been established through the European projects VP2HF, MD PAEDIGREE, SysAFib and with BarcelonaBeta research centre for Alzheimer.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Dr. Gabriel Ziegler (German Center for Neurodegenerative Disorder, DE) visited the group from Oct 14th to Oct 18t.
- Guillaume Lajoinie (Physics of Fluid laboratory, University of Twente, NL) visited the team from April until October 2019.
- Wilhelm Wimmer (Center ARTORG, University of Bern, CH) visited the team from Nov. 2018 until Oct. 2019.
- Pr. Dmitri Alekseevky (The Institute for Information Transmission Problems, Moscow) visited the Geometric Statistics group from february 6 to 13 2019.

8.5.1.1. Internships

- Buntheng LY, Master student at the University Claude Bernard Lyon 1, visited the Epione team from March to September 2019 to work with Maxime Sermesant on Machine Learning methods for the prediction of Sudden Cardiac Death.
- YingYu Yang, Master student at Ecole Polytechnique, visited the Epione team from April to September 2019 to work with Maxime Sermesant on Machine Learning and Pulmonary hypertension.
- Gaetan Desrues, Master student at University of Bordeaux, visited the Epione team from March to September 2019 to work with Maxime Sermesant on hyper-reduction of cardiac models using poly-affine deformation.
- Paul Blanc Durand, Master student at University Paris-Est Créteuil, visited the Epione team from April to October 2019 to work with Hervé Delingette on Mesh-based Registration of lung CT scans between inhale and exhale phases.
- Bastien Manach-Perennou, Master student at Ecole Central Supélec, visited the Epione team from September to January 2019 to work with Xavier Pennec on Registration synchronisation.
- Julien Moreira, Master student from University Côte d'Azur, visited the Epione team from April to June 2019 to work with Marco Lorenzi on the analysis of apathy and depression in the UK Biobank. The internship is within a collaboration with Centre de la Memoire de Nice.
- Yann Fraboni visited the Epione team from December 2019 to work with Marco Lorenzi on the analysis of bias of federated learning methods in distributed application. The internship is within a collaboration with Accenture Labs of Sophia Antipolis.

ERABLE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Muse

- Title: Multi-Omics and Metabolic models iNtegration to study growth Transition in *Escherichia coli*
- Coordinators: Delphine Ropers (EPI Ibis) and Marie-France Sagot
- ERABLE participants: Marie-France Sagot and Arnaud Mary.
- Type: IXXI Project (2018-2020).
- Web page: none for now.

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. Aster

- Title: Algorithms and Software for Third gEneration Rna sequencing
- Coordinator: Hélène Touzet, University of Lille and CNRS.
- ERABLE participants: Vincent Lacroix (ERABLE coordinator), Audric Cologne, Eric Cumunel, Alex di Genova, Leandro I. S. de Lima, Arnaud Mary, Marie-France Sagot, Camille Sessegolo, Blerina Sinaimeri.
- Type: ANR (2016-2020).
- Web page: http://bioinfo.cristal.univ-lille.fr/aster/.

8.2.1.2. GraphEn

- Title: Enumération dans les graphes et les hypergraphes : Algorithmes et complexité
- Coordinator: D. Kratsch
- ERABLE participant(s): A. Mary
- Type: ANR (2015-2019)
- Web page: http://graphen.isima.fr/

8.2.1.3. GrR

- Title: Graph Reconfiguration
- Coordinator: N. Bousquet
- ERABLE participant(s): A. Mary
- Type: ANR JCJC (2019-2021)
- Web page: Not available

8.2.1.4. Green

- Title: Deciphering host immune gene regulation and function to target symbiosis disturbance and endosymbiont control in insect pests
- Coordinator: A. Heddi
- ERABLE participant(s): M.-F. Sagot, C. Vieira
- Type: ANR (2018-2021)
- Web page: Not yet available

8.2.1.5. Hmicmac

- Title: Host-microbiota co-adaptations: mechanisms and consequences
- Coordinator: F. Vavre
- ERABLE participant(s): F. Vavre
- Type: ANR PRC (2017-2020)
- Web page: Not available

8.2.1.6. Networks

- Title: Networks
- Coordinator: Michel Mandjes, University of Amsterdam
- ERABLE participant(s): S. Pissis, L. Stougie
- Type: NWO Gravity Program (2014-2024)
- Web page: https://www.thenetworkcenter.nl/

8.2.1.7. Resist

- Title: Rapid Evolution of Symbiotic Interactions in response to STress: processes and mechanisms
- Coordinator: N. Kremer
- ERABLE participant(s): F. Vavre
- Type: ANR JCJC (2017-2020)
- Web page: Not available

8.2.1.8. Swing

- Title: Worldwide invasion of the Spotted WING Drosophila: Genetics, plasticity and evolutionary potential
- Coordinator: P. Gibert
- ERABLE participant(s): C. Vieira
- Type: ANR PCR (2016-2020)
- Web page: Not available

8.2.1.9. U4atac-brain

- Title: Rôle de l'épissage mineur dans le développement cérébral
- Coordinator: Patrick Edery, Centre de Recherche en Neurosciences de Lyon.
- ERABLE participants: Vincent Lacroix (ERABLE coordinator), Audric Cologne.
- Type: ANR (2018-2021).
- Web page: Not available.

8.2.2. Idex

8.2.2.1. Micro-be-have

- Title: Microbial Impact on insect behaviour: from niche and partner selection to the development of new control methods for pests and disease vectors
- Coordinator: F. Vavre
- ERABLE participant(s): F. Vavre
- Type: AO Scientific Breakthrough (2018-2021)
- Web page: Not available

8.2.3. Others

Notice that were included here national projects of our members from Italy and the Netherlands when these have no other partners than researchers from the same country.

8.2.3.1. AHeAD

- Title: efficient Algorithms for HArnessing networked Data
- Coordinator: G. Italiano
- ERABLE participant(s): R. Grossi, G. Italiano
- Type: MUIR PRIN, Italian Ministry of Education, University and Research (2019-2022)
- Web page: https://sites.google.com/view/aheadproject

8.2.3.2. CMACBioSeq

- Title: Combinatorial Methods for analysis and compression of biological sequences
- Coordinator: G. Rosone
- ERABLE participant(s): N. Pisanti
- Type: SIR, MIUR PRIN, Italian Ministry of Research National Projects (2015-2019)
- Web page: http://pages.di.unipi.it/rosone/CMACBioSeq.html

8.2.3.3. MyOwnResearch

- Title: MyOwnResearch: Homogeneous subgroup identification in fatigue management across chronic immune diseases through single subject research design
- Coordinator: A. Schönhuth
- ERABLE participant(s): A. Schönhuth
- Type: Health Holland project (2018-2021)
- Web page: Not available

8.2.3.4. Open Innovation: Digital Innovation for Driving

- Title: Open Innovation: Digital Innovation for Driving
- Coordinator: G. Italiano
- ERABLE participant(s): G. Italiano
- Type: Bridgestone (2018-2019)
- Web page: Not available

8.3. European Initiatives

8.3.1. Collaborations in European Programs, Except FP7 & H2020

8.3.1.1. Pangaia

- Title: Pan-genome Graph Algorithms and Data Integration
- Coordinator: Paola Bonizzoni, University of Milan, Italy
- ERABLE participant(s): S. Pissis, A. Schönhuth, L. Stougie
- Type: H2020 MSCA-RISE (2020-2022)
- Web page: Not available

8.3.2. Collaborations with Major European Organizations

By itself, ERABLE is built from what initially were collaborations with some major European Organisations (CWI, Sapienza University of Rome, Universities of Florence and Pisa, Free University of Amsterdam) and then became a European Inria Team.

8.4. International Initiatives

8.4.1. Inria Associate Teams Not Involved in an Inria International Lab

Compasso

- Title: COMmunity Perspective in the health sciences: Algorithms and Statistical approacheS for explOring it
- Duration: 2018, renewable from 2 to 5 years more
- Coordinator: On the Portuguese side, Susana Vinga, IST, Lisbon, Portugal; on the French side, Marie-France Sagot
- ERABLE participant(s): R. Andrade, M. Ferrarini, G. Italiano, A. Marchetti-Spaccamela, A. Mary, H. T. Pusa, M.-F. Sagot, B. Sinaimeri, L. Stougie, A. Viari, I. Ziska
- Web page: http://team.inria.fr/erable/en/projects/inria-associated-team-compasso/

8.4.2. Participation in Other International Programs

ERABLE is coordinator of a CNRS-UCBL-Inria Laboratoire International Associé (LIA) with the Laboratório Nacional de Computação Científica (LNCC), Petrópolis, Brazil. The LIA has for acronym LIRIO ("Laboratoire International de Recherche en bIOinformatique") and is coordinated by Ana Tereza Vasconcelos from the LNCC and Marie-France Sagot from BAOBAB-ERABLE. The LIA was created in January 2012 for 4 years, renewable once for 4 more years. This year (2019) is the final one. A web page for the LIA LIRIO is available at this address: http://team.inria.fr/erable/en/cnrs-lia-laboratoire-international-associe-lirio/.

Erable also participates in Network for Organismal Interactions Research (NOIR), a project funded by Conicyt in Chile within the call Internation Networking between Research Centers. The project started in 2019 and will last until the end of 2020. The coordinator on the Chilean side is Elena Vida from the Universidad Mayor, Santiago, Chile, and the Erable participants are Carol Moraga Quinteros, Mariana Ferrarini and Marie-France Sagot.

Finally, Marie-France Sagot participates in a Portuguese FCT project, Perseids for "Personalizing cancer therapy through integrated modeling and decision" (2016-2019), with Susana Vinga and a number of other Portuguese researchers. The budget of Perseids is managed exclusively by the Portuguese partner. Perseids ended in December 2019.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

In 2019, ERABLE greeted the following International scientists:

- In France: Alexandra Carvalho and Susana Vinga, Assistant and Associate professors resp., Instituto Superior Técnico, Lisbon, Portugal; Helisson Faoro, researcher, Instituto Carlos Chagas, Fiocruz, Paraná, Brazil; Ariel Silber, professor, Universidade de São Paulo, Brazil; Arnaldo Zaha, professor at Universidade Federal do Rio Grande do Sul, Brazil.
- In Italy: Travis Gaggie, Associate professor, Dalhousie University; Nicola Prezza, postdoc, University of Pisa; Elena Arseneva, Assistant professor, St Petersburg State University, Blerina Sinaimeri, Junior Researcher, Inria (see below); Marie-France Sagot, Senior researcher, Inria (see below).
- In the Netherlands: Wiktor Zuba, PhD student, University of Warsaw; Lorraine Ayad, Lecturer, King's College London; Grigorios Loukides, Lecturer, King's College London; Martin Farach-Colton, Professor, Rutgers University; Grigorios Loukides, Lecturer, King's College London; Martin Dyer, Professor, University of Leeds.

8.5.1.1. Internships

In 2019, ERABLE in France greeted the following Internships:

- Phablo Moura, postdoc, University of Campinas, Brazil.
- Diego Pérez and Evelyn Sanchéz, PhD students of Elena Vidal, Universidad Mayor, Santiago, Chile.

In the Netherlands, ERABLE greeted the following Internships: Luca Denti, University Bicocca of Milano, Italy, from October 2018 to January 2019, Mick van Dijk, TU Delft, from May 2018 to January 2019, Giulia Barnardini, University Bicocca of Milano, Italy, from September 2018 to November 2019.

8.5.2. Visits to International Teams

8.5.2.1. Sabbatical programme

From July 2019 to June 2020, Blerina Sinaimeri was on Sabbatical at Luiss University to work with Giuseppe Italiano, member of Erable.

8.5.2.2. Research Stays Abroad

In 2019, Marie-France Sagot visited Luiss University for 11 days as Visiting Professor from LUISS University to work with Blerina Sinaimeri who is on Sabbatical at Luiss University from July 2019 to June 2020, and with Giuseppe Italiano, member of Erable. While there, M.-F. Sagot also worked with Alberto Marchetti-Spaccamela from Sapienza University of Rome and from Erable.

FLUMINANCE Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. Comins'lab: SEACS : Stochastic modEl-dAta-Coupled representationS for the analysis, simulation and reconstruction of upper ocean dynamics

Participant: Etienne Mémin.

duration 48 months. The SEACS project whose acronym stands for: "Stochastic modEl-dAta-Coupled representationS for the analysis, simulation and reconstruction of upper ocean dynamics" is a Joint Research Initiative between the three Britanny clusters of excellence of the "Laboratoires d'Excellence" program: Cominlabs, Lebesgue and LabexMer centered on numerical sciences, mathematics and oceanography respectively. Within this project we aim at studying the potential of large-scale oceanic dynamics modeling under uncertainty for ensemble forecasting and satellite image data assimilation.

8.1.2. ANR BECOSE : Beyond Compressive Sensing: Sparse approximation algorithms for ill-conditioned inverse problems.

Participant: Dominique Heitz.

duration 48 months. The BECOSE project aims to extend the scope of sparsity techniques much beyond the academic setting of random and well-conditioned dictionaries. In particular, one goal of the project is to step back from the popular L1-convexification of the sparse representation problem and consider more involved nonconvex formulations, both from a methodological and theoretical point of view. The algorithms will be assessed in the context of tomographic Particle Image Velocimetry (PIV), a rapidly growing imaging technique in fluid mechanics that will have strong impact in several industrial sectors including environment, automotive and aeronautical industries. The consortium gathers the Fluminance and Panama Inria research teams, the Research Center for Automatic Control of Nancy (CRAN), The Research Institute of Communication and Cybernetics of Nantes (IRCCyN), and ONERA, the French Aerospace Lab.

8.1.3. IFPEN project

Participants: Jocelyne Erhel, Bastien Hamlat.

Contract with IFPEN (Institut Français du Pétrole et Energies Nouvelles) Duration: three years from October 2016. Title: Fully implicit Formulations for the Simulation of Multiphase Flow and Reactive Transport Coordination: Jocelyne Erhel. Contract with IFPEN (Institut FranÃ§ais du Pétrole et Energies Nouvelles). Duration: three years October 2016-September 2019. Title: Fully implicit Formulations for the Simulation of Multiphase Flow and Reactive Transport. Coordination: Jocelyne Erhel. Abstract: Modeling multiphase flow in porous media coupled with fluid-rock chemical reactions is essential in order to understand the origin of sub-surface natural resources and optimize their use. This project focused on chemistry models, with kinetic reactions. We developed a mathematical tool, which can be embedded into a reactive transport code.

8.1.4. GDR MANU

Participants: Yvan Crenner, Jocelyne Erhel, Bastien Hamlat.

Title: Mathematics for Nuclear industry
Duration: From 2016 to 2019
Coordination: C. Cancès
Webpage: http://gdr-manu.math.cnrs.fr/

Abstract: The working group MANU is a follow-up to the group MOMAS. It covers many subjects related to mathematical modeling and numerical simulations for problems arising from nuclear industry and nuclear waste disposal. We participated in a workshop on reactive transport (SITRAM), Pau, December 2019.

8.1.5. LEFE MANU: MSOM

Participants: Etienne Mémin, Long Li.

Title: Multiple Scale Ocean Model
Duration: From 2018 to 2021
Coordination: Bruno Deremble (CNRS LMD/ENS Paris)
Abstract: The objective of this project is to propose a numerical framework of a multiscale ocean model and to demonstrate its utility in the understanding of the interaction between the mean current and eddies.

8.2. International Initiatives

8.2.1. Inria International Partners

8.2.1.1. Informal International Partners

Imperial College, London (UK), Collaboration with Dan Crişan and Darryl Holm on Stochastic transport for the upper ocean dynamics

Chico California State University (USA), We have pursued our collaboration with the group of Shane Mayor on the GPU implementation of wavelet based motion estimator for Lidar data. This code is developped in coproperty between Inria and Chico.

8.2.1.2. International Initiatives

MATH-GEO

Title: MATHematical methods for GEOphysical flows

International Partners (Institution - Laboratory - Researcher):

- Universidad de Buenos Aires (Argentina) - CIMA - Juan Ruiz
- Universidad de la Republica Uruguay (Uruguay) - IMFIA, INCO
- CMM (Chile) - Center for Mathematical Modeling - Axel Osses
- Universidad San Ignacio de Loyola (USIL) (Peru) - Faculty of Engineering Alejandro Paredes

Duration: 2018 - 2019

Start year: 2018 http://mathgeo.cima.fcen.uba.ar

Nonlinear processes, such as advection and turbulent mixing, play a central role in geophysical sciences. The theory of nonlinear dynamical systems provides a systematic way to study these phenomena. Its stochastic extension also forms the basis of modern data analysis techniques, predictability studies and data assimilation methods. Contributions in the field of Topology and Dynamics of Chaos include methods conceived to unveil the structure organizing flows in phase space, building the gap between data and l ow-dimensional modeling. Low-order models in climate dynamics are highly desirable, since they can provide solutions in cases where high-resolution numerical simulations cannot be implemented, as in short-term wind forecasting. At the same time, the procedure provides a tool-kit for model validation, emulation or inter-model comparison, with interesting prospects in all fields of oceanographic and atmospheric sciences, including climate detection and attribution. The strategy constitutes an unprecedented and promising perspective, offering an original approach to the subject, with mathematical concepts that are not necessarily widespread in the geophysics scientific community. This proposal gathers specialists with a know-how in the most challenging aspects of the focused research field: coherent structure detection in fluid flows for the exploration and interactive visualization of scientific data (LIMSI France), data assimilation and fluid motion analysis from image sequences (Inria Rennes), numerical models and data assimilation (CMM-Chile) stochastic models for climate dynamics with application to El Niño Ocean models (USIL-Peru), mathematical methods for weather and climate (CIMA-UBA & IMIT / IFAECI, Argentina), geophysical flows and dynamical systems (LMD France), mixing structures and Lagrangian analysis of multisatellite data (LOCEAN France), marine and estuarine hydrodynamic and water properties numerical models (INCO & IMFIA-Uruguay), in situ measurements of oceanographic conditions (CEBC France, in program with CNES France and CONAE Argentina), global modelling technique and topological characterization of flows (CORIA with CESBIO, France).

8.3. International Research Visitors

8.3.1. Visits of International Scientists

- 1 week visit of Alejandro Paredes Universidad San Ignacio de Loyola (USIL) (Peru) to work with Etienne Mémin
- 1 week visit of André Cavaleri (Instituto Tecnologico de Aeronautica, SP, Brésil) to work with Gilles Tissot
- 3 months visit of Ruediger Brecht (May to August), PhD student at Memorial University of Newfoundland, Canada, supported by funding from Inria-Mitacs Globalink.

GENSCALE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Project Thermin: Differential characterization of strains of a bacterial species, Streptococcus thermophilus, with a Nanopore MinION

Participants: Jacques Nicolas, Emeline Roux, Grégoire Siekaniec, Dominique Lavenier.

Coordinator: J. Nicolas (Inria/Irisa, GenScale, Rennes)
Duration: 36 months (Oct. 2018 – Sept. 2021)
Partners: INRA (STLO, Agrocampus Rennes, E. Guédon and Y. Le Loir).

The Thermin project aims at exploring the capacities of a low cost third generation sequencing device, the Oxford Nanopore MinION, for rapid and robust pan-genome discrimination of bacterial strains and their phenotypes. It started with the recruitments of E. Roux (délégation Inria, Oct, 2018), a biochemist from Lorraine University, and G. Siekaniec (INRA -Inria collaboration, INRA grant), a new PhD student. We study pan-genomic representations of multiple genomes and the production of characteristic signatures of each genome in this context.

9.1.2. Project DNA-Store: Advanced error correction scheme for DNA-based data storage using nanopore technology

Participants: Dominique Lavenier, Emeline Roux.

Coordinator: L. Conde-Canencia (UBS, Lab-STCC, IAS)
Duration: 12 months (Feb. 2019 - Feb. 2020)
Partners: UBS (Lab-STCC, IAS, L. Conde-Canencia)

The DNA-Store project is funded by the Labex CominLabs. The goal is to explore the possibility to store information on DNA molecules. As DNA sequencing (the reading process) is performed with the Oxford Nanopore technology, powerful error correcting codes need to be developed together with dedicated genomic data processing.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. Project HydroGen: Metagenomics applied to ocean life study

Participants: Dominique Lavenier, Pierre Peterlongo, Claire Lemaitre.

Coordinator: P. Peterlongo (Inria/Irisa, GenScale, Rennes)
Duration: 42 months (Nov. 2014 – Apr. 2019)
Partners: CEA (Genoscope, Evry), INRA (AgroParisTech, Paris – MIG, Jouy-en-Jossas).

The HydroGen project aims to design new statistical and computational tools to measure and analyze biodiversity through comparative metagenomic approaches. The support application is the study of ocean biodiversity based on the analysis of seawater samples generated by the Tara Oceans expedition.

9.2.1.2. Project SpeCrep: speciation processes in butterflies

Participants: Dominique Lavenier, Fabrice Legeai, Claire Lemaitre, Pierre Peterlongo.

Coordinator: M. Elias (Museum National d'Histoire Naturelle, Institut de Systématique et d'Evolution de la Biodiversité, Paris)
Duration: 48 months (Jan. 2015 – Jul. 2019)

Partners: MNHN (Paris), INRA (Versailles-Grignon), Genscale Inria/IRISA Rennes.

The SpeCrep project aims at better understanding the speciation processes, in particular by comparing natural replicates from several butterfly species in a suture zone system. GenScale's task is to develop new efficient methods for the assembly of reference genomes and the evaluation of the genetic diversity in several butterfly populations.

9.2.1.3. Project Supergene: The consequences of supergene evolution.

Participants: Anne Guichard, Dominique Lavenier, Fabrice Legeai, Claire Lemaitre, Pierre Peterlongo.

Coordinator: M. Joron (Centre d'Ecologie Fonctionnelle et Evolutive (CEFE) UMR CNRS 5175, Montpellier)
Duration: 48 months (Nov. 2018 – Oct. 2022)
Partners: CEFE (Montpellier), MNHN (Paris), Genscale Inria/IRISA Rennes.

The Supergene project aims at better understanding the contributions of chromosomal rearrangements to adaptive evolution. Using the supergene locus controlling adaptive mimicry in a polymorphic butterfly from the Amazon basin (*H. numata*), the project will investigate the evolution of inversions involved in adaptive polymorphism and their consequences on population biology. GenScale's task is to develop new efficient methods for the detection and genotyping of inversion polymorphism with several types of re-sequencing data.

9.2.1.4. Project SeqDigger: Search engine for genomic sequencing data

Participants: Dominique Lavenier, Claire Lemaitre, Pierre Peterlongo.

Coordinator: P. Peterlongo
Duration: 48 months (jan. 2020 – Dec. 2024)
Partners: Genscale Inria/IRISA Rennes, CEA genoscpoe, MIO Marseille, Institut Pasteur Paris

https://www.cesgo.org/seqdigger/

The central objective of the SeqDigger project is to provide an ultra fast and user-friendly search engine that compares a query sequence, typically a read or a gene (or a small set of such sequences), against the exhaustive set of all available data corresponding to one or several large-scale metagenomic sequencing project(s), such as New York City metagenome, Human Microbiome Projects (HMP or MetaHIT), Tara Oceans project, Airborne Environment, etc. This would be the first ever occurrence of such a comprehensive tool, and would strongly benefit the scientific community, from environmental genomics to biomedicine.

9.2.2. PIA: Programme Investissement d'Avenir

9.2.2.1. RAPSODYN: Optimization of the rapeseed oil content under low nitrogen

Participants: Dominique Lavenier, Claire Lemaitre, Pierre Peterlongo, Gwendal Virlet.

Coordinator: N. Nesi (Inra, IGEPP, Rennes)
Duration: 99 months (2012-2020)
Partners: 5 companies, 9 academic research labs.

The objective of the Rapsodyn project is the optimization of the rapeseed oil content and yield under low nitrogen input. GenScale is involved in the bioinformatics work package to elaborate advanced tools dedicated to polymorphism detection and their application to the rapeseed plant. (http://www.rapsodyn.fr)

9.2.3. Programs from research institutions

9.2.3.1. Inria Project Lab: Neuromarkers

Participants: Dominique Lavenier, Pierre Peterlongo, Claire Lemaitre, Céline Le Beguec, Téo Lemane.

Coordinator: O. Colliot (Inria, Aramis, Paris)
Duration: 4 years (2017-2020)
Partners: Inria (Aramis, Pasteur, Dyliss, GenScale, XPOP), ICM

The Neuromarkers IPL aims to design imaging bio-markers of neuro-degenerative diseases for clinical trials and study of their genetic associations. In this project, GenScale brings its expertise in the genomics field. More precisely, given a case-control population, a first step is to identify small genetic variations (SNPs, small indels) from their genomes. Then, using these variations together with brain images (also partitioned into case-control data sets), the challenge is to select variants that present potential correlation with brain images.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

Program: ITN (Initiative Training Network)

Project acronym: IGNITE

Project title: Comparative Genomics of Non-Model Invertebrates

Duration: 48 months (April 2018, March 2022)

Coordinator: Gert Woerheide

Partners: Ludwig-Maximilians-Universität München (Germany), Centro Interdisciplinar de Investigação Marinha e Ambiental (Portugal), European Molecular Biology Laboratory (Germany), Université Libre de Bruxelles (Belgium), University of Bergen (Norway), National University of Ireland Galway (Ireland), University of Bristol (United Kingdom), Heidelberg Institute for Theoretical Studies (Germany), Staatliche Naturwissenschaftliche Sammlungen Bayerns (Germany), INRA Rennes (France), University College London (UK), University of Zagreb (Croatia), Era7 Bioinformatics (Spain), Pensoft Publishers (Bulgaria), Queensland Museum (Australia), Inria, GenScale (France), Institut Pasteur (France), Leibniz Supercomputing Centre of the Bayerische Akademie der Wissenschaften (Germany), Alphabiotoxine (Belgium)

Abstract: Invertebrates, i.e., animals without a backbone, represent 95 per cent of animal diversity on earth but are a surprisingly underexplored reservoir of genetic resources. The content and architecture of their genomes remain poorly characterised, but such knowledge is needed to fully appreciate their evolutionary, ecological and socio-economic importance, as well as to leverage the benefits they can provide to human well-being, for example as a source for novel drugs and biomimetic materials. IGNITE will considerably enhance our knowledge and understanding of animal genome knowledge by generating and analyzing novel data from undersampled invertebrate lineages and by developing innovative new tools for high-quality genome assembly and analysis.

9.3.2. Collaborations with Major European Organizations

Partner : PHC RILA 2019, Bulgaria

Two years France-Bulgaria bilateral Partnership Hubert Curien (PHC) RILA 2019 (project code : 43196Q). The topic of this project is "Integer Programming Approaches for Long-Reads Genome Assembly". Start year: 2019.

9.4. International Initiatives

9.4.1. HipcoGen

Title: High-Performance Combinatorial Optimization for Computational Genomics

International Partner (Institution - Laboratory - Researcher):

> Information Sciences group of Los Alamos National Laboratory (LANL), Los Alamos, NM 87544, USA. coordinator - Hristo Djidjev

Start year: 2017

See also: https://team.inria.fr/genscale/presentation/associated-team/

Genome sequencing and assembly, the determination of the DNA sequences of a genome, is a core experiment in computational biology. During the last decade, the cost of sequencing has decreased dramatically and a huge amount of new genomes have been sequenced. Nevertheless, most of recent genome projects stay unfinished and nowadays the databases contain much more incompletely assembled genomes than whole stable reference genomes. The main reason is that producing a complete genome, or an as-complete-as-possible-genome, is an extremely difficult computational task (an NP-hard problem) and, in spite of the efforts and the progress done by the bioinformatics community, no satisfactory solution is available today. New sequencing technologies (such as PacBio or Oxford Nanopore) are being developed that tend to produce longer DNA sequences and offer new opportunities, but also bring significant new challenges. The goal of this joint project, a cooperation between Los Alamos National Laboratory, US and Inria, is to develop a new methodology and tools based on novel optimization techniques and massive parallelism suited to these emerging technologies and able to tackle the complete assembly of large genomes.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

- Free University of Brussels, Belgium: Genome assembly [P. Perterlongo, D. Lavenier]

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Visit of Hristo Djidjev from Los Alamos National Laboratory, USA, June 2019
- Visit of Alla Lapidus and Anto korobeynikov, Center for Algoritmic Biotechnology, St. Petersburg State University, Russia, October 2019

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Visit of R. Andonov at Los Alamos National Laboratory, USA, from March 23 to April 30th, 2019.
- Visit of D. Lavenier at Los Alamos National Laboratory, USA, from May 13th to May 24th, 2019

IBIS Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

Project name	MuSE: MUlti-Omics and Metabolic models integration to study growth transition in Escherichia coli
Coordinator	D. Ropers
IBIS participants	D. Ropers, T. Etienne
Type	IXXI/BioSyl project (2018-2020)
Web page	http://www.biosyl.org/news/muse-2013-multi-omics-and-metabolic-models-integration-to-study-growth-transition-in-escherichia-coli

Project name	RNAfluo: Quantification d'ARN régulateurs *in vivo*
Coordinator	S. Lacour
IBIS participants	S. Lacour
Type	AGIR project Univ Grenoble Alpes (2016-2019)

7.2. National Initiatives

Project name	MEMIP – Modèles à effets mixtes de processus intracellulaires : méthodes, outils et applications
Coordinator	G. Batt
IBIS participants	E. Cinquemani, A. Marguet, D. Ropers
Type	ANR project (2016-2020)

Project name	ENZINVIVO – Détermination in vivo des paramètres enzymatiques dans une voie métabolique synthétique
Coordinator	G. Truan
IBIS participants	J. Geiselmann, H. de Jong
Type	ANR project (2016-2020)

Project name	MAXIMIC: Optimal control of microbial cells by natural and synthetic strategies
Coordinator	H. de Jong
IBIS participants	C. Boyat, E. Cinquemani, J. Geiselmann, H. de Jong, A. Pavlou, C. Pinel, D. Ropers
Type	ANR project (2017-2021)
Web page	https://project.inria.fr/maximic

Project name	RIBECO (RIBonucleotide ECOnomy): Engineering RNA life cycle to optimize economy of microbial energy
Coordinator	M. Cocaign-Bousquet
IBIS participants	E. Cinquemani, T. Etienne, D. Ropers
Type	ANR project (2018-2022)
Web page	https://project.inria.fr/ribeco/

Project name	COSY: real-time COntrol of SYnthetic microbial communities
Coordinator	E. Cinquemani
IBIS participants	E. Cinquemani, H. de Jong, J. Geiselmann, M. Mauri, T. Muszbek, C. Pinel, D. Ropers, M. Sangster
Type	Inria Project Lab (2017-2021)
Web page	https://project.inria.fr/iplcosy/

Project name	OPTICO : OPTImal COntrol software for microbial communities in a system of minibioreactors
Coordinator	E. Cinquemani
IBIS participants	E. Cinquemani, H. de Jong, J. Geiselmann, T. Muszbek
Type	Inria ADT (2019-2021)

Project name	AlgeaInSilico: Prédire et optimiser la productivité des microalgues en fonction de leur milieu de croissance
Coordinator	O. Bernard
IBIS participants	H. de Jong
Type	Inria Project Lab (2015-2019)
Web page	https://project.inria.fr/iplalgaeinsilico/

Project name	Analyse intégrative de la coordination entre stabilité des ARNm et physiologie cellulaire chez Escherichia coli
Coordinators	D. Ropers, M. Cocaign-Bousquet (Inra, LISBP)
IBIS participants	T. Etienne, D. Ropers
Type	Contrat Jeune Scientifique Inra-Inria (2016-2019)

7.3. International Research Visitors

7.3.1. Visits of International Scientists

Tomas Gedeon, professor in Mathematics at Montana State University (USA), visited the IBIS project-team during two months (May-July 2019) to work on modeling and analysis of resource allocation in microorganisms. His stay at Inria was funded by the Visiting researcher program of the research center Grenoble - Rhône-Alpes.

7.3.1.1. Internships

Emmanouil Sideris, enrolled in the MSc program in Computer Science at the University of Patras (Greece), did a Master internship with Eugenio Cinquemani.

LEMON Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

The MeDo project (lead by N. Chahinian) in which Carole Delenne participates is funded by Occitanie Region.

8.2. National Initiatives

Antoine Rousseau is member of the ANR project ANSWER (PI Céline Casenave), 2016-2020

Gwladys Toulemonde is head of a project (2019-2021) funded by INSU via the action MANU (MAthematical and NUmerical methods) of the LEFE program. This project, called Fraise, is focused on rainfall forcing by stochastic simulation for hydrological impact studies from dry periods to extreme events. The consortium involved in this project is larger than the Cerise one (14 researchers from 8 partners : AgroParisTech, CNRS, INRA, Inria, IRD, Université de Lyon 1, Université de Montpellier and the University of Venise in Italy).

Gwladys Toulemonde is member of the ANR project Gambas (PI Frédéric Mortier, Cirad), 2019-2023. The project GAMBAS focuses on joint species distribution models. These models can provide a better understanding and more accurate predictions of species distributions based on environmental variables while taking into account the effects of all other co-occurring species (e.g. competition).

Pascal Finaud-Guyot is member of the ANR project DEUFI (PI André Paquier, IRSTEA Lyon), 2019-2022

All the team is involved in the Inria ADT named SW2D-Lemon. This development project led to 2 coding sprints (of 2 weeks each) with the development team in Sophia. Thanks to this project, SW2D is now a C++ platform, with a dedicate GUI.

8.3. International Initiatives

Gwladys Toulemonde is member of the PHC Utique project (with Tunisia) AMANDE (PI Julie Carreau, IRD), 2019-2021. The project AMANDE focuses on stochastic and semi-parametric approaches combined to teledetection for the study of the water stress.

8.3.1. Inria International Labs

Inria Chile. Associate Team involved in the International Lab: NEMOLOCO

Title: NEw MOdeLing tOols for Coastal Oceanography

International Partner (Institution - Laboratory - Researcher): Pontificia Universidad Católica de Chile (Chile) - CIGIDEN - Rodrigo Cienfuegos

Start year: 2017

See also: https://team.inria.fr/lemon/en/

The NEMOLOCO project targets the improvement of models in the coastal zone. Expected contributions concern: 1) design and implementation of domain decomposition and coupling techniques for coastal modeling; 2) high resolution ocean simulation (including nesting) thanks to the software ROMS-CROCO, applied to biological tracers tracking.

8.3.2. Inria International Partners

8.3.2.1. Informal International Partners

A research collaboration agreement was signed with LSIA, Fès University, Morocco in the framework of Yassine Bel-Ghaddar PhD thesis.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Carlo Gaetan from the University of Venise in Italy has been invited thanks to the Fraise project one week in april, 2019.

LIFEWARE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR Projects

- ANR-FWF CyberCircuits (2018-2022): “Cybergenetic circuits to test composability of gene networks”, co-coordinated by C. Guet (IST Austria, Klosterneuburg, Austria) and J. Ruess (Inria EPI Lifeware);
- ANR-DFG SYMBIONT (2018-2021) on “Symbolic Methods for Biological Systems”, coordinated by T. Sturm (CNRS, LORIA, Nancy, France) and A. Weber (Univ. Bonn, Germany) with F. Fages and F. Boulier (U. Lille), O. Radulescu (U. Montpellier), A. Schuppert (RWTH Aachen), S. Walcher (RWTH Aachen), W. Seiler (U. Kassel);
- ANR-MOST BIOPSY (2016-2020) on “Biochemical Programming System”, coordinated by F. Molina (CNRS, Sys2diag, Montpellier) and J.H. Jiang (National Taiwan University), with F. Fages;
- ANR MEMIP (2016-2020) on “Mixed-Effects Models of Intracellular Processes”, coordinated by G. Batt, with P. Hersen, (CNRS/Paris7), E. Cinquemani (Inria EPI IBIS) and M. Lavielle (Inria/CNRS/Polytechnique, EPI XPOP);
- ANR COGEX (2016-2019) on “Computer Aided Control of Gene Expression” coordinated by P. Hersen (MSC lab, CNRS/Paris7), with G. Batt and G. Truan (LISBP, CNRS/INSA);

9.1.2. Inria Project Lab

- IPL COSY (2017-2021) on “real-time control of synthetic microbial communities”, coordinated by Eugenio Cinquemani (Ibis, Inria), with Jean-Luc Gouzé (Biocore, Inria), Grégory Batt, Frédéric Bonnans (Commands, Inria), Efimov Denis (Non-A, Inria), and Hans Geiselmann (BIOP, Université Grenoble-Alpes), Béatrice Laroche (Maiage, Inra Jouy-en-Josas).

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

- H2020 FET-OPEN COSY-BIO (2017-2020), on “Control Engineering of Biological Systems for Reliable Synthetic Biology Applications”, coordinated by Diego di Bernardo (Tigem), with Filippo Menolascina (Edinburgh U), Mario di Bernardo (Naples U), Pascal Hersen (Paris7 U), Mustafa Khammash (ETHZ), Grégory Batt, Guy-Bart Stan (Imperial College), and Lucia Marucci (Bristol U).

9.3. International Research Visitors

9.3.1. Visits of International Scientists

The following researchers have been invited for short visits:

- Jean-Louis Lassez, retired IBM Yorktown, USA
- Lucia Nasti, Univ. Pisa, Italy
- Claudia Lopez Zazueta, NTNU, Norway

9.3.1.1. Internships

- Orianne Bargain (TU Dresden Germany)
- Elisabeth Degrand (KTH, Stockholm Sweden)

M3DISIM Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

ANR JCJC LungManyScale, M. Genet, P. Moireau, D. Chapelle (383 k€) – The lungs' architecture and function are well characterized; however, many fundamental questions remain (e.g., there is no quantitative link between tissue- and organ-level material responses), which represent real health challenges (e.g., Idiopathic Pulmonary Fibrosis is a poorly understood disease, for which a mechanical vicious cycle has been hypothesized, but not demonstrated). The general objective of this project is twofold: (i) scientifically, to better understand pulmonary mechanics, from the alveola to the organ in health and disease; (ii) clinically, to improve diagnosis and prognosis of patients through personalized computational modeling. More precisely, This project aims at developing a many-scale model of the pulmonary biomechanics, linked by computational nonlinear homogenization. The model will integrate the experimental and clinical data produced by partners, through an estimation pipeline that will represent augmented diagnosis and prognosis tools for the clinicians.

ANR ODISSE, P. Moireau, S. Imperiale (154 k€) – Motivated by some recent developments from two different fields of research, that is, observer design for finite-dimensional systems and inverse problems analysis for some PDE systems, the ODISSE project aims at developing rigorous methodological tools for the design of estimating algorithms for infinite-dimensional systems arising from hyperbolic PDE systems.

ANR SIMR, P. Moireau, D. Chapelle (97 k€) SIMR is a multi-disciplinary project seeking a better understanding of the biophysical mechanisms involved in mitral valve (MV) regurgitation diseases, to improve decision-making in patients by helping to determine the optimal timing for surgery. This project aims at facing this major issue with the following main two objectives: (1) Evaluate the biophysical consequences of MV repair and (2) Design numerical tools, for cardiac hemodynamics, fluid-structure interaction and myocardium biomechanics to provide an in silico counterpart of the in vivo data obtained by tension measurement and imaging.

8.1.2. Other funding

IPM-MS project (for Imagerie Polarimétrique de Mueller pour la réalisation d'un système original de caractérisation des propriétés mécaniques des Matériaux Structurés), J.M. Allain (50k€ funded by the LABEX Lasips) – This project, which involves the LPICM laboratory (Ecole Polytechnique, CNRS), the LMS (Ecole Polytechnique, CNRS, Mines ParisTech) and the Centre des Matériaux (Mines ParisTech), aims at developing an optical tool to study the link between the mechanical properties of a material and its hierarchical organization. Despite the development of new methods to observe the microstructure, one of the limitations is the number of observations that can be obtained on a given sample in a realistic experimental time. To overcome this difficulty, we are planning to use the Mueller polarimetry to obtain at a fast rate (a few frames per second, compared to a few frames per half-hour) relevant information on the local anisotropy of biological (heart, skin) and composite (short fibers composite) samples.

8.2. European Initiatives

8.2.1. Collaborations with Major European Organizations

Partner 1: Division of Biomedical Engineering & Imaging Sciences (BMEIS), St Thomas' Hospital, King's College London, UK

Clinical-modeling topics mostly encompassing congenital heart diseases (BMEIS) acts as "Other participant" in the Inria Associate team ToFMOD, and R. Chabiniok additionally performs clinical MRI exams at St Thomas' hospital 0.5 days / week.

Partner 2: Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Czech Republic

Model-constrained image registrations, trans-valvular flow in pathological valves.

Partner 3: Institute for Clinical and Experimental Medicine in Prague

Cardiovascular MRI.

8.3. International Initiatives

8.3.1. Inria Associate Teams Not Involved in an Inria International Labs

8.3.1.1. ToFMod

Title: Cardiac Biomechanical Modeling of Chronic Right Ventricular Loading

International Partner (Institution - Laboratory - Researcher):

> UT Southwestern Medical Center, Dallas,Texas (United States), Mohammad Tarique Hussain

Start year: 2018

See also: https://m3disim.saclay.inria.fr/associated-team/

This collaboration aims at addressing a crucial issue in cardiology of congenital heart diseases, namely, the optimal timing of pulmonary valve replacement (PVR) in patients with surgically repaired tetralogy of Fallot (ToF) prone to chronic pulmonary regurgitation or right ventricular outflow tract stenosis. Our strategy consists in exploiting the predictive power of biomechanical modeling to shed light in the decision process. We will start by a detailed proof-of-concept study, based on datasets that will be acquired in patients indicated for percutaneous PVR, prior to the procedure, and in the follow-up at 3- and 12-months post-PVR. These datasets will be first used to calibrate the Inria M3DISIM patient-specific heart model simulating a cardiac cycle (at each follow-up time point) to access the myocardial properties – namely, the active contractility and passive stiffness. The instantaneous tissue properties will be statistically analyzed and compared with the level of reverse remodeling – i.e. the positive outcome of PVR. Secondly, the data at each time point will be used to calibrate and further develop the models of long-term tissue remodeling created by the M3DISIM researchers. It is only by combining such invaluable longitudinal data with biomechanical modeling expertise that progress can be achieved in the above objective, indeed.

8.4. International Research Visitors

8.4.1. Invited researchers

- T. Hussain, A. Tandon (Senior researchers at UTSW Medical Center Dallas): joint work in the scope of the Inria Associate team ToFMOD
- F. Regazzoni (3rd year PhD student from MOX, Milan, Italy): From January until March 2019 and from December 2019, joint work on model learning and data assimilation coupling.

MAGIQUE-3D Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Partnership with I2M in Bordeaux supported by Conseil Régional d'Aquitaine

title: COFIMUS.

Coordinator:Juliette Chabassier

Other partners: I2M CNRS Université Bordeaux I

The objective is to develop a virtual workshop for wind musical instrument makers.

This project is supported by the Conseil Régional d'Aquitaine, for a duration of 2 years and has funded the postdoctoral position of Augustin Ernoult since March 2019.

9.2. National Initiatives

9.2.1. Depth Imaging Partnership

Magique-3D maintains active collaborations with Total. In the context of Depth Imaging, Magique-3D coordinates research activities dealing with the development of high-performance numerical methods for solving wave equations in complex media. This project has involved 2 other Inria Team-Projects (Hiepacs and Nachos) which have complementary skills in mathematics, computing and in geophysics. DIP is fully funded by Total by the way of an outline agreement with Inria .

In 2014, the second phase of DIP has begun. Lionel Boillot has been hired as engineer to work on the DIP platform. Six PhD students have defended their PhD since 2014 and they are now post-doctoral researchers or engineers in Europe. DIP is currently employing 2 PhD students and one post-doctoral researcher.

9.2.2. PRE Concert

Magique 3D is hosting an Inria "exploratory research project" (PRE) about modeling and designing wind musical instruments. This project has funded the post-doctoral position of Robin Tournemenne from July 2017 until July 2019.

9.2.3. ANR Num4Sun

The ANR has launched a specific program for supporting and promoting applications to European or more generally International projects. Magique-3D has been selected in 2016 after proposing a project to be applied as a FET project on the occasion of a call that will open in 2017 April. This project will gather researchers of the MPS (https://www.mps.mpg.de/en), of the BSC (https://www.bsc.es/), of the BCAM (http://www.bcamath.org/en/), of Heriot-Watt University (https://www.hw.ac.uk/) and Inria teams.
A kick-off meeting has been held in November 2016 in Strasbourg and a second one in Paris in July 2017. Thanks to this support, we have submitted a ETPHPC proposal in September 2017 The project is funded for 18 months starting from August 2016. The funding amounts 30000€.

9.2.4. Grant from Fondation Blaise Pascal

The project Louis 14.0 has been selected by the Fondation Blaise Pascal as one of their supported projects for 2019. See more about the project at https://project.inria.fr/louis14point0/, in french.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. Mathrocks

Title: Multiscale Inversion of Porous Rock Physics using High-Performance Simulators: Bridging the Gap between Mathematics and Geophysics

Program: H2020

Duration: April 2018 - March 2022

Coordinator: Universidad Del Pais Vasco (EHU UPV)

Partners:

Bcam - Basque Center for Applied Mathematics Asociacion (Spain)

Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)

Universidad Del Pais Vasco Ehu Upv (Spain)

Universitat Politecnica de Catalunya (Spain)

REPSOL SA (Spain)

Pontificia Universidad Catolica de Valparaiso (Chile)

Curtin University of Technology (Australia)

The University of Texas System (USA)

University Nacional de Columbia (Colombia)

Pontificia Universidad Catolica de Chile (Chile)

Universidad Central de Venezuela (Venezuela)

University de Buenos Aires (Argentina)

Macquarie University (Australia)

Inria contact: Hélène BARUCQ

We will develop and exchange knowledge on applied mathematics, high-performance computing (HPC), and geophysics to better characterize the Earth´s subsurface. We aim to better understand porous rocks physics in the context of elasto-acoustic wave propagation phenomena. We will develop parallel high-continuity isogeometric analysis (IGA) simulators for geophysics. We will design and implement fast and robust parallel solvers for linear equations to model multi-physics electromagnetic and elasto-acoustic phenomena. We seek to develop a parallel joint inversion workflow for electromagnetic and seismic geophysical measurements. To verify and validate these tools and methods, we will apply the results to: characterise hydrocarbon reservoirs, determine optimal locations for geothermal energy production, analyze earthquake propagation, and jointly invert deep-azimuthal resistivity and elasto-acoustic borehole measurements. Our target computer architectures for the simulation and inversion software infrastructure consists of distributed-memory parallel machines that incorporate the latest Intel Xeon Phi processors. Thus, we will build a hybrid OpenMP and MPI software framework. We will widely disseminate our collaborative research results through publications, workshops, postgraduate courses to train new researchers, a dedicated webpage with regular updates, and visits to companies working in the area. Therefore, we will perform a significant role in technology transfer between the most advanced numerical methods and mathematics, the latest super-computer architectures, and the area of applied geophysics.

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. ANTS

Title: Advanced Numerical meThods for helioSeismology

International Partner (Institution - Laboratory - Researcher):

Max Plank Institut für Sonnensystemforschung (Germany) – Department Solar and Stellar Interiors – Laurent Gizon.

Start year: 2019

See also: https://team.inria.fr/ants/

Magique-3D has started an Associate Team project, ANTS (Advanced Numerical meThods for helioSeismology), with the Max Planck Institute for Solar System Research (MPS), led by Laurent Gizon. This helps promote the collaboration between Magique3D and the Solar group at the Max Planck Institute for Solar System Research at Göttingen (MPS) for the direct and inversion of solar models from Doppler data obtained at the surface of the Sun. The scientific project benefits from the expertise of Magique-3D in seismic imaging, and the expert knowledge of the MPS group on Solar physics, in order to design accurate and efficient methodology. A joint workshop was held at Inria Bordeaux Sud-Ouest in December 2019: https://project.inria.fr/antsworkshop201912/.

9.4.2. Inria International Partners

9.4.2.1. New international partner: The Berkeley Seismological Laboratory, University of California, Berkeley.

In September 2019, together with Barbara Romanowicz at the University of California Berkeley https://seismo.berkeley.edu/, we initiated a collaboration aiming at developing and deploying novel tomographic methods for imaging localized structures in the deep Earth that are either blurred out or not visible in the current global models.This effort is supported by the France-Berkeley Fund which granted our project for a period of 2 years. Amount: 11000€, Management: Berkeley University url: https://fbf.berkeley.edu/project/development-and-application-advanced-seismic-imaging-techniques-key-target-structures-deep

9.4.2.2. Declared Inria International Partners

9.4.2.2.1. MAGIC2

Title: Advance Modeling in Geophysics

International Partner (Institution - Laboratory - Researcher):

California State University at Northridge (United States) - Department of Mathematics - Djellouli Rabia

The Associated Team MAGIC was created in January 2006 and renewed in January 2009. At the end of the program in December 2011, the two partners, MAGIQUE-3D and the California State University at Northridge (CSUN) decided to continue their collaboration and obtained the "Inria International Partner" label in 2013.

See also: https://project.inria.fr/magic/

The ultimate objective of this research collaboration is to develop efficient solution methodologies for solving inverse problems arising in various applications such as geophysical exploration, underwater acoustics, and electromagnetics. To this end, the research program will be based upon the following three pillars that are the key ingredients for successfully solving inverse obstacle problems. 1) The design of efficient methods for solving high-frequency wave problems. 2) The sensitivity analysis of the scattered field to the shape and parameters of heterogeneities/scatterers. 3) The construction of higher-order Absorbing Boundary Conditions. In the framework of Magic2, Rabia Djellouli (CSUN) visited Magique 3D in February 2018

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Vianey Villamizar (Department of Mathematics, Brigham Young University) visited the team in September 2019

- Mounir Tlemcani (Université d'Oran, Algeria) visited Magique 3D in March 2019.
- Sevan Adourian (Univesity of California, Berkeley) visited Magique 3D for a week in June 2019, this visit has been sponsored by the France-Berkeley Fund.

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Nathan Rouxelin visited MPS at Göttingen in April 2019, during a month.
- Rose-Cloé Meyer visited prof. Steve Pride from Lawrence Berkeley National Laboratory in June 2019 during 1 month and in December 2019 during 3 weeks.
- In the framework of DIP, Pierre Jacquet visited Total Research Center at Houston, USA, in December 2019 during 1 week.
- Yder Masson, visited Barbara Romanowicz at the Berkeley Seismological Laboratory and Steve R. Pride at the Lawrence Berkeley Laboratory for two days the week following the AGU Fall Meeting Dec 9-13, 2019 , San Francisco, CA, USA)

MAMBA Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

Mamba (Marie Doumic and Philippe Robert) participates to the GDR "MeDyna" (mechanisms and dynamics of assemblies of peptides and proteins), coordinated by Stéphane Bressanelli from IBPC.

8.1.1. ANR

8.1.1.1. ANR Blanc 2014-2018 “Kibord”

This project gathers several members of the MAMBA team together with the ENS Cachan and Université Paris-Dauphine on the mathematical study of PDE models with application to biology.

8.1.1.2. ANR iLITE 2016 - 2020

Jean-Charles Duclos-Vallée, Paul Brousse Hospital, Villejuif. Partners are several departments in Paul Brousse Hospital, ENS Cachan, University of Compiègne and several companies all over France, and COMMEDIA team, Inria Paris. The pursued objective is the bioengineering design of an artificial liver intended for liver replacement.

8.1.1.3. ANR InTelo 2017-2020

Telomere dynamics, headed by Teresa Teixeira (IBPC, Paris).

8.1.1.4. INCa/DGOS; PRT-K 2018-2021

Khê HOANG-XUAN, Hôpital Universitaire La Pitié Salpêtrière, Paris. Mathematical modeling at micro and macroscopic level of primary central nervous system lymphomas (PCNSL).

8.1.2. ITMO Cancer 2016 - 2020, HTE call (heterogeneity of tumours in their ecosystems)

8.1.2.1. ITMO Cancer EcoAML

Early leukaemogenesis in Acute Myelogenous Leukaemia (AML), 8 teams headed by François Delhommeau (CDR St Antoine, Paris).

8.1.2.2. ITMO Cancer MoGlImaging

Treatment-induced treatment resistance and heterogeneity in glioblastoma, 8 teams headed by Elizabeth Moyal (INSERM, Toulouse).

8.2. International Initiatives

- **STIC AmSud 20-STIC-05**
  - Title: New Methods for Biological Control of the Arboviruses
  - International Partner (Institution - Laboratory - Researcher):

    CIRAD (Montpellier), UMR MISTEA (Montpellier), Université Paris 13, Université de Bordeaux, Université de Strasbourg, Université Paris-Dauphine - PSL; Universidad de Buenos Aires and Universidad Nacional de Salta (Argentina); Universidad de Chile (Chile); Universidad del Quindio, Universidad Autónoma de Occidente and Universidad del Valle (Colombia); National University of Asuncion (Paraguay).
  - Duration: 2020 - 2021
  - Start year: 2020

- The main focus of this project is modeling and analysis, using mathematical methods, of new strategies aimed at controling the spread of the dengue fever and other vector-borne diseases similar to Dengue and transmitted by Aedes mosquitoes, like Chikungunya and Zika virus.
- The key topics are the following.
  * Spatial aspects of biological control techniques
  * Estimation issues for vector-borne epidemics
  * Optimal and non-optimal control approaches for biological control techniques
  * Modelling the effects of conventional control methods on the success of biological control
  * Modelling the competition effects in larval phase during biological control
  * Modelling and efficacy measures for self-propagating genetic interventions
  * Genome-scale models for Wolbachia

- **ERC Advanced grant No 740623 ADORA**

  ADORA is the acronym for *Asymptotic approach to spatial and dynamical organizations*.

  Adora ERC project aims at understanding of spatial, social and dynamical organization of large numbers of agents, presently a fundamental issue in science. ADORA focuses on problems motivated by biology because, more than anywhere else, access to precise and numerous data has opened the route to novel and complex mathematical models. The address ed problems are written in terms of **nonlinear partial differential equations**. The flux-limited Keller-Segel system, the integrate-and-fire Fokker-Planck equation, kinetic equations with internal state, nonlocal parabolic equations and constrained Hamilton-Jacobi equations are among examples of the equations under investigation.

  The role of mathematics is not only to understand the analytical structure of these new problems, but it is also to **explain the qualitative behavior of solutions and to quantify their properties**. The challenge arises here because these goals should be achieved through a hierarchy of scales. Indeed, the problems under consideration share the common feature that the large scale behavior cannot be understood precisely without access to a hierarchy of finer scales, down to the individual behavior and sometimes its molecular determinants.

  Major difficulties arise because the numerous scales present in these equations have to be discovered and singularities appear in the asymptotic process which yields deep compactness obstructions. Our vision is that **the complexity inherent to models of biology can be enlightened** by mathematical analysis and a classification of the possible asymptotic regimes.

  However an enormous effort is needed to uncover the equations intimate mathematical structures, and bring them at the level of conceptual understanding they deserve being given the applications motivating these questions which range from medical science or neuroscience to cell biology.

8.2.1. MaMoCeMa

Title: Mathematical modeling of cell motility and of autophagy

International Partner (Institution - Laboratory - Researcher):

University of Vienna (Austria) - Wolfgang Pauli Institute - Christian Schmeiser

Start year: 2018

Numerous fruitful collaborations have been developed these last years between the WPI and the Inria team MAMBA. Diane Peurichard – newly recruited permanent member of the team MAMBA- worked two years (2016-2017) with Christian Schmeiser -member of the present project- through a post-doctoral contract at the university of Vienna. In collaboration with the biologists of IST, they developed mathematical tools to understand how cells move through adhesion-based and adhesion-free motion with applications in cancer development, prevalent theme of the team MAMBA.

Collaborations WPI-MAMBA have been maintained and ensured by the sabbatical of Marie Doumic (2016-2018) -, working at the university of Vienna with Christian Schmeiser and the PhD student Julia Delacour. They have initiated a collaboration on the mathematical modeling of autophagy, which requires both C. Schmeiser's expertise in biomechanics and M. Doumic's knowledge on aggregation processes. This team will also benefit of the strong links that C. Schmeiser has developed with the two biologists teams of S. Martens (on autophagy) and M. Sixt (on cell movement).

8.2.2. Participation in Other International Programs

- **BMBF (Germany) / LiSym; 2016-2020** LiSym addresses liver diseases and regeneration, namely, steatosis, fibrosis and cirrhosis, and acute on chronic liver failure. (Dirk Drasdo)
- **BMBF (Germany) / MSDILI; 2016-2019** MS-DILI addresses multiscale modeling of drug-induced liver disease focusing on the role of APAP. Dirk Drasdo participates in this project. (Dirk Drasdo)

8.3. International Research Visitors

Visitors in Paris (LJLL) invited by J. Clairambault: Zineb Kaïd, PhD student, University Abou Bekr Belkaïd, Tlemcen, Nov. 25 - Dec. 13; Jean-François Mascari, researcher, IAC-CNR, Rome, Dec. 9-13.

Visitors in Paris (Inria) invited by D. Drasdo: Jieling Zhao, Postdoc from IfADo, Jules Dichamp, Postdoc from ifADo, Paul van Liedekerke, Research engineer from IfADo.

Visitors in Paris (LJLL) invited by D. Peurichard and M. Doumic: P. Degond (Imperial College London) Nov 20 - 22, C. Schmeiser (University of Vienna), Dec. 1 - 7, Claudia Wytrzen (University of Vienna) feb 4-8 2019, M. Tournus and M. Escobedo (February 18-22), .

Visitors in Paris (LJLL) invited by P. A. Bliman: Prof. Héctor Jairo Martínez Romero (Universidade del Valle, Cali, Colombia) for two weeks, together with Oscar Eduardo Escobar Lasso, PhD student who was present one month.

Visitors in Paris (LJLL) invited by B. Perthame: Shugo Yasuda (University of Hyogo, Kobe, Japan), Min Tang (SJTU, China), Maria Caceres (Granada, Spain), Zhenan Zhou (Peking University), Weizhu Bao (Singapore university).

MATHNEURO Project-Team

6. Partnerships and Cooperations

6.1. European Initiatives

6.1.1. FP7 & H2020 Projects

6.1.1.1. HBP

Title: The Human Brain Project

Program: FP7

Duration: October 2013 - March 2016 (first part), then : April 2016 - March 2018 (second part) and then : April 2018 - March 2020 (third part)

Coordinator: EPFL

Partners:
see the webpage of the project.

Olivier Faugeras is leading the task T4.1.3 entitled "Meanfield and population models" of the Worpackage W4.1 "Bridging Scales".

Inria contact: Olivier Faugeras (first part) and then : Romain Veltz (second and third part)

Understanding the human brain is one of the greatest challenges facing 21st century science. If we can rise to the challenge, we can gain profound insights into what makes us human, develop new treatments for brain diseases and build revolutionary new computing technologies. Today, for the first time, modern ICT has brought these goals within sight. The goal of the Human Brain Project, part of the FET Flagship Programme, is to translate this vision into reality, using ICT as a catalyst for a global collaborative effort to understand the human brain and its diseases and ultimately to emulate its computational capabilities. The Human Brain Project will last ten years and will consist of a ramp-up phase (from month 1 to month 36) and subsequent operational phases.
This Grant Agreement covers the ramp-up phase. During this phase the strategic goals of the project will be to design, develop and deploy the first versions of six ICT platforms dedicated to Neuroinformatics, Brain Simulation, High Performance Computing, Medical Informatics, Neuromorphic Computing and Neurorobotics, and create a user community of research groups from within and outside the HBP, set up a European Institute for Theoretical Neuroscience, complete a set of pilot projects providing a first demonstration of the scientific value of the platforms and the Institute, develop the scientific and technological capabilities required by future versions of the platforms, implement a policy of Responsible Innovation, and a programme of transdisciplinary education, and develop a framework for collaboration that links the partners under strong scientific leadership and professional project management, providing a coherent European approach and ensuring effective alignment of regional, national and European research and programmes. The project work plan is organized in the form of thirteen subprojects, each dedicated to a specific area of activity.
A significant part of the budget will be used for competitive calls to complement the collective skills of the Consortium with additional expertise.

6.2. International Initiatives

6.2.1. Inria Associate Teams Not Involved in an Inria International Labs

6.2.1.1. NeuroTransSF

Title: NeuroTransmitter cycle: A Slow-Fast modeling approach

PI for Inria MathNeuro: Mathieu Desroches

International Partner (Institution - Laboratory - Researcher):

Basque Center for Applied Mathematics (BCAM) (Spain) - Mathematical, Computational and Experimental Neuroscience (MCEN) Team - Serafim Rodrigues

Start year: 2019

See also: https://team.inria.fr/neurotranssf/

This associated team project proposes to deepen the links between two young research groups, on strong Neuroscience thematics. This project aims to start from a joint work in which we could successfully model synaptic transmission delays for both excitatory and inhibitory synapses, matching experimental data, and to supplant it in two distinct directions. On the one hand, by modeling the endocytosis so as to obtain a complete mathematical formulation of the presynaptic neurotransmitter cycle, which will then be integrated within diverse neuron models (in particular interneurons) hence allowing a refined analysis of their excitability and short-term plasticity properties. On the other hand, by modeling the postsynaptic neurotransmitter cycle in link with long-term plasticity and memory. We will incorporate these new models of synapse in different types of neuronal networks and we will then study their excitability, plasticity and synchronisation properties in comparison with classical models. This project will benefit from strong experimental collaborations (UCL, Alicante) and it is coupled to the study of brain pathologies linked with synaptic dysfunctions, in particular certain early signs of Alzheimer's Disease. Our initiative also contains a training aspect with two PhD student involved as well as a series of mini-courses which we will propose to the partner institute on this research topic; we will also organise a "wrap-up" workshop in Sophia at the end of it. Finally, the project is embedded within a strategic tightening of our links with Spain with the objective of pushing towards the creation of a Southern-Europe network for Mathematical, Computational and Experimental Neuroscience, which will serve as a stepping stone in order to extend our influence beyond Europe.

6.2.2. Inria International Partners

6.2.2.1. Informal International Partners

VU Amsterdam (Netherlands), Faculty of Science, Mathematics: Daniele Avitabile

ENS Paris, Laboratoire de Neurosciences Cognitives: Boris Gutkin

University of the Balearic Islands (Spain), Dept of Applied Mathematics: Antonio Teruel

Polytechnic University of Catalunya (Spain), Dept of Applied Mathematics: Antoni Guillamon

6.3. International Research Visitors

6.3.1. Visits of International Scientists

Invitation of Nikola Popovic, University of Edinburgh (UK), April 2019

Invitation of Tomás Lázaro, Polytechnic University of Catalunya (Spain), May 2019

6.3.1.1. Internships

Ariane Delrocq (étudiante Ecole Polytechnique, Paris): April - July 2019

6.3.2. Visits to International Teams

Visit of Yuri Rodrigues and Romain Veltz to Cian O'Donnell (University of Bristol, UK) in December 2019

6.3.2.1. Research Stays Abroad

One-month research stay of Mathieu Desroches at BCAM (Bilbao, Spain) on an invited professor scholarship to work with Serafim Rodrigues, June-July 2019

MIMESIS Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

At the regional level, the MIMESIS team collaborates with

9.1.1. ICube Automatique Vision et Robotique (AVR)

We have been collaborating with the medical robotics team on percutaneous procedures, in particular robotized needle insertion (with Prof. Bernard Bayle), and needle tracking in medical images (with Elodie Breton). We are also collaborating with Jonathan Vappou on elastography.

9.1.2. ICube Informatique Géométrique et Graphique

MIMESIS joined the IGG team to collaborate in the domain of dynamic topologies, mainly through the use of the CGoGN framework. CGoGN is a C++ library for the manipulation of meshes. It implements combinatorial maps and their multiresolution extensions and has been used in various high level application like the simulation of crowds of autonomous agents and the simulation of cuts, tears and fractures in the context of surgical simulations.

9.1.3. Institute of Image-Guided Surgery (IHU)

We have several active projects and collaborations with IHU Strasbourg in order to collect and use medical images (such as MRI, CT, Fluoroscopy and Ultrasound) before, during and after minimally-invasive surgical procedures (percutaneous, endovascular and laparoscopic). Such images represent an essential support for the development of numerical simulations for intra-operative assistance through augmented and virtual reality. We also collaborate in the field of elastic registration with X-ray images and surgical training for flexible endoscopy.

9.2. National Initiatives

9.2.1. ADT (Action de Développement Technologique)

MIMESIS received a support for the development of the project **LOSAR: Liver Open Surgery with Augmented Reality** that aims at developing tools for a per-operative usage of registration algorithms developed in the team. Our goal is to be able to repeatedly test our method for one or more important publications in medical conferences. This type of publication requires to methodically repeat our solution on several patients. However, the steps are still insufficiently automated and the algorithm needs to be improved for greater reliability. These essential elements lie outside traditional research missions and require significant development and engineering effort. Indeed, an effort of automation and ergonomics will have to be made to make the use of the software sufficiently simple to be used in the operating room. Furthermore, the accuracy of the deformed model (anatomical distances modeled versus actual anatomical relationships) must also be verified and validated through experimentation. This project is done in collaboration with Paul Brousse Hospital in Paris.

9.2.2. ANR (Agence Nationale de la Recherche)

MIMESIS coordinates the ANR project entitled **SPERRY: SuPervisEd Robotic suRgerY** - application to needle insertion. Percutaneous medical procedures (using surgical needles) are among the least invasive approaches to accessing deep internal structures of organs without damaging surrounding tissues. Today, many surgical procedures rely on the use of needles allowing for complex interventions such as curie-therapies or thermo-ablations of tumors (cryoablation, radio frequencies). Unlike traditional open surgery, these approaches only affect a localized area around the needle, reducing trauma and risks of complications. These treatments also offer new solutions for tumors or for metastases for which traditional methods may be contraindicated due to the age of the patient and the extent or location of the disease. In this project, we want to develop new solutions for the control of medical robots interacting with soft tissues. This work is motivated by recent advances in the field of medical simulation achieving a sufficient level of realism to help surgeons during the operation. The maturity of these techniques now suggests the ability to use a simulation intra-operatively to control the motion of a robotic system for needle insertion. This is really a challenge, because in general, few information can be extracted in real time from images during an intervention. We believe that even minimal knowledge of the mechanical behavior of structures, associated with the use of images can make it possible and allow a robot to reach a pre-identified target during a planning stage, without human intervention.

9.2.3. Inria Collaborations

MIMESIS is closely connected to the SOFA Consortium, created by Inria in November 2015 with the objective to support the SOFA community and encourage contributions from new SOFA users. The consortium should also be a way to better answer to the needs of academic or industrial partners. MIMESIS actively participates at the development of SOFA and contributes to the evolution of the framework. Moreover, MIMESIS also participates in an initiative aiming at verification and validation of codes and algorithms of SOFA. Further, MIMESIS actively collaborates with the following Inria teams:

MAGRIT: The team at Inria Grand-Est focuses on research in computer vision and is also actively involved in computer-based solutions for the planning or the simulation of interventional radiology procedures. Currently, two PhD are co-supervised by researcher from Magrit: Jaime Garcia and Guevara Raffaella Trivisonne.

DEFROST: The team conducts research in soft robotics. We continue mutual interaction with DEFROST mainly in the context of contact modeling.

9.2.4. National Collaborations

At the national level, the MIMESIS team collaborates with:

The LML laboratory*(Laboratoire de Mécanique de Lille)*: a French research laboratory (UMR CNRS 8107) part of the Carnot institute ARTS. With more than two hundred researchers, LML focuses on the following research areas: mechanical reliability and tribology, fluid mechanics, civil engineering and soil mechanics.

Hôpital Paul-Brousse a hospital in South Paris. We collaborate with *Centre Hépato-Biliaire* via the co-supervision of the Ph.D. thesis of Nicolas Golse, MD, who is a surgeon specialized in hepatic surgery.

IRMA Research Institut on Advanced Mathematics, a research laboratory at Strasbourg university. A collaboration started in the fields of shape optimisation methods via the co-supervision of the PhD of Guillaume Mestdagh.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

- **HiPerNav** is an Innovative Training Network (ITN) funded through a Marie Skłodowska-Curie grant. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 722068. There is 14 fully funded and 2 partially funded PhD working on the project. The project aims to improve soft tissue navigation through research and development, to improve several bottleneck areas:
  - Creating effective pre-operative model(s) and planning
  - Faster and more accurate intra-operative model updates
  - Faster and more accurate model-to-patient registration
  - More intuitive user-interaction and effective workflow
  - Usage of high performance computing (e.g. GPU)

  From these 14 PhD students, two of them are from the Mimesis team: **Jean-Nicolas Brunet** and **Sergei Nikolaev**
- **Driven** The overall aim of the DRIVEN project is to boost the scientific excellence and innovation capacity in data-driven simulation of the University of Luxembourg (UL) and partners (Inria, University of Limerick, and University of Texas at Austin). To boost their scientific excellence and technology transfer capacity in data-driven simulation, the partners will implement a research and innovation strategy focused on three sub-topics:
  - Mathematical foundations for data-driven simulations – UL with UT Austin,
  - Data-driven simulations for computer-assisted therapy – UL with Inria,
  - Data-driven simulations for functional composite materials –UL with ULIM.

9.4. International Initiatives

9.4.1. Informal International Partners

- **CAMERA group, University of Bath, UK:** Collaboration on non-rigid registration using **RGB-D** sensors
- **PRISMA Lab, University of Naples, Italy:** Collaboration on soft object robotic manipulation, along with DEFROST team at Inria Lille, and collaboration on visual perception for robotic surgery.
- **University of Twente, Netherlands:** we collaborate with Prof. Stefano Stramigioli, head of a group in Robotics and Mechatronics laboratory, on the development of a low-cost training system for flexible endoscopy.
- **Verona University, Italy:** we collaborate with the ALTAIR Robotics Lab on computer-aided ultrasound guidance using real-time registration. This resulted in 2 publications this year: [19] and [23].
- **Faculty of Informatics, Masaryk University, Czech Republic:** We collaborate on simulation of living cells in fluorescent microscopy.
- **Team Legato, University of Luxembourg:** We have an active collaboration with Prof. Stéphane Bordas on error estimation in real-time simulations of deformable objects.
- **ARTORG Center for Biomedical Engineering Research, Bern, Switzerland:** Collaboration in the projects related to deep learning.
- **CIMIT and Harvard Medical School:** we collaborate with members of the Center for Minimally Invasite Therapy and faculty from HMS on the development of a training system for Resuscitative endovascular balloon occlusion of the aorta (REBOA).

9.5. International Research Visitors

Eleonora Tagliabue, PhD student at the robotics laboratory of Verona University, visited the team from April to June 2019. During her stay we collaboration of the comparison of different physics-based approaches to model soft tissues. This led to a publication in the International Journal of Computer Assisted Radiology and Surgery. We also applied our deep physics network to the problem od registration of breast model onto ultrasound data. This was presented at the MICCAI workshop on Computational Biomechanics in September 2019.

9.5.1. Visits to International Teams

Jean-Nicolas Brunet and Sergei Nikolaev spent 2 weeks in Forchheim (Germany) to visit Siemens R&D and product development groups, as part of the H2020 HiPerNav project.

MNEMOSYNE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. EcoMob

Participants: Frédéric Alexandre, Snigdha Dagar, Nicolas Rougier.

Project gathering researchers from: University of La Rochelle (Cerege lab in social sciences and L3I lab in computer science); University of Bordeaux (IRGO lab in organisation management); Town and suburbs of La Rochelle.

The goal of this project is to study and model user urban mobility behaviours in an eco-responsibility context. Interactive mobile applications are used to measure the effective evolution of behaviour. Our team is in charge of studying models of decision in such complex contexts, in interaction with teams in social sciences aiming at influencing user behaviours.

9.1.2. PsyPhINe

Participant: Nicolas Rougier.

Project gathering researchers from: MSH Lorraine (USR3261), InterPsy (EA 4432), APEMAC, EPSaM (EA4360), Archives Henri-Poincaré (UMR7117), Loria (UMR7503) & Mnemosyne.

PsyPhiNe is a pluridisciplinary and exploratory project between philosophers, psychologists, neuroscientists and computer scientists. The goal of the project is to explore cognition and behavior from different perspectives. The project aims at exploring the idea of assignments of intelligence or intentionality, assuming that our intersubjectivity and our natural tendency to anthropomorphize play a central role: we project onto others parts of our own cognition. To test these hypotheses, we ran a series of experiments with human subject confronted to a motorized lamp that can or cannot interact with them while they're doing a specific task. We've organized our third national conference in Nancy gathering speakers from philosophy, robotics, art and psychology and closed a three years cycle. The group now aims at publishing a book gathering text from all the invited speakers.

9.2. National Initiatives

9.2.1. FUI Sumatra

Participants: Frédéric Alexandre, Thalita Firmo Drumond, Xavier Hinaut, Nicolas Rougier, Thierry Viéville.

This FUI project, supported by the Aerospace Valley Innovation Pole, gathers two industrial groups (Safran Helicopter and SPIE), three research labs and four SME. Its goal is to provide contextualized information to maintenance operators by the online analysis of the operating scene. We are concerned in this project with the analysis of visual scenes, in industrial contexts, and the extraction of visual primitives, categories and pertinent features, best decribing the scenes, with biologically inspired neuronal models.

Firstly, this is an opportunity for us to revisit the principles of deep network architectures by adapting principles that we will elaborate from the context of the hierarchical architecture of the temporal visual cortex. Secondly, we intend to exploit and adapt our model of hippocampus to extract more heterogenous features. This project is an excellent opportunity to associate and combine our models and also to evaluate the robustness of our models in real-world applications.

9.2.2. ANR SOMA (PRCI)

Participants: Nicolas Rougier, Remya Sankar.

This project is a convergence point between past research approaches toward new computational paradigms: adaptive reconfigurable architecture, cellular computing, computational neuroscience, and neuromorphic hardware:

1. SOMA is an adaptive reconfigurable architecture to the extent that it will dynamically re-organize both its computation and its communication by adapting itself to the data to process.
2. SOMA is based on cellular computing since it targets a massively parallel, distributed and decentralized neuromorphic architecture.
3. SOMA is based on computational neuroscience since its self-organization capabilities are inspired from neural mechanisms.
4. SOMA is a neuromorphic hardware system since its organization emerges from the interactions between neural maps transposed into hardware from brain observation.

This project represents a significant step toward the definition of a true fine-grained distributed, adaptive and decentralized neural computation framework. Using self-organized neural populations onto a cellular machine where local routing resources are not separated from computational resources, it will ensure natural scalability and adaptability as well as a better performance/power consumption tradeoff compared to other conventional embedded solutions.

9.2.3. ANR MACAQUE40

Participant: Nicolas Rougier.

Most of the theoretical models in economics proposed so far to describe money emergence are based on three intangible assumptions: the omniscience of economic agents, an infinite time and an extremely large number of agents (not bounded). The goal of this interdisciplinary study is to investigate the condition of apparition of a monetary economy in a more ecological framework provided with the assumption that the market is made up of a finite number of agents having a bounded rationality and facing a time constraint.

In this study, we propose a generic model and environment of monetary prospecting. Our first objective is to artificially identify structural (trading organisation, agents specialisation) and cognitive conditions (learning skills, memory and strategic anticipation abilities, tradeoff exploration/exploitation) that allowed money emergence. This will provide relevant environmental constraints that we will use during our manipulations in the laboratory. The agents that will be involved in these manipulations will be of two types: non-human primates (rhesus macaques) and humans.

9.3. International Initiatives

9.3.1. Participation in Other International Programs

9.3.1.1. Project LingoRob with Germany

LingoRob - Learning Language in Developmental Robots - is a project of the Programme Hubert Curien PHC Procope with Germany (University of Hamburg). The scientific objective of the collaboration is to better understand the mechanisms underlying language acquisition and enable more natural interaction between humans and robots in different languages, while modelling how the brain processes sentences and integrates semantic information of scenes. Models developed in both labs involve artificial neural networks, and in particular Echo State Networks (ESN), also known as pertaining to the Reservoir Computing framework. These neural models allow insights on high-level processes of the human brain, and at the same time are well suited as robot control platform, because they can be trained and executed online with low computational resources. The collaborators will also combine Deep Learning networks to the reservoir models already used in order to benefit from their very good feature extraction abilities.

MONC Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Plan Cancer

9.1.1.1. NUMEP

Plan Cancer NUMEP: 2016–2019. Numerics for Clinical Electroporation
Funding: 460 kE.
Partners: Institut de Pharmacologie de Toulouse, CHU J. Verdier de Bondy.
Duration: Octobre 2016—Septembre 2019.
Project leader: C. Poignard
Co-PI: M-P. Rols (IPBS), O. Séror (CHU J. Verdier)

9.1.1.2. Moglimaging

Project acronym - Moglimaging: Modeling of Glioblastoma treatment-induced resistance and heterogeneity by multi-modal imaging.
Partners - Inria Monc, IUCT, Institut Pasteur, Univ. Grenoble, INSERM, Inria Mamba.
Duration - from Nov. 2016 to May 2020.
Coordinator - E. Cohen-Jonathan Moyal, Institut Universitaire du Cancer Toulouse / Local coordinator - O. Saut.
Team participants - S. Benzekry, A. Collin, C. Poignard, O. Saut.

9.1.1.3. Systems Biology of Renal Carcinoma

Title: Plan Cancer Systems Biology of Renal Carcinoma using a Mouse RCC model
Partners : LAMC, INSERM-Univ. Bordeaux.
Duration - June 2018 to June 2021
Team participants: O. Saut, S. Benzekry (co-PI)
Funding: 116.64k€

9.1.1.4. QUANTIC

Plan Cancer QUANTIC: 2020–2022. QUANTitative modeling combined to statistical learning to understand and predict resistance to Immune-checkpoint inhibition in non-small cell lung Cancer.
Funding: 338 k€
Partners: Inria Team MONC, SMARTc (Centre de Recherche sur le Cancer de Marseille, Inserm, CNRS), Assistance Publique Hôpitaux de Marseille
Duration: Décembre 2019 — Décembre 2022
Project leader: S. Benzekry
Co-PI: D. Barbolosi (SMARTc), F. Barlési (AP-HM)

9.1.2. Transnation call: INCA/ARC

Title: Minimally and non-invasive methods for early detection and/or progression of low grade glioma
Partners: Inria Monc, Inria SISTM, INSERM, Humanitas Research Hostital, Univ. Bergen
Acronym: Glioma PRD
Team participants: A. Collin, C. Poignard, O. Saut (local PI)
Total funds: 1M150, Monc's share 275k€.

9.1.3. Competitivity Clusters

Labex TRAIL (http://trail.labex.u-bordeaux.fr): MOD Project Consolidation. 1 2-years post-doc position (100k€), led by A. Collin, 1 PhD funding (100k€) led by O. Saut.

9.2. International Initiatives

9.2.1. Inria International Labs

Inria@SiliconValley

Associate Team involved in the International Lab:

9.2.1.1. Num4SEP

Title: Numerics for Spherical Electroporation

International Partner (Institution - Laboratory - Researcher):

University of California, Santa Barbara (United States) Frederic Gibou

Start year: 2017

See also: http://num4sep.bordeaux.inria.fr/

Electroporation-based therapies (EPTs) consist in applying high voltage short pulses to cells in order to create defects in the plasma membrane. They provide interesting alternatives to standard ablative techniques, for instance for deep seated badly located tumors. However their use is still limited due to a lack of knowledge of tissue electroporation. The goal of the associate team is to focus on the multiscale numerical modeling of spheroid electroporation, in order to provide new insights in electroporation at the mesoscopic scales (spheroids provide interesting tumor-like biological models). Benefiting from the expertise of F. Gibou's team in HPC for multiphysics, and the expertise of the team MONC in tumor growth and cell electroporation modeling, the goal of the associate team Num4SEP is to obtain accurate and efficient numerical tools for the quantitative evaluation of the EPTs at the mesoscopic scale.

9.2.2. Inria Associate Teams Not Involved in an Inria International Labs

9.2.2.1. METAMATS

Title: Modeling ExperimenTAl MetAsTasiS

International Partner (Institution - Laboratory - Researcher):

Roswell Park Cancer Institute (United States) - Department of Cancer Genetics Department of Medicine Department of Pharmacology and Therapeutics (Graduate Program) - John Ebos

Start year: 2017

See also: http://metamats.bordeaux.inria.fr/

The aim of the METAMATS associate team is to bring together a cancer biology experimental laboratory led by John ML Ebos (Roswell Park Cancer Institute) and the inria MONC team composed of applied mathematicians. The Ebos laboratory is specialized in the study of anti-cancer therapeutics (in particular, novel biologically targeted therapeutics such as anti-angiogenics and immunotherapies) on the development of metastases and produces unique, hard-to-obtain data sets on this process' dynamics. The MONC team is specialized in mathematical models in oncology, with a dedicated axis about modeling support and methodological development for analysis of data from preclinical studies. In particular, the work of S. Benzekry puts emphasis on proposing, studying and validating mathematical models of metastatic development under the action of various therapeutic modalities. Indeed, metastatic expansion remains the main challenge in the treatment of cancer and integrative studies combining experiments, mathematical models and clinical data have the potential to yield predictive computational tools of help to assist both the design of clinical trials and clinical oncologists in therapeutic decisions such as the control of the toxicity/efficacy balance or the optimal combination of treatment modalities.

MORPHEME Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Labex Signalife

The MORPHEME team is member of the SIGNALIFE Laboratory of Excellence.

Florence Besse and Xavier Descombes are members of the Scientific Committee.

8.1.2. Idex UCA Jedi

Luca Calatroni is responsible of the project "Action 2, DEP attractivité du territoire du IDEX JEDI, Académie 2 'Systemes complexes'".

Xavier Descombes is co-PI of the MOORPHEUS project funded by the Academy 4 of IDEX-JEDI ("Modélisation computationnelle de la croissance et de l'organisation spatiale dynamique des organoides/tumoroides de prostate"), in collaboration with C3M.

Biological Image Super-resolution Enhanced with Tensor (Biset) supported by Académie 1 RISE. Participants : E. Debreuve, L. Blanc-Féraud, S. Schaub.

Multiscale Tomography : imaging and modelling ancient materials, technical traditions and transfers, (ToMaT), supported by Idex UCA JEDI structuring Project, Participants: L. Blanc-Féraud, Vanna-Lisa Coli, Juliette Leblond, Didier Binder, Louise Gomart, Serge Cohen.

The PhD grant of Clara Sanchez is funded by the IDEX EUR DS4H. Participants: E. Debreuve, C. Rovère (IPMC).

8.1.3. 3AI Côte d'Azur

Laure Blanc-Féraud and Grégoire Malandain are chair holders of the 3AI Côte d'Azur, in the "Computational Biology and Bio-Inspired AI" axis.

The PhD grant of Vasiliki Stergiopoulou is funded by the 3AI Côte d'Azur.

8.2. National Initiatives

8.2.1. ANR RNAGRIMP

Participants: Florence Besse [PI], Fabienne de Graeve, Xavier Descombes, Eric Debreuve, Somia Rahmoun.

Here, we propose to study the molecular bases underlying the assembly and regulation of RNA granules, using the highly conserved IMP-containing granules as a paradigm. Specifically, we propose to perform an unbiased genome-wide RNAi screen on Drosophila cultured cells to identify mutant conditions in which the organization and/or distribution of IMP-containing granules is altered. To quantitatively and statistically analyze mutant conditions, and to define precise and coherent classes of mutants, we will combine high throughput microscopy with the development of a computational pipeline optimized for automatic analysis and classification of images. The function of positive hits isolated in the screen will then be validated in vivo in Drosophila neurons using fly genetics and imaging techniques, and characterized at the molecular and cellular levels using biochemical assays, in vitro phase transition experiments and live-imaging. Finally, the functional conservation of identified regulators will be tested in zebrafish embryos combining gene inactivation and live-imaging techniques. This integrative study will provide the first comprehensive analysis of the functional network that regulates the properties of the conserved IMP RNA granules. Our characterization of the identified regulators in vivo in neuronal cells will be of particular significance in the light of recent evidence linking the progression of several degenerative human diseases to the accumulation of non-functional RNA/protein aggregates.

This 4-years project started january, 2016 and is leaded by F. Besse (iBV, Nice). Participants are iBV, institut de biologie Paris Seine (IBPS, Paris), and Morpheme.

8.2.2. ANR HMOVE

Participants: Xavier Descombes, Eric Debreuve, Somia Rahmoun.

Among the signaling molecules involved in animal morphogenesis are the Hedgehog (Hh) family proteins which act at distance to direct cell fate decisions in invertebrate and vertebrate tissues. To study the underlying process we will develop accurate tracking algorithm to compare trajectories of different Hh pools transportation in live animals. This will allow us to analyze the contribution of the different carriers in the establishment of the Hh gradient. Moreover, we will develop new methods to modify the spatio-temporal and dynamical properties of the extra-cellular Hh gradient and separate the contribution of the apical versus basal Hh pools. We will complete this study with a genome-wide screen to identify genes and related cellular processes responsible for Hh release. The particular interest of this collaboration lies in the combination of development of tracking algorithm to analyze Hh distribution and trajectories with extremely powerful genetics, ease of in vivo manipulation and lack of genetic redundancy of Drosophila.

This 4-years project started january, 2016 and is leaded by P. Thérond (iBV, Nice). Participants are iBV and Morpheme.

8.2.3. ANR Cell Whisper

Participant: Grégoire Malandain.

Successful embryogenesis requires the differentiation of the correct cell types, in defined numbers and in appropriate positions. In most cases, decisions taken by individual cells are instructed by signals emitted by their neighbours. A surprisingly small set of signalling pathways is used for this purpose. The FGF/Ras/ERK pathway is one of these and mutations in some of its individual components cause a class of human developmental syndromes, the RASopathies. Our current knowledge of this pathway is, however, mostly static. We lack an integrated understanding of its spatio-temporal dynamics and we can imperfectly explain its highly non-linear response to a graded increase in input stimulus.

This systems biology project combines advanced quantitative live imaging, pharmacological/optogenetics perturbations and computational modelling to address 3 major unanswered questions, each corresponding to a specific aim:

- Aim 1: What is the spatio-temporal dynamic of intracellular signal transduction in response to FGF?
- Aim 2: What is the molecular basis of the switch-like response to graded extracellular signals?
- Aim 3: Can the results be integrated into a predictive computational model of the pathway?

Through this approach, in a simplified model system, we hope to gain an integrated view of the pathway's dynamics.

This 4-years project started october the 1st, 2019 and is leaded by P. Lemaire (CRBM, Montpellier). Participants are CRBM (Montpellier), LIRMM (Montpellier), MOSAIC (Inria Grenoble) and Morpheme.

8.2.4. Inria Large-scale initiative Naviscope

Participant: Grégoire Malandain.

This action gathers the expertise of seven Inria research teams (Aviz, Beagle, Hybrid, Morpheme, Parietal, Serpico and Mosaic) and other groups (MaIAGE, INRA, Jouy-en-Josas and UMR 144, Institut Curie Paris) and aimed at developing original and cutting-edge visualization and navigation methods to assist scientists, enabling semi-automatic analysis, manipulation, and investigation of temporal series of multi-valued volumetric images, with a strong focus on live cell imaging and microscopy application domains. More precisely, the three following challenges will be addressed:

- Novel machine learning methods able to detect the main regions of interest, and automatic quantification of sparse sets of molecular interactions and cell processes during navigation to save memory and computational resources.

- Novel visualization methods able to encode 3D motion/deformation vectors and dynamics features with color/texture-based and non-sub-resolved representations, abstractions, and discretization, as used to show 2D motion and deformation vectors and patterns.
- Effective machine learning-driven navigation and interaction techniques for complex functional 3D+Time data enabling the analysis of sparse sets of localized intra-cellular events and cell processes (migration, division, etc.).

8.3. International Research Visitors

8.3.1. Visits of International Scientists

Alin Achim, professor at Bristol university, is an invited professor in Morpheme since september 2019 for a ten months period (Leverhulme grant).

MOSAIC Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. ENS de Lyon projets Emergents - Phyllo (2018 - 2019)

Participants: Christophe Godin, Bruno Leggio, Teva Vernoux [External Collaborator].

The aim in this project is to develop a model of phyllotaxis that would be compatible with the recent detailed and quantitative observations made by our group of the distribution of auxin in space and time at the SAM. In particular the work will seek at using the new quantitative data to estimate the parameters of the stochastic model previously developed of organ patterning.

7.1.2. IDEX Lyon Impulsion - MecaField (2019 - 2020)

Participants: Christophe Godin, Bruno Leggio, Teva Vernoux [External Collaborator].

In a previous work, we have shown that the coupling of mechanical and hydraulical descriptions in a 2D model of multicellular tissue growth induces the emergence of remarkable phenomena at tissue level. In particular, we have shown that the growth of an organ may induce a lateral inhibition surrounding the organ that prevents other organs to grow in its vicinity. The goal of this project is to estimate the hydraulic and mechanical parameters of such a model from confocal images of a growing SAM and to compare observations with the order of magnitude of the predicted inhibitory zones and of their amplitude at cellular resolution.

7.2. National Initiatives

7.2.1. Inria ADT - Gnomon

Participants: Olivier Ali, Romain Azaïs, Guillaume Cerutti, Florian Gacon, Christophe Godin, Jonathan Legrand, Grégoire Malandain [External Collaborator], Teva Vernoux [External Collaborator].

Gnomon is a user-friendly computer platform developed by the Mosaic team for seamless simulation of form development in silico. It is intended to be a major tool for the team members to develop, integrate and share their models, algorithms and tools. Flexible components (plugins) make it possible to up-load or to create such data-structures, to program their development, to analyze, visualize them and interact with them in 3D+time.

Based on the past experience of the team with the OpenAlea platform, the goal of this ADT is to develop a more scalable software engineering solution based on the dtk kernel developed by the group of software engineers (SED) from the Sophia-Antipolis Inria Center.

Partners:

- SED Sophia Antipolis Inria Research Centre
- Morpheme Inria projec-team, Sophia Antipolis, France

7.2.2. Inria IPL - Naviscope

Participants: Guillaume Cerutti, Emmanuel Faure [External Collaborator], Christophe Godin, Jonathan Legrand, Grégoire Malandain [External Collaborator].

In this project, we plan to develop original and cutting-edge visualization and navigation methods to assist scientists, enabling semi-automatic analysis, manipulation, and investigation of temporal series of multi-valued volumetric images, with a strong focus on live cell imaging and microscopy application domains. We will build Naviscope upon the strength of scientific visualization and machine learning methods in order to provide systems capable to assist the scientist to obtain a better understanding of massive amounts of information. Such systems will be able to recognize and highlight the most informative regions of the dataset by reducing the amount of information displayed and guiding the observer attention. Finally, we will overcome the technological challenge of gathering up the software developed in each team to provide a unique original tool for users in biological imaging, and potentially in medical imaging.

7.2.3. ANR - Imago (2016 - 2019)

Participants: Guillaume Cerutti, Christophe Godin, Jonathan Legrand.

The goal of this project is to investigate the role of ovule growth constraints on germ cell fate establishment. This project is motivated by recent findings from the partners' groups suggesting that disturbances in cell divisions and expansion in early (pre-meiotic) ovules are sufficient to induce ectopic germ cells. These observations suggest novel routes to engineer apomixis in plants but remains poorly understood. Recent developments in high-resolution 3D imaging, image processing, and modeling offer a powerful combination of approaches to investigate this question. IMAGO proposes to elucidate patterning rules governing ovule growth, and their contribution to female germ cell fate acquisition. We use a combination of high-resolution static and real-time 3D imaging, quantitative image processing, cell-based growth models and functional approaches to (1) define cellular growth patterns in the ovule primordium using quantitative imaging (2) test patterning rules in silico by cell-based growth models (3) validate patterning rules in vivo using genetic, pharmacological and mechanical perturbations.

Partners:

- UMR DIADE, IRD, Montpellier, France
- Department of Plant and Microbial Biology, Zurich, Swisszerland
- RDP, ENS de Lyon, France

7.2.4. ANR DigEM (2015 - 2019)

Participants: Christophe Godin, Bruno Leggio, Patrick Lemaire [External Collaborator], Grégoire Malandain [External Collaborator].

In this project, we will use advanced ligh-sheet imaging of live embryos to quantitatively describe embryonic morphogenesis in ascidians, a class of animals that undergo very rapid genomic divergence, yet show an extraordinary stasis of embryonic morphologies, based on invariant early cell lineages shared by all studied species. The global aims of the proposal, which will bridge micro- and macroevolutionary scales of analysis, are: i) to provide a global systems-level description at cellular resolution of an animal embryonic program; ii) to use this description to characterize intra-specific and inter-specific patterns of morphogenetic variations; iii) to analyze possible molecular mechanisms explaining the unusual robustness of this program to environmental and genetic perturbations. To achieve these aims, we will combine advanced live light-sheet microscopy, computational biology, functional gene assays and evolutionary approaches.

Partners:

- UMR CRBM, CNRS Montpellier, France
- Morpheme Inria projec-team, Sophia Antipolis, France

7.2.5. ERA-CAPS Genes2shape (2018 - 2021)

Participants: Olivier Ali, Guillaume Cerutti, Christophe Godin, Bruno Leggio, Jan Traas [External Collaborator].

This project is aimed at understanding how molecular regulation integrates with mechanics to control overall plant shape, an unresolved problem with wide implications for both fundamental and applied biology. We will address this issue in the Arabidopsis flower, which, besides their obvious importance as reproductive structures, are amongst the best characterised systems in plant developmental biology. From a mechanistic point of view, it is widely accepted that regulatory molecular networks interfere with the properties of the structural cellular elements (cell wall, cytoskeleton) to induce particular growth patterns. How this occurs and how this is coordinated in space is not known. To obtain a mechanistic understanding of such a complex process, information from multiple scales, from molecular networks to physical properties and geometry have to be combined into a single picture. An integrated tool to do so is currently not available. Building on our complementary experience in interdisciplinary research on plant development, we will therefore develop a tool, called the "Computable Flower" that permits (i) integration of data on geometry, gene expression and biomechanics and (ii) the user to explore, interpret and generate hypotheses based on data supported by mechanistic modelling approaches. The tool therefore provides an integrated description in the form of a 3D dynamic template of the growing flower bud.

Partners:

- University of Cambridge (Sainsbury Lab.)
- California Institute of Technology
- MaxPlanck Institutes of Molecular Plant Physiology

7.2.6. MITI - MISGIVING (2019)

Participant: Romain Azaïs.

The diving performance of lung-breathing vertebrates, such as seabirds, can be quantified using measurement devices equipped on animals that allow us to reconstruct their activity at sea. During a classic dive, diving animals are faced with a dilemma: on the one hand, they want to optimize the time spent in contact with prey and therefore increase the time spent in diving; but, on the other hand, they are forced to return to the surface to breathe and will want to minimize this duration which remains however constrained by physiological rules. In addition, the dives are gathered in sequences because the prey are generally grouped in patches. In this project, we propose to use specific mathematical models to understand the complexity of the multi-scale decision processes that condition not only the optimal duration of the dive but also dives within a bout and therefore the total duration of the bout.

Partners:

- Centre d'Etudes Biologiques de Chizé
- Inria team CQFD in Bordeaux

7.3. European Initiatives

7.3.1. FP7 & H2020 Projects

Program: H2020

Project acronym: ROMI

Project title: RObotics for MIcrofarms

Duration: November 2017 - October 2021

Coordinator: Sony

Other partners: Iaac, (Spain), FEI (France), Inria (France), CNRS (France), UBER (Germany), Chatelain (France)

Abstract: All over Europe, young farmers are starting small market farms and direct sales businesses. These farms can be found both in rural, peri-urban and urban areas. They grow a large variety of crops (up to 100 different varieties of vegetables per year) on small surfaces (0.01 to 5 ha) using organic farming practices. These farms have proven to be highly productive, sustainable and economically viable. However, a lot of work is done manually, resulting in physically challenging work conditions. ROMI will develop an open and lightweight robotics platform for these microfarms. We will assist these farms in weed reduction and crop monitoring. This will reduce manual labour and increase the productivity through advanced planning tools. Thanks to ROMI's weeding robot, farmers will save 25 percents of their time. This land robot will also acquire detailed information on sample plants and will be coupled with a drone that acquires more global information at crop level. Together, they will produce an integrated, multi-scale picture of the crop development that will help the farmer monitor the crops to increase efficient harvesting. For this, ROMI will have to adapt and extend state-of-the-art land-based and air-borne monitoring tools to handle small fields with complex layouts and mixed crops. To achieve this, we will: (i) develop and bring to the market an affordable, multi-purpose, land-based robot, (ii) develop a weeding app for this robot that is adapted for organic microfarms, (iii) apply advanced 3D plant analysis and modelling techniques to in-field data acquisition, (iv) integrate these analysis techniques in the robot for detailed plant monitoring, (iv) integrate these techniques also in the aerial drone N-E-R-O for multi-scale crop monitoring, (v) extend the robot with novel, adaptive learning techniques to improve sensorimotor control of the plant monitoring app, and (vii) test the effectiveness of our solution in real-world field conditions.

7.3.2. Collaborations with Major European Organizations

Laboratoire International Associé (LIA): Computing Plant Morphogenesis

The focus of this LIA headed by Teva Vernoux (RDP) and Ottoline Leyser (SLCU) is on plant morphogenesis i.e. the mechanisms allowing the generation of plant shapes at different scales. Both the RDP and SLCU Laboratories are leaders of this field. The scenario for morphogenesis that has recently emerged is that chemical signals controlling cell identities lead to changes in mechanical properties of cells, triggering changes in shapes feeding back on the gene regulatory network. This in turn affects the distribution of chemical signals and mechanical forces, thus channeling morphogenesis. However, our understanding of the molecular and physical basis of morphogenesis in plants or in any other eukaryotic system is still in its infancy due to the complexity and non-linearity of processes involved in morphogenesis dynamics (or Morphodynamics). Understanding morphodynamics requires a modeling environment for the explicit representation of forms at multiple scales and for incorporating complex data from different origins and nature (chemical, mechanical, geometrical). In addition to creating a unique scientific environment, this LIA will gather the critical mass and interdisciplinary expertise required to create such a computational platform and to generate the data to produce an integrated vision of how chemical and mechanical signals interaction drive morphogenesis.

Partners: Sainsbury Lab. University of Cambridge (SLCU)

7.4. International Research Visitors

7.4.1. Visits of International Scientists

- Farah Ben Naoum, associate professor in computer science at the University of Sidi Bel Abbes, Algeria, visited the team in March 2019 for 3 weeks and worked with Romain Azais and Christophe Godin on the definition of a strategy to make efficient random walks in spaces of trees.
- Gabriela Mosca was a visiting researcher from Celia Baroux's Lab (U. Zurich, Switzerland) in the context of the ANR project IMAGO. She spent 3 weeks in the team working with Guillaume Cerutti, Jonathan Legrand, Olivier Ali and Christophe Godin to set up a protocol to reconstruct ovule development from confocal imaging.

7.4.1.1. Internships

- Salah Eddine Habibeche is a PhD student supervised by Farah Ben Naoum from the University of Sidi Bel Abbes. The PhD subject of Salah consists of developing compressing schemes for semi-ordered trees. During his visit, he will study methods of compression of trees with loss of information.
- Caro Chavez Hernandez is a PhD student from Elena Alvarez-Buylla, UNAM University, Mexico. Caro visited the MOSAIC group to work with Christophe Godin to integrate the extensive gene regulatory network she assembled of key molecular processes involved at different phases of plant development into a model of plant architecture development written in LPy.

NEUROSYS Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Within the *Contrat de Projet État Région (CPER) IT2MP* 2015-2020 on *Technological innovations, modeling and Personalized Medicine*, we are contributing on platform SCIARAT (*cognitive stimulation, Ambient Intelligence, Robotic assistance and Telemedicine*) observing electroencephalographic activity of humans during motor tasks. The acquisition of a new 64-channel EEG system has been approuved.

8.2. National Initiatives

8.2.1. ANR

Program: PRCE CES 33 (interaction, robotics)

Project acronym: Grasp-IT

Project title: Design and evaluation of a tangible and haptic brain-computer interface for upper limb rehabilitation after stroke

Duration: Jan 2020 - Jan 2024

Coordinator: Laurent Bougrain (Neurosys)

Other partners: 4 research teams (UL/Perseus, Inria/Camin, Inria/Hybrid) and 3 centers or hospital departments for physical medicine and rehabilitation (IRR/CMPR Lay St Christophe, CHU Rennes, CHU Toulouse) and 1 manufacturer of 3D printers (Alchimies/OpenEdge)

Abstract: This project aims to recover upper limb control improving the kinesthetic motor imagery (KMI) generation of post-stroke patients using a tangible and haptic interface within a gamified Brain-Computer Interface (BCI) training environment. (i) This innovative KMI-based BCI will integrate complementary modalities of interactions such as tangible and haptic interactions in a 3D printable flexible orthosis. We propose to design and test usability (including efficacy towards the stimulation of the motor cortex) and acceptability of this multimodal BCI. (ii) The GRASP-IT project proposes to design and integrate a gamified non-immersive virtual environment to interact with. This multimodal solution should provide a more meaningful, engaging and compelling stroke rehabilitation training program based on KMI production. (iii) In the end, the project will integrate and evaluate neurofeedbacks, within the gamified multimodal BCI in an ambitious clinical evaluation with 75 hemiplegic patients in 3 different rehabilitation centers in France.
The GRASP-IT project represents a challenge for the industrial 3D printing field. The materials of the 3D printable orthosis, allowing the integration of haptic-tangible interfaces, will come from a joint R & D work performed by the companies Alchimies and Open Edge.

8.3. International Research Visitors

8.3.1. Visits of International Scientists

- Hiroaki Wagatsuma, Ass. Prof, 11-28 Jun. 2019, Kyutech (Japan). Methodological design for integration of human EEG data with behavioral analyses into human-human/robot interactions in a real-world context.

8.3.1.1. Internships

- Asako Watanabe, Master Student, Jan-Mar 2019, Kyutech (Japan). Feature Extraction of EEG Signals Using Power Spectral Entropy.

8.3.2. Visits to International Teams

L. Bougrain, A. Aussel and S. Rimbert participated in the Kyutech-LORIA workshop organized jointly by University of Lorraine and Kyutech (4-8 March 2019).

NUMED Project-Team

5. Partnerships and Cooperations

5.1. National Initiatives

INSERM / Plan Cancer 2019 - 2022: Evolutionary Mechanisms of Metabolic Adaptation and Scheduling of Therapy in ONcology (250 kE).

Project: This project combines mathematical models integrating heterogeneous phenotypic and genetic data with multiple in vitro models of cancer evolution. Triple Negative Breast Cancers (TNBC) are unsuited to targeted therapy and display high diversity and resistance. We will thus use 3 existing TNBC models, of common origin but subjected to different tumor initiating oncogenic insults, treated over several generations with two drugs targeting antagonist receptors involved in metabolism. By following phenotypic and genetic properties over time, we aim to uncover and quantify how distinct tumor initiation contexts shape evolutionary trajectories and the emergence of resistance. Using mathematical models and simulations, we will investigate how to optimise therapeutic regimens based on the intrinsic evolutionary properties of each model, before validating our predictions in vivo via murine xenografts. Results: The results of this project will help better characterize the influence of the initiating genetic alterations on the ensuing dynamics of development and resistance in TNBC. It will also pave the way to optimise novel therapeutic strategies aiming to leverage cell metabolism to control tumor evolution in the clinic.

5.2. International Research Visitors

5.2.1. Visits to International Teams

5.2.1.1. Research Stays Abroad

Paul Vigneaux spend one year at UCB (University British Columbia)

OPIS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- DATAIA UltraBioLearn (2019-2022). The project aims to research machine learning approaches for medical applications, in particular by leveraging semi-supervised learning using generative, graph-based and certifiable networks, in the context of predicting patient response to cancer treatments. Responsible: H. Talbot, F. Malliaros (N. Lassau, Institut Gustave Roussy).

9.2. National Initiatives

9.2.1. ANR

- Program: ANR PRC

  Project acronym: CoMeDIC

  Project title: Convergent Metrics for DIscrete Calculus

  Duration: 2016-2021

  Coordinator: J.-O. Lachaud (Univ. Rhones Alpes Savoie Mont-Blanc), Local: H. Talbot
- Program: ANR PRCE

  Project acronym: R-Vessel-X

  Project title: Extraction et interprétation robustes des réseaux vasculaires dans les images biomédicales hépatiques

  Duration: 2018-2022

  Coordinator: A. Vacavant (Univ. Clermont Auvergne), local: H. Talbot
- Program: ANR JCJC

  Project acronym: MajIC

  Project title: Majorization-Minimization Algorithms for Image Computing

  Duration: 2017-2021

  Coordinator: E. Chouzenoux
- Program: ANR JCJC

  Project acronym: AVENUE

  Project title: A Visual memory network for scene understanding

  Duration: 2018-2022

  Coordinator: Dr. Karteek Alahari (Inria Grenoble - Rhône-Alpes). Local: F. Malliaros.

9.2.2. Others

- Program: CNRS-CEFIPRA

  Project acronym: NextGenBP

  Project title: Looking Beyond Backpropagation in Deep Learning

  Duration : 2017-2019

  Coordinator: E. Chouzenoux
- Program: PHC - Campus France

  Projet acronym: POLONIUM

Project title: When Poisson and Gauss meet in imaging
Duration: 2018-2020
Coordinator: J.C. Pesquet

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

- Program: H2020 ITN Marie Sklodowska-Curie
  Projet acronym: SUNDIAL
  Project Title: SUrvey Network for Deep Imaging Analysis and Learning
  Duration: 2017-2021
  Coordinator: Reynier Peletier (U. Groningen, NL), local: Hugues Talbot

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- Sup'Com Tunis - Prof. Amel Benazza-Benhayia. Collaboration Topic: Multispectral imaging and image compression.
- North Carolina State University - Prof. Patrick Louis Combettes. Collaboration Topic: Fixed point theory.
- Heriot-Watt University, UK - Prof. Audrey Repetti and Prof. Yves Wiaux. Collaboration Topic: Large-scale image restoration.
- University of Edinburgh, UK - Prof. Victor Elvira. Collaboration Topic: Bayesian signal processing.
- Indraprastha Information Institute Technology, Delhi, India - Prof. Angshul Majumdar. Collaboration Topic: Dictionary learning.
- Universidad Técnica Federico Santa María, Valparaíso, Chile - Prof. Luis M. Briceño-Arias. Collaboration Topic: Stochastic optimization.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Prof. Angshul Majumdar, IIIT Delhi, India, June 2019 and December 2019
- Prof. Apostolos N. Papadopoulos, Aristotle University of Thessaloniki, June 2019 to July 2019
- Prof. Patrick L. Combettes, North Carolina State University, US, 18-22 February 2019
- W. Tang (PhD student), North Carolina State University, US, 2-29 May 2019
- S. Sharma (PhD student), IIIT Delhi, India, June 2019 to August 2019

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- M. Vakalopoulou, visiting researcher for 1 month (June-July 2019): Stony Brook University, research team of D. Samaras.
- T. Estienne, 4 months internship (May-August 2019): Center for Biomedical Image Computing and Analytics (CBICA) of University of Pennsylvania.
- E. Battistella, 4 months internship (August-December 2019): Computational Robotics, AI & Biomedicine Lab of RICE University.
- M. Sahasrabudhe, 2 months intership (November-December 2019): Boston Children's Hospital & Harvard Medical School.

PARIETAL Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Inserm-Inria project

This project is funded by the joint Inserm and Inria program ‘médecine numérique’ and is conducted in collaborations with our clinical partners from the Lariboisière hospital, Inserm uni U942 BioCANVAS (Biomarkers in Cardio-Neuro-VAScular diseases). It supports the PhD thesis of David Sabbagh.

Participants:

- Denis Engemann [coordinator, co-advisor]
- Alexandre Gramfort [thesis director, co-advisor]
- Etienne Gayat [clinical collaborator, co-advisor]
- Fabrice Vallée [clinical collaborator]
- David Sabbagh [PhD Student]

Post-operative delirium (POD) is a potential complication of anesthesia during surgery. It is often associated with adverse outcomes and is aggravated by aging. In elderly patients, post-operative complications have been estimated to incur tens of million US dollars of costs each year in the United States by prolonging hospitalization and potentially affecting health prognosis. Recent studies suggest that POD can already be prevented by improving electrophysiological monitoring of anesthesia depth and individual dosage of anesthetic agents. Doing so probably minimizes the time patients spend in a coma-like state that manifests itself in isoelectric burst suppression, an electroencephalogram (EEG) pattern characterized by alternation between quiescence and high-amplitude bursts, and causally linked to POD. However, such an enterprise, currently, depends on the trained clinical electrophysiologist and guidance by commercially provided EEG indices of states of consciousness. One such metric is the bispectral index (BIS), which, like other related metrics, does not explicitly take into account baseline changes related to normative aging and may therefore be biased when used naively.

While electrophysiological signatures of aging (e.g. drop in Alpha and Gamma band power), states of consciousness (e.g. drop in Theta band long-range connectivity) and drug response (e.g. anteriorization of alpha band power in propofol anesthesia) have been separately investigated in the past years, their common denominators are not known. It is therefore difficult to detect individual risk, choose the optimal dosage, and automate anesthesia monitoring readily for any patient in any hospital.

The goal of this research project is to build statistical models that enable prediction of burst suppression and subsequent POD by exploiting diverse EEG-signatures of states of consciousness in the context of aging. We approach this challenge by recasting it as a problem of learning brain-age from the point of view of electrophysiology of consciousness.

9.1.2. CoSmic project

Participants: Philippe Ciuciu [Correspondant], Nicolas Chartier, Loubna El Gueddari, Zaccharie Ramzi, Chaithya Giliyar Radhkrishna.

This project is funded by CEA DRF-Impulsion.

the DRF-impulsion CEA program which has been transformed into a CEA PTC program for 2 years (2018-2020), in collaboration with Pierre Kestener, La Maison de la Simulation (CEA/CNRS).

Compressed Sensing is a recent theory in maths that allows the perfect recovery of signals or images from compressive acquisition scenarios. This approach has been popularized in MRI over the last decade as well as in astrophysics (noticeably in radio-astronomy). So far, both of these fields have developed skills in CS separately. The aim of the COSMIC project is to foster collaborations between CEA experts in MRI (Parietal team within NeuroSpin) and in astrophysics (CosmoStat lab within the Astrophysics Department). These interactions will allow us to share different expertise in order to improve image quality, either in MRI or in radio-astronomy (thanks to the interferometry principle). In this field, given the data delivered by radio-telescopes, the goal consists in extracting high temporal resolution information in order to study fast transient events.

9.1.3. Metacog

Participants: Bertrand Thirion [Correspondant], Gaël Varoquaux, Jérome Dockès.

This project is funded by Digiteo.

This is a Digicosme project (2016-2019) and a collaboration with Fabian Suchanek (Telecom Paritech).

Understanding how cognition emerges from the billions of neurons that constitute the human brain is a major open problem in science that could bridge natural science –biology– to humanities –psychology. Psychology studies performed on humans with functional Magnetic Resonance Imaging (fMRI) can be used to probe the full repertoire of high-level cognitive functions. While analyzing the resulting image data for a given experiment is a relatively well-mastered process, the challenges in comparing data across multiple datasets poses serious limitation to the field. Indeed, such comparisons require to pool together brain images acquired under different settings and assess the effect of different *experimental conditions* that correspond to psychological effects studied by neuroscientists.

Such meta-analyses are now becoming possible thanks to the development of public data resources –OpenfMRI http://openfmri.org and NeuroVault http://neurovault.org. As many others, researchers of the Parietal team understand these data sources well and contribute to them. However, in such open-ended context, the description of experiments in terms of cognitive concepts is very difficult: there is no universal definition of cognitive terms that could be employed consistently by neuroscientists. Hence meta-analytic studies loose power and specificity. On the other hand, http://brainspell.org provide a set of curated annotation, albeit on much less data, that can serve as a seed or a ground truth to define a consensual ontology of cognitive concepts. Relating these terms to brain activity poses another challenge, of statistical nature, as brain patterns form high-dimensional data in perspective with the scarcity and the noise of the data.

The purpose of this project is to learn a semantic structure in cognitive terms from their occurrence in brain activation. This structure will simplify massive multi-label statistical-learning problems that arise in brain mapping by providing compact representations of cognitive concepts while capturing the imprecision on the definition these concepts.

9.1.4. HidimStat

Participants: Bertrand Thirion [Correspondant], Jerome-Alexis Chevalier, Joseph Salmon.

This project is funded by Digiteo.

This is a Digicosme project (2017-2020) and a collaboration with Joseph Salmon (Telecom Paritech).

The HiDimStat project aims at handling uncertainty in the challenging context of high dimensional regression problem. Though sparse models have been popularized in the last twenty years in contexts where many features can explain a phenomenon, it remains a burning issue to attribute confidence to the predictive models that they produce. Such a question is hard both from the statistical modeling point of view, and from a computation perspective. Indeed, in practical settings, the amount of features at stake (possibly up to several millions in high resolution brain imaging) limit the application of current methods and require new algorithms to achieve computational efficiency. We plan to leverage recent developments in sparse convex solvers as well as more efficient reformulations of testing and confidence interval estimates to provide several communities with practical software handling uncertainty quantification. Specific validation experiments will be performed in the field of brain imaging.

9.1.5. Template estimation for arbitrary alignments: application to brain imaging.

Participants: Bertrand Thirion [Correspondant], Thomas Bazeille.

This project is funded by Digiteo.

In the recent years, the nature of scientific inference has shifted quite substantially from model-based to predictive approaches, thanks to the generalization of powerful machine learning techniques. While this has certainly improved scientific standards, this has also obscured the objects and concepts on which inference is drawn. For instance, it is now possible –based on some initial data– to predict individual brain activity topographies, yet the very notion of a standard brain template has become increasingly elusive. Given the importance of establishing models for the progress of knowledge, we revisit the problem of model inference on data with high variance. Specifically, in a context where almost arbitrary transformation can successfully warp observations to each other with high accuracy, what is the common definition of a population model underlying all these observations? What is the working definition of a template ? We plan to leverage recent developments on optimal transport and multivariate analysis to build working definition of templates; we will use them in a brain imaging context to build a novel generation of brain templates.

9.1.6. CDS2

Participants: Alexandre Gramfort [Correspondant], Gaël Varoquaux, Maria Telenczuk, Jiaping Liu.

CDS2 is an "Strategic research initiative” of the Paris Saclay University Idex https://www.datascience-paris-saclay.fr/. Although it groups together many partners of the Paris Saclay ecosystem, Parietal has been deeply involved in the project. It currently funds 2 engineers: Maria Telenczuk and Jiaping (Lucy) Liu.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. Neuroref: Mathematical Models of Anatomy / Neuroanatomy / Diffusion MRI

Participants: Demian Wassermann [Correspondant], Antonia Machlouzarides Shalit, Valentin Iovene.

While mild traumatic brain injury (mTBI) has become the focus of many neuroimaging studies, the understanding of mTBI, particularly in patients who evince no radiological evidence of injury and yet experience clinical and cognitive symptoms, has remained a complex challenge. Sophisticated imaging tools are needed to delineate the kind of subtle brain injury that is extant in these patients, as existing tools are often ill-suited for the diagnosis of mTBI. For example, conventional magnetic resonance imaging (MRI) studies have focused on seeking a spatially consistent pattern of abnormal signal using statistical analyses that compare average differences between groups, i.e., separating mTBI from healthy controls. While these methods are successful in many diseases, they are not as useful in mTBI, where brain injuries are spatially heterogeneous.

The goal of this proposal is to develop a robust framework to perform subject-specific neuroimaging analyses of Diffusion MRI (dMRI), as this modality has shown excellent sensitivity to brain injuries and can locate subtle brain abnormalities that are not detected using routine clinical neuroradiological readings. New algorithms will be developed to create Individualized Brain Abnormality (IBA) maps that will have a number of clinical and research applications. In this proposal, this technology will be used to analyze a previously acquired dataset from the INTRuST Clinical Consortium, a multi-center effort to study subjects with Post-Traumatic Stress Disorder (PTSD) and mTBI. Neuroimaging abnormality measures will be linked to clinical and neuropsychological assessments. This technique will allow us to tease apart neuroimaging differences between PTSD and mTBI and to establish baseline relationships between neuroimaging markers, and clinical and cognitive measures.

9.2.1.2. DirtyData: Data integration and cleaning for statistical analysis

Participants: Gaël Varoquaux [Correspondant], Patricio Cerda Reyes, Pierre Glaser.

Machine learning has inspired new markets and applications by extracting new insights from complex and noisy data. However, to perform such analyses, the most costly step is often to prepare the data. It entails correcting errors and inconsistencies as well as transforming the data into a single matrix-shaped table that comprises all interesting descriptors for all observations to study. Indeed, the data often results from merging multiple sources of informations with different conventions. Different data tables may come without names on the columns, with missing data, or with input errors such as typos. As a result, the data cannot be automatically shaped into a matrix for statistical analysis.

This proposal aims to drastically reduce the cost of data preparation by integrating it directly into the statistical analysis. Our key insight is that machine learning itself deals well with noise and errors. Hence, we aim to develop the methodology to do statistical analysis directly on the original dirty data. For this, the operations currently done to clean data before the analysis must be adapted to a statistical framework that captures errors and inconsistencies. Our research agenda is inspired from the data-integration state of the art in database research combined with statistical modeling and regularization from machine learning.

Data integrating and cleaning is traditionally performed in databases by finding fuzzy matches or overlaps and applying transformation rules and joins. To incorporate it in the statistical analysis, an thus propagate uncertainties, we want to revisit those logical and set operations with statistical-learning tools. A challenge is to turn the entities present in the data into representations well-suited for statistical learning that are robust to potential errors but do not wash out uncertainty.

Prior art developed in databases is mostly based on first-order logic and sets. Our project strives to capture errors in the input of the entries. Hence we formulate operations in terms of similarities. We address typing entries, deduplication -finding different forms of the same entity- building joins across dirty tables, and correcting errors and missing data.

Our goal is that these steps should be generic enough to digest directly dirty data without user-defined rules. Indeed, they never try to build a fully clean view of the data, which is something very hard, but rather include in the statistical analysis errors and ambiguities in the data.

The methods developed will be empirically evaluated on a variety of dataset, including the French public-data repository, http://www.data.gouv.fr. The consortium comprises a company specialized in data integration, Data Publica, that guides business strategies by cross-analyzing public data with market-specific data.

9.2.1.3. FastBig Project

Participants: Bertrand Thirion [Correspondant], Jerome-Alexis Chevalier, Tuan Binh Nguyen.

In many scientific applications, increasingly-large datasets are being acquired to describe more accurately biological or physical phenomena. While the dimensionality of the resulting measures has increased, the number of samples available is often limited, due to physical or financial limits. This results in impressive amounts of complex data observed in small batches of samples.

A question that arises is then : what features in the data are really informative about some outcome of interest ? This amounts to inferring the relationships between these variables and the outcome, conditionally to all other variables. Providing statistical guarantees on these associations is needed in many fields of data science, where competing models require rigorous statistical assessment. Yet reaching such guarantees is very hard.

FAST-BIG aims at developing theoretical results and practical estimation procedures that render statistical inference feasible in such hard cases. We will develop the corresponding software and assess novel inference schemes on two applications : genomics and brain imaging.

9.2.1.4. MultiFracs project

Participant: Philippe Ciuciu [Correspondant].

The scale-free concept formalizes the intuition that, in many systems, the analysis of temporal dynamics cannot be grounded on specific and characteristic time scales. The scale-free paradigm has permitted the relevant analysis of numerous applications, very different in nature, ranging from natural phenomena (hydrodynamic turbulence, geophysics, body rhythms, brain activity,...) to human activities (Internet traffic, population, finance, art,...).

Yet, most successes of scale-free analysis were obtained in contexts where data are univariate, homogeneous along time (a single stationary time series), and well-characterized by simple-shape local singularities. For such situations, scale-free dynamics translate into global or local power laws, which significantly eases practical analyses. Numerous recent real-world applications (macroscopic spontaneous brain dynamics, the central application in this project, being one paradigm example), however, naturally entail large multivariate data (many signals), whose properties vary along time (non-stationarity) and across components (non-homogeneity), with potentially complex temporal dynamics, thus intricate local singular behaviors.

These three issues call into question the intuitive and founding identification of scale-free to power laws, and thus make uneasy multivariate scale-free and multifractal analyses, precluding the use of univariate methodologies. This explains why the concept of scale-free dynamics is barely used and with limited successes in such settings and highlights the overriding need for a systematic methodological study of multivariate scale-free and multifractal dynamics. The Core Theme of MULTIFRACS consists in laying the theoretical foundations of a practical robust statistical signal processing framework for multivariate non homogeneous scale-free and multifractal analyses, suited to varied types of rich singularities, as well as in performing accurate analyses of scale-free dynamics in spontaneous and task-related macroscopic brain activity, to assess their natures, functional roles and relevance, and their relations to behavioral performance in a timing estimation task using multimodal functional imaging techniques.

This overarching objective is organized into 4 Challenges:

1. Multivariate scale-free and multifractal analysis,
2. Second generation of local singularity indices,
3. Scale-free dynamics, non-stationarity and non-homogeneity,
4. Multivariate scale-free temporal dynamics analysis in macroscopic brain activity.

9.2.1.5. DARLING: Distributed adaptation and learning over graph signals

Participant: Philippe Ciuciu [Correspondant].

The project will be starting in 2020 with a post-doc to be hired probably in 2021.

The DARLING project will aim to propose new adaptive learning methods, distributed and collaborative on large dynamic graphs in order to extract structured information of the data flows generated and/or transiting at the nodes of these graphs. In order to obtain performance guarantees, these methods will be systematically accompanied by an in-depth study of random matrix theory. This powerful tool , never exploited so far in this context although perfectly suited for inference on random graphs, will thereby provide even avenues for improvement. Finally, in addition to their evaluation on public data sets, the methods will be compared with each other using two advanced imaging techniques in which two of the partners are involved: radio astronomy with the giant SKA instrument (Obs. Côte d'Azur) and magnetoencephalographic brain imaging (Inria Parietal at NeuroSpin, CEA Saclay). These involve the processing of time series on graphs while operating at extreme observation scales.

9.2.1.6. meegBIDS.fr: Standardization, sharing and analysis of MEEG data simplified by BIDS

Participant: Alexandre Gramfort [Correspondant].

The project accepted by ANR in 2019 will be starting in 2020 with an engineer to be hired in 2020. This project is in collaboration with the MEG groups at CEA NeuroSpin and the Brain and Spine Institute (ICM) in Paris.

The neuroimaging community recently started an international effort to standardize the sharing of data recorded with magnetoencephalography (MEG) and with electroencephalography (EEG). This format, known as the Brain Imaging Data Structure (BIDS), now needs a wider adoption, notably in the French neuroimaging community, along with the development of dedicated software tools that operate seamlessly on BIDS formatted datasets. The meegBIDS.fr project has three aims: 1) accelerate the research cycles by allowing analysis software tools to work with BIDS formated data, 2) simplify data sharing with high quality standards thanks to automated validation tools, 3) train French neuroscientists to leverage existing public BIDS MEG/EEG datasets and to share their own data with little efforts.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. VirtualBrainCloud

Title:

Programm: H2020 FET Open

Duration: 01/01/2019 - 31/12/2022

Coordinator: Petra Ritter

Inria contact: Bertrand Thirion

Summary:

The central goal of this project is the development of a cloud-based platform for biomedical research and clinical decision-making that helps to improve early patient-specific diagnosis and treatment of NDD and has substantial potential for significant positive socioeconomic impact.

The platform integrates several aims that revolve around early diagnosis, prognosis, and personalized treatment of neurodegenerative diseases (NDD) like Alzheimer's disease (AD) and Parkinson's disease (PD). It is becoming increasingly clear that meeting this objective requires a multifactorial approach that takes into account individual genetic, metabolic and environmental aspects, and that integrates them with the understanding of the biophysical processes underlying NDD.

More information can be found here https://virtualbraincloud-2020.eu/tvb-cloud-main.html.

9.3.1.2. Neurolang

Title: Accelerating Neuroscience Research by Unifying Knowledge Representation and Analysis Through a Domain Specific Language

Programm: ERC Starting researcher

Duration: 01/03/2018 - 28/02/2023

Coordinator: Demian Wassermann

Inria contact: Demian Wassermann

Summary:

Neuroscience is at an inflection point. The 150-year old cortical specialization paradigm, in which cortical brain areas have a distinct set of functions, is experiencing an unprecedented momentum with over 1000 articles being published every year. However, this paradigm is reaching its limits. Recent studies show that current approaches to atlas brain areas, like relative location, cellular population type, or connectivity, are not enough on their own to characterize a cortical area and its function unequivocally. This hinders the reproducibility and advancement of neuroscience.

Neuroscience is thus in dire need of a universal standard to specify neuroanatomy and function: a novel formal language allowing neuroscientists to simultaneously specify tissue characteristics, relative location, known function and connectional topology for the unequivocal identification of a given brain region.

The vision of NeuroLang is that a unified formal language for neuroanatomy will boost our understanding of the brain. By defining brain regions, networks, and cognitive tasks through a set of formal criteria, researchers will be able to synthesize and integrate data within and across diverse studies. NeuroLang will accelerate the development of neuroscience by providing a way to evaluate anatomical specificity, test current theories, and develop new hypotheses.

NeuroLang will lead to a new generation of computational tools for neuroscience research. In doing so, we will be shedding a novel light onto neurological research and possibly disease treatment and palliative care. Our project complements current developments in large multimodal studies across different databases. This project will bring the power of Domain Specific Languages to neuroscience research, driving the field towards a new paradigm articulating classical neuroanatomy with current statistical and machine learning-based approaches.

9.3.1.3. SLAB (698)

Title: Signal processing and Learning Applied to Brain data

Programm: ERC Starting researcher

Duration: 01/04/2017 - 31/08/2021

Coordinator: Alexandre Gramfort

Partner: LTCI , Telecom ParisTech (France)

Inria contact: Alexandre Gramfort

Summary:

Understanding how the brain works in healthy and pathological conditions is considered as one of the challenges for the 21st century. After the first electroencephalography (EEG) measurements in 1929, the 90's was the birth of modern functional brain imaging with the first functional MRI and full head magnetoencephalography (MEG) system. In the last twenty years, imaging has revolutionized clinical and cognitive neuroscience.

After pioneering works in physics and engineering, the field of neuroscience has to face two major challenges. The size of the datasets keeps growing. The answers to neuroscience questions are limited by the complexity of the signals observed: non-stationarity, high noise levels, heterogeneity of sensors, lack of accurate models. SLAB will provide the next generation of models and algorithms for mining electrophysiology signals which offer unique ways to image the brain at a millisecond time scale.

SLAB will develop dedicated machine learning and signal processing methods and favor the emergence of new challenges for these fields. SLAB focuses on five objectives: 1) source localization with M/EEG for brain imaging at high temporal resolution 2) representation learning to boost statistical power and reduce acquisition costs 3) fusion of heterogeneous sensors 4) modeling of non-stationary spectral interactions to identify functional coupling between neural ensembles 5) development of fast algorithms easy to use by non-experts.

SLAB aims to strengthen mathematical and computational foundations of brain data analysis. The methods developed will have applications across fields (computational biology, astronomy, econometrics). Yet, the primary impact of SLAB will be on neuroscience. The tools and high quality open software produced in SLAB will facilitate the analysis of electrophysiology data, offering new perspectives to understand how the brain works at a mesoscale, and for clinical applications (epilepsy, autism, tremor, sleep disorders).

9.3.1.4. HBP SGA2

Title: Interactive Computing E-Infrastructure for the Human Brain Project

Programm: FET Flagship

Duration: 01/04/2018 - 31/03/2020

Coordinator: Katrin Amunts

Partners: see https://www.humanbrainproject.eu/en/open-ethical-engaged/contributors/partners/

Inria contact: Bertrand Thirion

Summary:

The HBP Flagship was launched by the European Commission's Future and Emerging Technologies (FET) scheme in October 2013, and is scheduled to run for ten years. The Flagships, represent a new partnering model for visionary, long-term European cooperative research in the European Research Area, demonstrating the potential for common research efforts. The HBP has the following main objectives:

- Create and operate a European scientific Research Infrastructure for brain research, cognitive neuroscience, and other brain-inspired sciences

- Gather, organise and disseminate data describing the brain and its diseases
- Simulate the brain
- Build multi-scale scaffold theory and models for the brain
- Develop brain-inspired computing, data analytics and robotics
- Ensure that the HBP's work is undertaken responsibly and that it benefits society.

More information on the HBP's Flagship Objectives is available in the Framework Partnership Agreement.

The timeline of the Project is split into multiple phases, each of which will be covered by a separate funding agreement. The current phase is Specific Grant Agreement Two (SGA2), which spans the two-year period from April 2018–April 2020. The HBP is funded via several sources. Total funding is planned to be in the region of EUR 1 billion; around one half of which will be provided by the European Union, and the other by Member States and private funding sources. The European Union contributed EUR 54 million to the Project in the Ramp-Up Phase (October 2013 to March 2016), EUR 89 million for the second phase (SGA1), and EUR 88 million for the current phase (SGA2). The FET Flagships Staff Working Document provides further information on how Flagships are funded.

9.4. International Initiatives

9.4.1. Inria International Labs

Inria@SiliconValley
Associate Team involved in the International Lab:

9.4.1.1. Meta&Co

Title: Meta-Analysis of Neuro-Cognitive Associations

International Partner (Institution - Laboratory - Researcher):

Stanford (United States) - Psychology department. - Russel Poldrack

Start year: 2018

See also: http://team.inria.fr/parietal

Cognitive science and psychiatry describe mental operations: cognition, emotion, perception and their dysfunction. Cognitive neuroimaging bridge these mental concepts to their implementation in the brain, neural firing and wiring, by relying on functional brain imaging. Yet aggregating results from experiments probing brain activity into a consistent description faces the roadblock that cognitive concepts and brain pathologies are ill-defined. Separation between them is often blurry. In addition, these concepts and subdivisions may not correspond to actual brain structures or systems. To tackle this challenge, we propose to adapt data-mining techniques used to learn relationships in computational linguistics. Natural language processing uses distributional semantics to build semantic relationships and ontologies. New models are needed to learn relationships from heterogeneous signals: functional magnetic resonance images (fMRI), on the one hand, combined with related psychology and neuroimaging annotations or publications, on the other hand. Such a joint effort will rely on large publicly-available fMRI databases shared by Podrack Lab, as well as literature mining.

Inria@SiliconValley
Associate Team involved in the International Lab:

9.4.1.2. LargeSmallBrainNets

Title: Characterizing Large and Small-scale Brain Networks in Typical Populations Using Novel Computational Methods for dMRI and fMRI-based Connectivity and Microstructure

International Partner (Institution - Laboratory - Researcher):

Stanford (United States) - Stanford Cognitive and Systems Neuroscience Laboratory - Vinod Menon

Start year: 2019

See also: http://pages.saclay.inria.fr/demian.wassermann/largesmallbrainnets/

In the past two decades, brain imaging of neurotypical individuals and clinical populations has primarily focused on localization of function and structures in the brain, revealing activation in specific brain regions during performance of cognitive tasks through modalities such as functional MRI. In parallel, technologies to identify white matter structures have been developed using diffusion MRI. Lately, interest has shifted towards developing a deeper understanding of the brain's macroscopic and microscopic architectures and their influence on cognitive and affective information processing. Using for this resting state fMRI and diffusion MRI to build the functional and structural networks of the human brain.

The human brain is a complex patchwork of interconnected regions, and graph-theoretical approaches have become increasingly useful for understanding how functionally connected systems engender, and constrain, cognitive functions. The functional nodes of the human brain, i.e. cortical regions, and their structural inter-connectivity, collectively the brain's macrostructure or "connectome", are, however, poorly understood. Quantifying in vivo how these nodes' microstructure, specifically cellular composition or cytoarchitecture, influences the cognitive tasks in which these are involved is fundamental problem in understanding the connectome. Furthermore, the coupling between within and across-subject contributions to the connectome and cognitive differences hampers the identification and understanding of the link between brain structure and function, and human cognition.

Critically, there is a dearth of computational methods for reliably identifying functional nodes of the brain, their micro and macrostructure in vivo, and separating the population and subject-specific effects. Devising and validating methods for investigating the human connectome has therefore taken added significance.

The first major goal of this project is to develop and validate appropriate sophisticated computational and mathematical tools relate the brain's macrostructure with its function. Specifically, we will focus on being able to separate population and subject-specific contributions within these models using state-of-the-art human brain imaging techniques and open-source data from the Human Connectome Project (HCP) and the Adolescent Brain Cognitive Development study (ABCD). To this end, we will first develop and validate novel computational tools for (1) formulating and fitting large scale random effect models on graphs derived from functional and structural connectivity and (2) implement techniques enabling us to impose different regularization schemes based on sparsity and multicollinearity of the model parameters.

The second major goal of this project is characterizing the cytoarchitecture of the nodes, i.e. cortical regions, at the microscopic level and their relationship with the brain's hemodynamical function and cognition. For this, we will (1) identify cortical areas with specific cytoarchitecture in the human cortex and use them to develop diffusion MRI-based models, (2) validate these models with numerical simulations of the dMRI signal and animal models, and (3) establish the relationship between cytoarchitecture and hemodynamical function measured from fMRI and cognition. For this we will leverage multi-shell high-angular diffusion MRI from public databases such as HCP and ABCD.

Finally, we will use to use our newly developed computational tools to characterize normal structural and functional brain networks in neurotypical adults. Due to the complementarity of the cognitive science and imaging techniques expertise the synergy between the two laboratories of this associate team will allow us to reveal in unprecedented detail the structural and functional connectivity of the human brain and its relation to cognition.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Aapo Havärinen has been with parietal since April 2019 for a one-year visit, funded by the Dataia convergence institute.
- Luigi Gresele (MPI Tübingen) has been visiting the team in November-December 2019.
- Cedric Xu (UPenn) visited the team for three months in June-August 2019.
- James Cole (UCL) visited the team in December 2019.
- Yu Zhang (BIC, Montreal) visited the team during one week in September 2019
- Bemsibom Toh (HWU, Edinburgh) visited the team during two months in September-November 2019

9.5.2. Visits to International Teams

9.5.2.1. Sabbatical programme

Gael Varoquaux is spending one year in Montreal (September 2019-September 2020), hosted at MILA and Montreal Neuroimaging Institute at McGill Unviversity.

PLEIADE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Malabar

This is a project funded by labex COTE (University of Bordeaux) as a collaboration with IFREMER at Arcachon, EPOC (Talence), and ETI chair of the labex. The guideline of the project is to build models in statistical ecology on a series of molecular based invetories (300 samples) from occurence matrices of OTUs in samples, with environmental variables. The samples have been collected in 2018-2019, the sequences produced by BioGeCo in 2019, and data analysis will begin in 2020.

8.1.2. High-performance computing and metabarcoding

PLEIADE is member of two projects, one funded by the Région Nouvelle Aquitaine and one funded as Inria ADT Gordon, connecting Chameleon, StartPU and NewMadeleine, where the use case of metabarcoding (questions, data sets) hase been selected to link these layers together. This will permit us to address unsupervised clustering of one million reads next year. These projects are in collaboration with the HiePACS, TADAAM, and STORM project-teams.

8.1.3. COTE – Continental to Coastal Ecosystems

The Labex cluster of excellence COTE (Continental To coastal Ecosystems: evolution, adaptability and governance) develops tools to understand and predict ecosystem responses to human-induced changes as well as methods of adaptative management and governance to ensure their sustainability. The LabEx includes nine laboratories of the University of Bordeaux and major national research institutes involved in research on terrestrial and aquatic ecosystems (INRA, CNRS, IFREMER and IRSTEA).

8.2. National Initiatives

8.2.1. Agence Française pour la Biodiversité

The AFB is a public law agency of the French Ministry of Ecology that supports public policy in the domains of knowledge, preservation, management, and restoration of biodiversity in terrestrial, aquatic, and marine environments. PLEIADE is a partner in two AFB projects developed with the former ONEMA: one funded by ONEMA, the second by labex COTE, where BioGeCo/Pleiade is responsible for data analysis, with implementaton of the tools recently developed for scaling MDS. Calculations have been made on CURTA at MCIA and PlaFRIM at Inria.

8.2.2. Inria Projet Lab in silico Algae

In 2017 PLEIADE joined the IPL “In silico Algae” coordinated by Olivier Bernard. The IPL addresses challenges in modeling and optimizing microalgae growth for industrial applications. PLEIADE worked this year on comparative genomic analysis of genes implicated in lipid production by the picoalgae *Ostreococcus tauri*, in collaboration with Florence Corellou of the CNRS UMR 5200 (Laboratoire de Biogénèse Membranaire). The goal of this work is the production of long-chain polyunsaturated fatty acids, developed as nutritional additives. Mercia Ngoma Komb’s two-month internship in PLEIADE contributed to this work.

8.3. European Initiatives

8.3.1. Collaborations in European Programs, Except FP7 & H2020

Program: COST

Project title: COST Action DNAqua.net

Abstract: PLEIADE is responsible for the WG "Data Analysis and storage" in this action. As such, we have organized with CNR Verbana (Italy) two Europeanwide workshops: one in Lyon in February 2019, and one in Limassol (Cyprus) in October 2019. As a follow up of these workshops, Pleiade and BioGeCo will be responsible for taking in charge data analysis of OTU picking in two European wide projects:

- a benchmark for different tools for OTU picking, with datasets from different European teams
- a comparison between different organisms (metabarcoding inventories) for assessing the quality of the water of Danube river, in collaboration with raparian countries

Program: EOSC

Project title: EOSC-Pillar

Abstract: This is a follow up of our former participation in EOSC-Pilot. In collaboration with HiePACS, PLEIADE is involved in task 7.4, for bringing use cases in metabarcoding as testbeds for circulation of codes between different infrastructures, including PlaFRIM.

8.4. International Initiatives

8.4.1. Vitapalm – Food and nutrition security and sustainable agriculture in Africa

PLEIADE participates in the Vitapalm program financed by LEAP-Agri [0], the joint Europe Africa Research and Innovation (R&I) initiative related to Food and Nutrition Security and Sustainable Agriculture. Vitapalm uses genomics and selection to improve the nutritional quality and the stability of palm oil produced by Africa smallholdings for local consumption. Project partners are from Cameroon, France, Germany, and Ghana.

8.4.2. Simulation of metacommunities

In collaboration with the Pasteur Institute in Cayenne and the INRA MIA Research Team in Toulouse, PLEIADE is developing a stochastic model for simulation of metacommunities, in the framework of patch occupancy models. The objective is a better understanding of zoonose propagation, namely rabies through bat hosts in connection with disturbances of pristine forests in French Guiana, which have an impact on the exposure of human populations to wildlife that act as reservoirs of zoonoses.

8.4.3. CEBA – Center for the study of biodiversity in Amazonia

The Laboratoire of excellence CEBA promotes innovation in research on tropical biodiversity. It brings together a network of internationally-recognized French research teams, contributes to university education, and encourages scientific collaboration with South American countries. PLEIADE participates in three current international projects funded by CEBA:

- *MicroBIOMES: Microbial Biodiversities*. 2017-19.
- *Neutrophyl: Inferring the drivers of Neotropical diversification*. 2017-19.
- *Phyloguianas: Biogeography and pace of diversification in the Guiana Shield*. 2015-present

PLEIADE is involved with BioGeCo as partner of Institut Pasteur de Guyane at Cayenne for developing the domain of so-called Ecoviromics for some zoonoses in French Guiana. The spine of this collaboration is co-supervizing of a PhD student at IPG in cayenne, in bioinformatics and statistical ecology to decipher the respective roles of host phylogeny and environmetal variables in the virome of different hosts (bats, rodents, birds).

[0] http://www.leap-agri.com/

REO Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

Irene Vignon Clementel is a member of the project iLite (09/16-10/21), RHU-santé grant, a large French hospital-medical research consortium that aims at developing innovations for liver and tissue engineering (Inria PI: Dirk Drasdo).

8.1.2. APHP-Inria collaboration

Participants: Nour Bou Saleh, Quentin Nicolas, Nicolas Golse, Irene Vignon-Clementel [local coordinator].

Collaboration with Eric Vibert (APHP - Inserm U1193) for cosupervision of surgery interns (N. Bousaleh, D. Dousse) and engineering intern (Q Nicolas) in the context of the APHP-Inria PhD of N. Golse, on liver modeling and ICG fluorescence.

8.2. European Initiatives

8.2.1. Collaborations in European Programs, Except FP7 & H2020

SimInhale COST Action MP1404, a pan-European network of experts in the field of inhaled medicine, coordinated by Prof. Stavros Kassinos, end: 2019 (http://www.siminhale-cost.eu).

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

Collaboration with :

- Prof. Pal Dag Line from U. of Oslo, Oslo hospital U. with E. Vibert (APHP, Inserm) - N. Golse, I. Vignon-Clementel
- CHUM Centre Hospitalier de l'Université de Montreal (G Soulez and colleagues) - F. Joly (Inria), I. Vignon-Clementel

SERENA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

MILC (DMI RFSI, 2018–2019): "Mesure et Intégrale de Lebesgue en Coq", with LIPN (Université de Paris 13), and TOCCATA (Inria Saclay - Île-de-France). SERENA representants are François Clément and Vincent Martin (UTC).

GiS: scientific collaboration network between ten public institutions from the Paris (Ile-de-France) region, focused on natural resources and environment. The project-team SERENA is a member.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

- ERC GATIPOR: "Guaranteed fully adaptive algorithms with tailored inexact solvers for complex porous media flows". The subject of this consolidator grant are new approaches to porous media multiphase flows: inexact Newton-multigrid solvers, local stopping criteria, adaptivity, and a posteriori error control. The goal is to guarantee the overall simulation error and to speed-up importantly the present-day simulations. SERENA representant is M. Vohralík (grant leader, 75% commitment), period 2015–2020.
- ERC EMC2: " Extreme-scale Mathematically-based Computational Chemistry". The goal of this project is to develop physical and chemical models in chemistry, condensed matter physics, molecular biology, materials science, and nanosciences, altogether with mathematically-certified and numerically-efficient algorithms, and to implement them in a scalable way on various computer architectures. There are 4 principal investigators and a little more than 10 co-investigators. SERENA representant is M. Vohralík (co-investigator, 10% commitment), period 2019–2025.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

Erik Burman, Professor, University College London, unfitted methods.

Ulrich Rüde, Professor, University of Erlangen-Nürnberg, multigrid methods.

Iain Smears, Lecturer, University College London, local-global approximations.

Benjamin Stamm, Professor, RTWH Aachen University, eigenvalue problems (first-principle molecular simulation).

Barbara Wohlmuth, professor, Technical University Munich, multigrid methods.

9.3.2. Participation in Other International Programs

9.3.2.1. Inria International Chairs

IIC GUERMOND Jean-Luc

Title: Curved H(div), H(curl) elements, and magnetohydrodynamics & Approximation of hyperbolic systems

International Partner (Institution - Laboratory - Researcher):

Texas A&M University (United States) - Department of Mathematics - Jean-Luc Guermond

Duration: 2019 - 2023

Start year: 2019

See also: https://www.math.tamu.edu/~guermond/

The program is articulated around two themes: (1) Theoretical aspects in finite elements and applications to multi-physics magneto-hydrodynamics; (2) Finite element approximation of hyperbolic systems and applications. The results from this research will have applications in problems related to porous media flows, magnetohydrodynamics, water management, and compressible and incompressible fluid flows.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Hend Ben Ameur, Professor at IPEST and member of ENIT-Lamsin, Tunis, Tunisia, November 4–15.

Gregor Gantner, Vienna University of Technology. Collaboration on IGA methods. September 23–27.

Thirupathi Gudi, Indian Institute of Science, Bangalore. Collaboration on local-global approximations. June 10–17.

Dirk Praetorius, Vienna University of Technology. Collaboration on cost-optimality of fully adaptive algorithms. March 21–23.

Ivan Yotov, Professor, University of Pittsburgh. Inria Paris invited professor, September 1–December 15, 2019. Collaboration on multilevel and space-time domain decomposition methods.

9.4.1.1. Internships

Théo Kaprélian, internship at Ecole Centrale de Lyon, from September 2019 to February 2020, supervised by Martin Vohralík.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

+ Géraldine Pichot was invited for a one week stay at Pennstate University, USA for a collaboration with Pr. Ludmil Zikatanov.

+ Géraldine Pichot was invited for a one week stay at University of Bergen, Norway for a collaboration with Pr. Florin Radu.

SERPICO Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Motion saliency analysis in videos

Participants: Léo Maczyta, Patrick Bouthemy.
Duration: 36 months (Oct 2017 – Sep 2020).

See Section 8.1.2.

Funding: DGA (National Defense Agency) and Région-Bretagne.

9.2. National Initiatives

9.2.1. France-BioImaging project

Participants: Sylvain Prigent, Patrick Bouthemy, Charles Kervrann, Jean Salamero.
Duration: 2011 – 2024.

The goal of the France-BioImaging project (http://france-bioimaging.org/) is to build a distributed coordinated French infrastructure for photonic and electronic cellular bioimaging, dedicated to innovation, training and technology transfer. High-computing capacities are needed to exhaustively analyse image flows. SERPICO is co-head of the IPDM (Image Processing and Data Management) node of the FBI network composed of 6 nodes. In this context, we address the following scientific problems: i/ exhaustive analysis of bioimaging data sets; ii/ deciphering of key steps of biological mechanisms at organ, tissular, cellular and molecular levels through the systematic use of time-lapse 3D microscopy and image processing methods; iii/ storage and indexing of extracted and associated data and metadata through an intelligent data management system. SERPICO recruited R&D engineers to disseminate image processing software, to build the Mobyle@serpico web portal and to manage the IGRIDA-SERPICO cluster (200 nodes; batch scheduler: OAR; File management: Puppet/Git/Capistrano; OS: Linux Debian 7; User connexion: public ssh key) opened for end-users and dedicated to large scale computing and data sets processing (storage: 200 TeraBytes) (see Section 6.13).

Funding: Investissement d'Avenir, ANR INBS-PIA 2011.
Coordinator: CNRS (J. Salamero, UMS 3714 CEMIBIO & CNRS-UMR 144, Institut Curie, PSL Research University).
Partners: CNRS, University of Paris-Diderot-Paris 7, Aix-Marseille University, University of Bordeaux, University of Montpellier, Institut Pasteur, Institut Curie, Inria, ENS Paris, University of Paris Descartes, UPMC, Ecole Polytechnique, INSERM.

9.2.2. ANR NucleoPLASTIC: Plasticity of the Nuclear Pore Complex

Participant: Jean Salamero.
Duration: 48 months (Oct 2015 – Sep 2019).

In this project, we have deciphered molecular/structural changes on the nuclear face of the Nuclear Pore Complex, their dynamics during cell division, and highlighted their role in the dynamics of association with the heart of the pore with consequences on maintaining the integrity of the genome. This was possible through the development of a 3D localization software GenLoc3D (https://team.inria.fr/serpico/software/genloc3d/, FIJI/ImageJ plug-in).

Funding: ANR (Agence Nationale de la Recherche).
Coordinator: C. Dargemont (INSERM, Hopital St Louis, Paris).
Partners: CNRS-UMR 144, Institut Curie, PSL Research, Paris.

9.2.3. ANR DALLISH project: Data Assimilation and Lattice LIght SHeet imaging for endocytosis/exocytosis pathway modeling in the whole cell

Participants: Antoine Salomon, Anca-Georgiana Caranfil, Sandeep Manandhar, Cesar Augusto Valades Cruz, Patrick Bouthemy, Ludovic Leconte, Jean Salamero, Charles Kervrann.
Duration: 48 months (Oct 2016 – Sep 2020).

Cutting-edge Light Lattice Sheet microscopy represents the novel generation of 3D fluorescence microscopes dedicated to single cell analysis, generating extraordinarily high resolved and sharp, but huge 3D images and videos. One single live cell experiment in one single biological condition can result into up to one terabyte of data.The goal of the project is to develop new paradigms and computational strategies for image reconstruction and 3D molecule motion estimation and tracking. Furthermore, establishing correspondences between image-based measurements and features, stochastic motion models, and underlying biological and biophysical information remains a challenging task. In a larger perspective, the quantitative description of image data corresponding to protein transport will be a prerequisite for understanding the functioning of a cell in normal and pathological situations including cancer, viral infection and neurodegenerative diseases (see Sections 7.2–7.6 and 7.8).

Funding: ANR (Agence Nationale de la Recherche) PRC (Collaborative Research Project).
Coordinator: C. Kervrann.
Partners: Inria (SERPICO, BEAGLE, FLUMINANCE teams), INRA MaIAGE Unit Jouy-en-Josas, Institut Curie (CNRS-UMR 144 & U1143 INSERM / UMR 3666) Paris.

9.2.4. Inria Project Labs (IPL / DEFI), Exploratory Research Actions and Technological Development Actions

9.2.4.1. NAVISCOPE: image-guided NAvigation and VISualization of large data sets in live cell imaging and microCOPy

Participants: Gwendal Fouché, Cesar Augusto Valades Cruz, Ludovic Leconte, Anais Badoual, Jean Salamero, Charles Kervrann.
Duration: 60 months (2018 – 2022).

In the frame of the "Naviscope" IPL project (https://project.inria.fr/naviscope/), our objective is to develop original and cutting-edge visualization and navigation methods to assist scientists, enabling semi-automatic analysis, manipulation, and investigation of temporal series of multi-valued volumetric images, with a strong focus on live cell imaging and microscopy application domains. Naviscope, built upon the strength of scientific visualization and machine learning methods, will provide systems capable to assist the scientist to obtain a better understanding of massive amounts of information. Such systems will be able to recognize and highlight the most informative regions of the dataset by reducing the amount of information displayed and guiding the observer attention. We address the three following challenges and issues:

- Novel machine learning methods able to detect the main regions of interest, and automatic quantification of sparse sets of molecular interactions and cell processes during navigation to save memory and computational resources.
- Novel visualization methods able to encode 3D motion and deformation vectors and dynamics features with color and texture-based and non-sub-resolved representations, abstractions, and discretization, as used to display 2D motion and deformation vectors and patterns.
- Effective machine learning-driven navigation and interaction techniques for complex functional 3D+Time data enabling the analysis of sparse sets of localized intra-cellular events and cell processes (migration, division, etc.) (see Section 7.9).

Meanwhile, we address the technological challenge of gathering up the software developed in each team to provide a unique original tool for users in biological imaging, and potentially in medical imaging.

Funding: Inria (IPL / DEFI).
Coordinator: C. Kervrann.
Partners: AVIZ Inria team (Saclay); BEAGLE Inria team (Lyon), HYBRID Inria team (Rennes), MORPHEME Inria team (Sophia-Antipolis); MOSAIC Inria team (Lyon), PARIETAL Inria team (Saclay), SERPICO Inria team (Rennes); MaIAGE INRA Unit (Jouy-en-Josas); CNRS-UMR 144, Institut Curie, PSL Research University (Paris).

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

9.3.1.1. ESFRI initiative programm

SERPICO is involved in the ESFRI Euro-BioImaging (https://www.eurobioimaging.eu/) initiative, one of the four new biomedical science projects in the roadmap of the European Strategic Forum on Research Infrastructures (ESFRI). The mission of Euro-BioImaging is to provide access, service and training to state-of-the-art imaging technologies and foster the cooperation and networking at the national and European level including multidisciplinary scientists, industry, regional, national and European authorities. SERPICO is also involved in the French initiative, the so-called “France-BioImaging” (FBI) network which gathers several outstanding cellular imaging centers (microscopy, spectroscopy, probe engineering and signal processing) as described in Section 9.2.1 .

Coordinator: Turku University (J. Eriksson, Turku, Finland).
Funding: Member states of the European Union.
Partners: 15 European countries.

9.3.1.2. EIT Digital program

Participants: Sylvain Prigent, Charles Kervrann.
Duration: 12 months (Nov 2019 – Oct 2020).

SERPICO is involved in a European project which aims at developing a connected wearable device for diagnosis and treatment of photodermatoses. Using the data on skin sun sensitivity and UV exposure habits with machine learning algorithms will enable to make more precise optimal sun exposure predictions for patients. The wearable device will be useful for a larger population to increase awareness around overexposure to UV as a main cause of sun damage and worst-case skin cancer.

Funding: EIT Digital.
Inria coordinator: C. Kervrann.
Partners: UVisio and Nobleo Projects B.V., Eindhoven, The Netherlands.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- Collaboration with Max-Planck Institute, Martinsried, Germany (with A. Martinez and W. Baumeister): Detection and segmentation of macromolecules in cryo-electron tomography (project in progress with E. Moebel and C. Kervrann) (see Sections 6.9 [30] and 6.12 [22]).
- Collaboration with University of Texas SouthWestern (UTSW) Medical Center, Dallas, United States (P. Roudot, E. Welf and G. Gaudenz): 3D optical flow for cell migration quantification (project in progress with S. Manandhar, P. Bouthemy and C. Kervrann) (see Sections 6.11 and 7.4 [21]).
- Collaborations with the MRC laboratory of Molecular Biology (with E. Derivery and J. Boulanger) and the Cambridge Advanced Imaging Centre (with L. Muresan), Cambridge, UK (project in progress with A. Salomon and C. Kervrann) (see Section 7.2).
- Collaboration with the PKU University, Institute of Molecular Medicine, Beijing (with L. Chen and Y.M. Liu): 3D reconstitution of the biogenesis of Endoplasmic Reticulum-plasma membrane contact sites (ER-PM MSCs upon Ca2+ store depletion or replenishment) (project in progress with C.A. Valades Cruz and J. Salamero).

9.5. International Research Visitors

9.5.1. Visits to International Teams

- Charles Kervrann visited the MRC laboratory of Molecular Biology and the Cambridge Advanced Imaging Centre (June, 1 week, Cambridge, UK).

SISTM Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

The team have strong links with :

- Research teams of the research center Inserm U1219 : "Injury Epidemiology, Transport, Occupation" (IETO), "Biostatistics", "Pharmacoepidemiology and population impact of drugs", "Multimorbidity and public health in patients with HIV or Hepatitis" (MORPH3Eus), "Computer research applied to health" (ERIAS) emerging research team.
- Bordeaux CHU ("Centre Hospitalier Universitaire").
- Institut Bergonié, Univ Bordeaux through the Euclid F-CRIN Clinical Trials platform and CIC-EC (CIC1401)
- Inria Project-team MONC, M3DISIM and CQFD

The project team members are involved in:

- EUCLID/F-CRIN clinical trials platform (Laura Richert)
- The Clinical Epidemiology module of the Clinical Investigations Center (CIC1401) (Laura Richert)
- The research project “Self-management of injury risk and decision support systems based on predictive computer modelling. Development, implementation and evaluation in the MAVIE cohort study” funded by the Nouvelle-Aquitaine regional council (Marta Avalos).
- Phenotyping from Electronic Health Records pilot project in cooperation with with the ERIAS Inserm emerging team in Bordeaux and the Rheumatology service from the Bordeaux Hospital (Boris Hejblum)
- A cancer research project (GLIOMA-PRD) in collaboration with Inria MONC team and with the the Inserm Angiogenesis and Tumor micro-environment team on glioblastoma

9.2. National Initiatives

- Labex Vaccine Research Institute (VRI) There are strong collaborations with immunologists involved in the Labex Vaccine Research Institute (VRI) as Rodolphe Thiébaut and Laura Richert are leading the Data science division (previously Biostatistics/Bioinformatics) http://vaccine-research-institute.fr.
- Collaboration with Inserm PRC (pôle Recherche clinique).
- Collaboration with Inserm Reacting (REsearch and ACTion targeting emerging infectious diseases) network
- Collaboration with Inserm RECap (Recherche en Epidémiologie Clinique et en Santé Publique) network

9.2.1. Expert Appraisals

- Rodolphe Thiébaut is a member of the CNU 46.04 (Biostatistiques, informatique médicale et technologies de communication).
- Rodolphe Thiébaut is a member of the Scientific Council of Inserm.
- Mélanie Prague is an expert for ANRS (France Recherche Nord&Sud Sida-HIV Hépatites) in the CSS 3 (Recherches cliniques et physiopathologiques dans l’infection à VIH) and AC 47 (Dynamique et contrôle des épidémies VIH et hépatites).
- Laura Richert is an expert for the PHRC (Programme hospitalier de recherche Clinique).

- Marta Avalos is an expert for the ANSM (Agence nationale de sécurité du médicament et des produits de santé)

9.2.2. Various Partnership

The project team members are involved in:

- DRUGS-SAFE platform funded by ANSM (Marta Avalos). Initiated in 2015-2018. Renewed for 2019.
- F-CRIN (French clinical research infrastructure network), initiated in 2012 by ANR under "Programme des Investissements d'avenir". (Laura Richert)
- INCA (Institut National du Cancer) funded the project *Evaluation de l'efficacité d'un traitement sur l'évolution de la taille tumorale et autres critères de survie : développement de modèles conjoints.* (Principal PI Virginie Rondeau Inserm U1219, Mélanie Prague is responsible of Work package 4 “mechanistic modeling of cancer: 5800 euros”).
- Contrat Initiation ANRS MoDeL-CI: Modeling the HIV epidemic in Ivory Coast (Principal PI Eric Ouattara Inserm U1219 in collaboration with University College London, Mélanie Prague is listed as a collaborator).

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

The member of SISTM Team are involved in EHVA (European HIV Vaccine Alliance):

EHVA: European HIV Vaccine Alliance: a EU platform for the discovery and evaluation of novel prophylactic and therapeutic vaccine candidates

Coordinator: Inserm/University of Lausanne. Other partners: EHVA consortium gathers 41 partners. Duration: 60 months. 01 /01 /2016 - 31 /12 /2020

With 37 million people living with HIV worldwide, and over 2 millions new infections diagnosed each year, an effective vaccine is regarded as the most potent public health strategy for addressing the pandemic. Despite the many advances in the under-standing, treatment and prevention of HIV made over the past 30 years, the development of broadly-effective HIV vaccine has remained unachievable. The EHVA international alliance, which includes academic and industrial research partners from all over Europe, as well as sub-Saharan Africa and North America, will work to discover and progress novel vaccine candidates through the clinic. EHVA fosters a multidisciplinary approach to the challenge of developing broadly effective HIV vaccines. EHVA's program primary goals are:

- To develop a Multidisciplinary Vaccine Platform (MVP) for prophylactic and therapeutic HIV vaccines
- To move at least two novel prophylactic vaccine candidates to clinical development
- To identify immune correlates associated with control of HIV replication following immunological intervention
- To establish a strong scientific basis for further development of EHVA vaccine candidates in larger clinical trials

  To this purpose, EHVA bring to the field 4 multidisciplinary research platforms representative of the latest advances in clinical trials and preclinical vaccine development. These four platforms cover all aspects of vaccine development from early-stage discovery to clinical trials.
- The Discovery Platform will work to disclose promising vaccine candidates based on the induction of T-cell and antibody responses (ie, neutralizing antibody and non-neutralizing antibody).

- The Immune-Profiling Platform will advance assays to predict the immunogenicity of potential vaccine candidates. The ability to generate a profile of a potential vaccine candidate, using models that emulate the immune system's response, will assist with benchmarking novel and existing vaccine candidates.
- The Data Management/Integration and Down-Selection Platform is developed around the WP10 led by Rodolphe Thiébaut. SISTM provides here state-of-the-art statistical tools for the analysis and interpretation of complex data and algorithms for the efficient selection of vaccines.
- The Clinical Trial Platform includes pharmaceutical industry expertise for late stage development, a network of top European clinical centers for conducting large cohort studies, as well as relationships with leading scientists based in Africa. Future testing of EHVA vaccine in Sub-Saharan Africa is a research priority because it is the area of the world with the greatest number of people infected with HIV.

IP-CURE-B: Immune profiling to guide host-directed interventions to cure HBV infections. Coordinated by Inserm (France), the project includes a total of 13 Beneficiaries: Centre Hospitalier Universitaire Vaudois (Switzerland), Karolinska Institutet (Sweden), Institut Pasteur (France), Universita degli studi di Parma (Italy), Fondazione IRCCS CA' Granda – Ospedale maggiore policlinico (Italy), Universitaetsklinikum Freiburg (Germany), Ethniko Kai Kapodistriako Panepistimio Athinon (Greece), Fundacio Hospital Universitari vall d'Hebron (Spain), Gilead Sciences Inc. (USA), Spring Bank Pharmaceuticals, Inc (USA), European Liver Patients Association (Belgium), Inserm Transfert SA (France). Duration: 60 months. $01/01/2020 - 31/12/2024$

HBV infections, are a major global public health threat with over 257 million people worldwide chronically infected and over 887,000 deaths per year. 4.7 million people live with HBV in the European Union (EU) and European Economic Area (EEA). W.H.O. estimates that HBV causes almost 40% of the cases of hepatocellular carcinoma (HCC), which is the 2nd leading cause of cancer-related mortality worldwide. HBV kills nearly 900,0000 people around the world each year. The current prophylactic vaccine has no impact on established chronic infection.

The objective of the IP-CURE-B project is to develop novel curative concepts for chronic hepatitis B (CHB). Specific aims will be to: 1) improve the rate of functional cure of CHB by boosting innate immunity with immune modulators and stimulating adaptive immune responses with a novel therapeutic vaccine; ii) characterize immune and viral biomarker signatures for patient stratification and treatment response monitoring; iii) integrate biological and clinical data to model the best combination treatment for future trials; iv) model the effectiveness of novel curative therapies with respect to disease spectrum, patient heterogeneity, and constraints of National Health Systems.

The project organization combines: i) a Proof of Concept clinical trial of a combination of 2 novel compounds stimulating innate immunity; ii) a preclinical immune therapy platform in humanized mice combining immune-modulatory strategies to stimulate innate immunity, rescue exhausted HBV-specific T cells and generate anti-HBV adaptive responses; iii) extensive virologic and immune profiling to identify correlates of cure in patients, iv) the integration of large biological and clinical data-sets, v) a cost-effectiveness modelling of new therapeutic interventions, vi) project management, vii) results exploitation and dissemination.

In the IP-CURE-B project, SISTM coordinates WP6 Data science platform for data integration and statistical modeling which will provide powerful data management and statistical tools for the analysis and interpretation of the complex heterogeneous and high-dimensional data generated in the other WPs. For data management and data sharing, SISTM will leverage on a data warehouse system, based on Lab-key Server, the primary structure already established within the EU funded H2020 EHVA project. SISTM will develop and apply statistical methods for integrating data from several assay platforms to better describe and understand the mechanisms of the experimental products and to define predictive signatures of viral control and functional cure. Indeed, the immune system forms a sophisticated network of tissues, cells and molecules that interact in order to achieve viral control.

Understanding how this complex network responds to interventions aimed at HBV functional cure requires the use and integration of data from multiple assay technologies. Two main strategies will be used: 1) statistical approaches to relate and down-select several high-dimensional data from the various assays in humanized mice and humans; 2) a modelling approach, taking into account biological knowledge and the results from the first step, to better capture and understand the non-linear relationships between the components of the immune system, viral control and their dynamics over time. Statistical and mechanistic models will be used, based on ordinary differential equation systems or other approaches. At the end of the process, if an adequate model is identified, this can be used to down-select immunomodulatory and vaccine regimens and make in silico predictions about optimized strategies or stratified treatment approaches. These approaches have been successfully applied in HIV immunotherapy trials and in vaccine trials by SISTM.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

The members of SISTM are also involved in Innovative Medicine Initiative 2 (IMI2) projects which are all under the IMI Ebola+ program that was launched in response to the Ebola virus disease outbreak of 2014. SISTM is active in 3 projects which are all in collaboration with Janssen Vaccines & Preventions B.V. The overall aim of the EBOVAC program is to assess the safety, immunogenicity and efficacy of a novel 2-dose Ad26 + MVA prophylactic vaccine regimen against Ebola Virus Disease. In this context, the 3 projects develop as follows:

EBOVAC1: Development of a Prophylactic Ebola Vaccine Using an Heterologous Prime-Boost Regimen.

Coordinated by London School of Hygiene & Tropical Medicine (United Kingdom). Other beneficiaries: Janssen a Pharmaceutical Companies of Johnson & Johnson, The Chancellor, Masters and Scholars of the University of Oxford (United Kingdom), Inserm (France), University of Sierra Leone (Sierra Leone). Duration: 84 months. 01 /12 /2014 - 30 /11 /2021.

EBOVAC1 is dedicated to the Phase I and III development of prime-boost vaccine based on Ad26.ZEBOV and MVA-BN-Filo. Phase I was conducted in the US, the UK and in Africa (Sierra Leone, Uganda, Kenya and Tanzania) for a total of 231 volunteers enrolled. Phase III was conducted in Sierra Leone in several phases leading to the successful enrolment of more than 2800 volunteers including around 500 children aged 1-17 years. In EBOVAC1, SISTM is modelling the immune response to the Ad26.ZEBOV and MVA-BN-Filo, using the data obtained in the project.

EBOVAC2: Development of a Prophylactic Ebola Vaccine Using a 2-Dose Heterologous Vaccination Regimen: Phase 2.

Coordinated by Rodolphe Thiébaut with the following partners: Inserm (France), Labex VRI (France), Janssen Pharmaceutical Companies of Johnson & Johnson, London School of Hygiene & Tropical Medicine (United Kingdom), The Chancellor, Masters and Scholars of the University of Oxford (United Kingdom), Le Centre Muraz (Burkina Faso), Inserm Transfert (France). Duration: 72 months. 01 /12 /2014 - 30 /11 /2020.

EBOVAC2 main objective is to provide extensive and robust data on the safety and immunogenicity of the Ad26.ZEBOV and MVA-BN-Filo vaccine. This was designed by: 1. Carrying out translational studies to link vaccine elicited immune responses in humans to protection from Ebola in vaccinated non-human primates 2. Carrying out Phase II trials in African and European volunteers in approximately 6 countries, four in Africa and two in the EU with an overall target enrolment of approximately 1,500 subjects. Given the compressed nature of this development program, the Phase II studies were conducted in parallel with the planned Phase III study (EBOVAC1). The rationale for inclusion of European volunteers in Phase 2, in addition to the trials in Africa, is to allow for higher sensitivity in safety signal detection in populations with low incidence of febrile illnesses, to generate negative control specimens for assay development, to allow for inclusion of health care workers or military personnel that may be deployed to Ebola-endemic regions. 3. Evaluating the vaccine response in special population groups, such as children (ages 1-17 years), the elderly (ages

50-65) and individuals infected with HIV, to confirm safety and immunogenicity. The Phase II trials started as soon as preliminary safety data were available from Phase I trials. 4. Monitoring and characterizing immune response to the proposed vaccine through different set of analysis of the humoral and cellular response with different approaches (ICS, luminex, gene expression analysis, T and B cell activation assays, Virus neutralization assays...) leading to a unique set of data. In EBOVAC2, in addition to the coordination of the whole project, SISTM is involved in the statistical analysis of the results obtained by the VRI lab responsible for an important part of the exploratory work, but also in the integrative data analysis of these high dimension and complex data. A Labkey environment was established in SISTM for EBOVAC2 to facilitate the exchange and following treatment of the project data.

EBOVAC3: Bringing a prophylactic Ebola vaccine to licensure.

Coordinated by the London School of Hygiene & Tropical Medicine (United Kingdom). Other beneficiaries: Janssen a Pharmaceutical Companies of Johnson & Johnson, Inserm (France), The University of Antwerpen (Belgium), University of Sierra Leone (Sierra Leone). Duration: 60 months. 01 /06 /2018 - 30 /05 /2023.

EBOVAC3 aims at supporting an essential part of the remaining clinical and manufacturing activities required for licensure in the European Union (EU) and the United States (US) for the candidate heterologous Ad26.ZEBOV and MVA-BN-Filo prophylactic vaccine regimen against Ebola virus disease. As a follow-up project, the IMI2 funded EBOVAC3 project, has started in June 2018. In this project, the vaccine strategy is further evaluated in specific populations in Africa (infants in Guinea and Sierra Leone; and front line workers in RDC). The project includes a work package on modelling, which is led by Rodolphe Thiébaut. Three workshop have been organized in Bordeaux (October 29th-30th, 2018), Arcachon (May 2nd-3rd, 2019) and Leiden (November 20th, 2019) to discuss and collaborate with the EBOVAC3 partners on the planned modelling work.

PREVAC-UP: The Partnership for Research on Ebola VACcinations-extended follow-UP and clinical research capacity build-UP.

SISTM is also involved in PREVAC-UP, an EDCTP2 project in direct link with the research carried out on the Ebola vaccines.

Coordinated by Inserm (France). Other beneficiaries: CNFRSR (Guinea), CERFIG (Guinea), LSHTM (UK), COMAHS (Sierra-Leone), NIAID (USA), NPHIL (Liberia), USTTB (Mali), Centre pour le Développement des Vaccins (Mali), Inserm Transfert SA (France). Duration: 60 months. 01 /01 /2019 - 31 /12 /2023.

Human-to-human transmission of Ebola virus in West Africa was interrupted in 2016 but the risk of reemergence of the disease is real. Thus, efforts to develop a safe and effective vaccine against Ebola virus disease with a durable prophylactic effect in communities must continue. The PREVAC-UP project is built around the PREVAC consortium. The Partnership for Research on Ebola Vaccinations (PREVAC) is an international consortium including the French Institute of Health and Medical Research, the London School of Hygiene & Tropical Medicine, the US National Institutes of Health, health authorities and scientists from Guinea, Liberia, Mali and Sierra Leone, a non-governmental organization (Alliance for International Medical Action), and Merck, Johnson & Johnson and Bavarian Nordic companies. The PREVAC trial is a phase IIB, randomized, placebo controlled, multicentre trial evaluating the safety and immunogenicity over 12 months of three vaccine strategies in children and adults. Participants are randomized to one of five groups: (i) vaccination with Ad26.ZEBOV prime and MVA-BN-Filo boost, (ii) vaccination with rVSVδG-ZEBOV-GP prime and a boost of the same vaccine, (iii) vaccination with rVSVδG-ZEBOV-GP vaccine without boost, (iv) placebo group 1 and (v) placebo group 2. Preliminary phases started in Liberia and Guinea in March 2017; the main phase of the trial evaluating the five regimens will begin in Liberia, Guinea Sierra Leone and Mali in April 2018 with an enrolment targets of 1,400 adults and 1,400 children.

PREVAC-UP two primary objectives are to determine (i) the long-term immunogenicity and safety and (ii) durability of humoral and cellular immune responses of Ebola vaccine regimes over 60 months. We will also evaluate the effect of co-infections, such as malaria and helminths on the immune response to vaccination. An integrative statistical analysis of the immune response will be used under the coordination of SISTM to explore the mechanism of action of the vaccines and to identify early correlates of durable antibody induction. PREVAC-UP will also build on the extensive community mobilization efforts previously generated through PREVAC to provide a trans-national platform for social and health science research and training. Finally, this research proposal will expand and sustain capacity building and training of scientists in the four participant African countries. This program is expected to significantly impact Ebola prevention and control in adults and children in Africa. PREVAC-UP will also strengthen capacity for science relevant to the development and evaluation of new vaccines in sub-Saharian Africa.

In PREVAC-UP, SISTM leads the WP4 Utilisation of a system vaccinology approach using integrative statistical analyses and mechanistic modelling of the immune response to explore the interrelationship of immune response to Ebola vaccines. System vaccinology approach helps in better understanding and predicting the response to vaccines as demonstrated in the context of yellow fever, flu and many other vaccines. The idea is to integrate the massive data generated by high-throughput technologies (transcriptomics, flow cytometry, multiplex data) and population characteristics (sociodemographics and coinfections) to isolate the main markers/signatures associated to the vaccine response. Then, a mechanistic model of the response can be built and hopefully predict the individual long-term response. The PREVAC trial is a unique opportunity for setting up such an approach and apply it to the most advanced vaccine platforms against Ebola. The Inserm-SISTM team has produced several publications highlighting how within-host mechanistic models could play an important role in predicting vaccine efficacy and in improving treatment regimens, notably in HIV. The team has started to work on modelling the response to the Ad26.ZEBOV/MVA platform. In PREVAC-UP, it is expected that signatures and the mechanistic model itself will be different according to the type of vaccine as, specifically, the rVSV is a replicative vector. Two main outcomes are expected. One is a better understanding of the individual variability of the immune response and another is the prediction of the response with two specific aspects: after a new boost and on the long-term (5 years) for a new vaccinees. Identification and validation of an early correlate of later antibody responses would allow early prediction of whether an individual, or group of individuals is likely to be a poor responder and then to recommend subsequent interventions to test in this subset (such as change in vaccination strategy or additional boosts). Heterogeneity in antibody responses is expected within each group as it has been observed in former studies. In PREVAC-UP, information will be collected to inform the reason of this variability. Specific aspects will be explored such as the impact of malaria and various infectious agents on the immune response. Integrating such information in a mechanistic model of the immune response may help understanding the pathway leading to blunted response in vaccines and also to generate new hypotheses that could be biologically validated later on. Another important aspect of the modelling approach is the quantification of the impact of each potential factor helping to order the relative importance of various factors. In conclusion, this work is definitely at the confluence of the other work packages, integrating and ordering all the available information to understand and predict the effects of the promising vaccine strategy evaluated in the PREVAC trial.

9.3.3. Collaborations with Major European Organizations

University of Oxford;

London School of Hygiene and Tropical Medicine;

University Hospital Hambourg (UKE);

Heinrich Pette Institute for Experimental Virology, Hambourg;

MRC, University College London;

MRC Biostatistics Unit, University of Cambridge;

The University of Antwerpen;

University of Milan;

University of Bergen.

9.4. International Initiatives

9.4.1. Inria International Labs

Inria@EastCoast
Associate Team involved in the International Lab:

9.4.1.1. DYNAMHIC

Title: DYNAMical modeling of HIV Cures

International Partner (Institution - Laboratory - Researcher):

Harvard University (United States) - Harvard Program for Evolutionary Dynamics - Alison HILL

Start year: 2019

See also: https://team.inria.fr/dynamhic/

The aim of the DYNAMHIC Associate Team is to bring together a mathematical biology team at Harvard and the Inria team SISTM of applied statisticians at Bordeaux Sud-ouest. This collaboration will allow the analysis of unique pre-clinical non human primates data of HIV cure interventions. In particular, we will focus on immunotherapy and therapeutic vaccine, which are very promising in term of efficacy and are at the leading edge of pre-clinical research in the area. The novelty of the approach is to propose an integrative project studying complex biological processes with novel mathematical statistical models, which has the potential to yield predictive computational tools to assist in the design of both therapeutic products and clinical trials for HIV cure

Finally, the associate team is the opportunity to provide the research group with an official administrative framework. And, to continue to develop a promising research topic connected but different from those funded up to now.

Inria@SiliconValley
Associate Team involved in the International Lab:

9.4.1.2. SWAGR

Title: Statistical Workforce for Advanced Genomics using RNAseq

International Partner (Institution - Laboratory - Researcher):

RAND Corporation (United States) - Statistics group - Denis Agniel

Start year: 2018

See also: https://team.inria.fr/swagr/

The SWAGR Associate Team aims at bringing together a statistical workforce for advanced genomics using RNAseq. SWAGR combines the biostatistics experience of the SISTM team from Inria BSO with the mathematical expertise of the statistics group at the RAND Corporation in an effort to improve RNAseq data analysis methods by developing a flexible, robust, and mathematically principled framework for detecting differential gene expression. Gene expression, measured through the RNAseq technology, has the potential of revealing deep and complex biological mechanisms underlying human health. However, there is currently a critical limitation in widely adopted approaches for the analysis of such data, as edgeR, DESeq2 and limma-voom can all be shown to fail to control the type-I error, leading to an inflation of false positives in analysis results. False positives are an important issue in all of science. In particular in biomedical research when costly studies are failing to reproduce earlier results, this is a pressing issue. SWAGR propose to develop a rigorous statistical framework modeling complex transcriptomic studies using RNAseq by leveraging the synergies between the works of B. Hejblum and D. Agniel. The new method will be implemented in open-source software as a Bioconductor R package, and a user friendly web-application will be made available to help dissemination. The new method will be applied to clinical studies to yield significant biological results, in particular in vaccine trials through existing SISTM partnerships. The developed method is anticipated to become a new standard for the analysis of RNAseq data, which are rapidly becoming common in biomedical studies, and has therefore the potential for a large impact.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Internships

- Eva Reiner (Germany), intern in the Translational Vaccinology axis (March-July 2019)
- Aaron Sonabend, PhD student from Harvard University, collaborator in the High-dimensional statistical learning axis (June-August 2019) funded by the Harvard Rose Fellowship.

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Boris Hejblum did a research stay at the Biostatistics Unit of The Medical Research Council at the University of Cambridge (Cambridge, UK) for a cumulative period of 1.5 month in 2019. This stay was devoted to collaborative work with Paul DW Kirk on scalalble bayesian computational methods.
- Boris Hejblum did a research stay at the Rand Corporation (offices in both Santa Monica CA and Boston MA) and at the Harvard Medical School (Boston MA, USA) for a cumulative period of 2 weeks in 2019. This stay was devoted to collaborative work with Denis Agniel in the context of the SWAGR Associate Team and with Tianxi Cai on high-dimensional statistical inference.
- Mélanie Prague did a research stay abroad in Harvard.

STEEP Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. QAMECS / MOBIL'AIR : ATMOSPHERIC POLLUTION: Characterization of novel exposure markers, of biological, health, economic and societal impacts and evaluation of public policies

Project funded by ADEME, Grenoble metropolis, IDEX Université Grenoble Alpes
Duration: 2016–2022
Project coordinator: Remy Slama (INSERM) and Sandrine Mathy (GAEL, CNRS). Inria Coordinator: Emmanuel Prados
Other partners: Air Rhône-Alpes, CNRS, Sciences Po Grenoble, Inserm, IAB, Université Grenoble-Alpes
Abstract: Urban atmospheric pollution is one of the main threats to human health that can be to some extent controlled by public action. In Europe, many cities have implemented various types of low emission zones (LEZ, focused on traffic and heating emissions), France being a notable exception. Although fine particulate matter (PM2.5) is usually assessed through its mass concentration, other metrics, such as PM chemical speciation as well as the so far little considered oxidative potential (OP) of PM, are worth considering, both in terms of associations with human health and in the context of monitoring of the efficiency of LEZ. QAMECS covers all dimensions from atmospheric emissions, impact of meteorological conditions on air pollution human behaviours related to transportation, environmental levels, health, associated economic costs and societal awareness. The project relies on environmental measurements, modelling, repeated observational (representative) population studies, an existing mother-child cohort, a controlled human experiment, health impact and related economic assessment. It is conducted by a consortium of specialists of chemistry and physics of air pollution, economics, sociology, epidemiology, geography, in relation with local authorities. It will bring results important for urban planning, public health, and more fundamental research on the measurement of PM and assessment of their biological and health impact.

8.2. National Initiatives

8.2.1. AF Filières : Analyse des Flux des Filières biomasse pour des stratégies régionales de bioéconomie

Project funded by ADEME
Duration: 2017-2019
Coordinator: Jean-Yves COURTONNE (Equipe STEEP, Inria) [Emmanuel Prados (STEEP/Inria) for Inria partner]
Other partners: Equipe STEEP, Inria, Grenoble Rhônalpénergie-Environnement (RAEE), Lyon Laboratoire d'Economie Forestière (LEF), INRA / AgroParisTech Nancy.
Keywords: Environmental assessment, Ecological accounting, Material Flow Analysis, Sustainable supply chains, Multicriteria analysis.
Abstract: Flow analyses of biomass supply chains for regional bioeconomy policies. The goals of the project are the following:

- Improve knowledge on the material flows of the forest-wood and agri-food supply chains in France at national and regional levels,
- Provide a holistic vision of the situation by associating environmental and socio-economic indicators to material flows,
- Provide a more precise assessments (quantitatively and qualitatively) in the case of the Auvergne-Rhône-Alpes region.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

University of Lausanne (UNIL), Department of Ecology and Evolution (Jérôme Gippet): development of the MoRIS model of propagation of invasive species.

8.3.2. Participation in Other International Programs

Pierre-Yves Longaretti is involved in TARA (Transition adaptation research alliance); he animated the theme *Operationalizing reflexive sustainability* at the TARA Workshop in Bogor, Indonesia, November 2019.

TONUS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

The thesis of Pierre Gerhard devoted to numerical simulation of room acoustics is supported by the Alsace-region. It is a joint project with CEREMA (Centre d'études et d'expertise sur les risques, l'environnement, lamobilité et l'aménagement) in Strasbourg.

9.2. National Initiatives

9.2.1. National projects

PEPS "initiative Jeunes" CNRS. E. Franck with A. Crestetto (leader), M. Badsi, "Asymptotic scheme for multiscale problems in Plasma".

PEPS "initiative Jeunes" CNRS. C. Courtès with R. Côte (IRMA), P. A. Hervieux (IPCMS), R. Ignat (IMT), G. Manfredi (IPCMS), "Study of the influence of the temperature and the external magnetic field on the magnetization reversal".

9.2.2. HPC resources

Big Challenge GENCI: Simulation of electromagnetic interaction between connected objects and the human body. We solve the 3D Maxwell equations to compute the antena emission Bluetooth Low Energy (BLE) close to the body. The main goal is to scale the computation on the new supercomputer Jean Zay to treat a realistic test case.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Eurofusion project MAGYK, *Mathematics and Algorithms for GYrokinetic and Kinetic models* (2019-2021), led by E. Sonnendrucker.
Participants: L. Navoret

Eurofusion project *Strengthening the non-linear MHD code JOREK for application to key questions of the fusion roadmap* (2019-2021), led by M. Hoelzl.
Participants: E. Franck

XPOP Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

Mixed-Effects Models of Intracellular Processes: Methods, Tools and Applications (MEMIP)

Coordinator: Gregory Batt (InBio Inria team)

Other partners: InBio and IBIS Inria teams, Laboratoire Matière et Systèmes Complexes (UMR 7057; CNRS and Paris Diderot Univ.)

9.1.2. Institut National du Cancer (INCa)

Targeting Rac-dependent actin polymerization in cutaneous melanoma - Institut National du Cancer

Coordinator: Alexis Gautreau (Ecole Polytechnique)

Other partners: Laboratoire de Biochimie (Polytechnique), Institut Curie, INSERM.

9.2. International Initiatives

9.2.1. International Initiatives

SaSMoTiDep

Title: Statistical and Stochastic modeling for time-dependent data

International Partners (Institution - Laboratory - Researcher):

Universidad de Valparaiso (Chile) - Centro de Investigación y Modelamiento de Fenómenos Aleatorios Valparaíso (CIMFAV) - Cristian Meza Becerra

Universidad Nacional de Colombia (Colombia) - Department of Statistics - Viswanathan Arunachalam

Duration: 01/01/2018 - 31/12/2019

Start year: 2018

See also: https://sasmotidep.uv.cl

In many applications, multiple measurements are made on one or several experimental units over a period of time. Such data could be called time-dependent data. From a statistical point of view, if we consider only one experimental unit, we can use a time series analysis. In the other hand, if we consider experimental designs (or observational studies) for several experimental units (or subjects) where each subject is measured at several points in time, we can use the term longitudinal data. In this project, we propose to study several statistical and stochastic models for repeated measures using parametric and non-parametric approaches. In particular, we will study the inference in complex mixed effects models, we will propose novel segmentation models for multiple series, non-parametric methods in dependent models and stochastic models. We will apply these methods to real data from several fields as biometrics, reliability, population dynamics and finance.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

Ricardo Rios, Universidad Central de Venezuela, Caracas: September 2019.

Cristian Meza, Universidad de Valparaiso, Chile, September 2019.

AGORA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- FIL Grant, 2019
  Participants: Razvan Stanica
  The partners of this project, supported by the *Fédération d'Informatique de Lyon*, are: CITI, LIP.
  WLANs (Wireless Local Area Networks) are typically based on IEEE 802.11 (known as WiFi). However, WLANs are prone to performance issues such as unfairness and inefficiencies. 802.11 includes a Rate Adaptation (RA) mechanism that allows user devices to change their transmission rate with regard to the current quality of the radio channel. The RA mechanism is based on preset values that may lead to suboptimal WLAN performance. Our goal is to address this issue by making fine adjustments to the parameters related to the RA mechanism. The search for an adequate setting is made complex due to the vast number of parameters to be considered that precludes the finding of general closed-form expressions. We propose to explore a data-driven approach based on techniques from Machine Learning to design an adaptive and distributed solution.
- Labex IMU 3M'Air 2018-2021
  Participants: Walid Beckhit, Ahmed Boubrima, Manoel Dahan, Mohamed Anis Fekih, Ichrak Mokhtari, Hervé Rivano.
  The partners in this project are: EVS, LMFA, Métropole de Lyon, Ville de Lyon , Atmo AURA, Météo France, Lyon Météo. Inria Agora is the leader of this project.
  The 3M'Air project explores the potential of participatory sensing to improve local knowledge of air quality and urban heat islands. The main aim of this project is therefore to equip citizens with low-cost mobile sensors and then ensure an efficient real-time data collection and analysis. This allows to obtain a finer spatiotemporal granularity of measurements with lighter installation and operational costs while involving citizens.
- ARC6 Robot fleet mobility under communication constraints, 2016-2019.
  Participant : Fabrice Valois.
  This work is a joint project with the Inria Chroma research group. Considering a fleet of drones moving in a 3D area, looking for a given target, we focus on how to maintain the wireless connectivity of the network of drones while the drones patrol autonomously. The other partners in this project are University of Grenoble and Viameca.
- Labex IMU Veleval, 2017-2019
  Participant: Hervé Rivano.
  The partners in this project are: EVS, LIRIS, LLSETI and CITI, with LAET leading the project.
  The goal of this pluridisciplinary project is to study, understand and model the behavior of cyclists in an urban environment with a methodology combining quantitative measurements of mobility traces and image analysis with qualitative information from reactivation interviews. In particular the input of Agora is to provide crowdsourcing tools for gathering mobility data that are optimized for the practice of urban cycling.

9.2. National Initiatives

9.2.1. ANR

- ANR CANCAN 2019 - 2022
  Participants: Solohaja Rabenjamina, Razvan Stanica.
  The partners in this project are: CEDRIC, Inria, Orange Labs, with Thalès Communications & Security leading the project.
  The ANR CANCAN (Content and context based adaptation in mobile networks) targets the following objectives: *i)* collecting novel measurement datasets that describe mobile network data traffic at unprecedented spatial and temporal accuracy levels, and for different mobile services separately. The datasets will be gathered in an operational nationwide network, *ii)* evaluating existing analytics for classification, prediction and anomaly detection within real-world high-detail per-service mobile network data, and tailoring them to the specifications of the management of resources at different network levels, and *iii)* demonstrating the integration of data analytics within next-generation cognitive network architectures in several practical case studies.
- ANR MAESTRO 5G 2019 - 2022
  Participants: Hervé Rivano, Razvan Stanica.
  The partners in this project are: CEDRIC, Inria, L2S, LIA, Nokia Bell Labs, TSP, with Orange Labs leading the project.
  The ANR MAESTRO 5G (Management of slices int he radio access of 5G networks) is expected to provide: *i)* a resource allocation framework for slices, integrating heterogeneous QoS requirements and spanning on multiple resources including radio, backhauling/fronthauling and processing resources in the RAN, *ii)* a complete slice management architecture including provisioning and re-optimization modules and their integration with NFV and SDN strata, *iii)* a business layer for slicing in 5G, *iv)* a demonstrator showing the practical feasibility as well as integration of the major functions and mechanisms proposed by the project, on a 5G Cloud RAN platform. The enhanced platform is expected to support the different 5G services.
- ANR CoWorkWorlds 2018 - 2020.
  Participants: Solohaja Rabenjamina, Razvan Stanica.
  The ANR CoWorkWorlds (Sustainability and spatiality in co-workers' mobility practices) project is led by ENTPE. Its focus is on the study of co-working environments, and more precisely on the mobility behavior of users of such spaces. Our role in the project is to collect and analyse mobility data from a set of users, using the PrivaMov smartphone application.

9.2.2. GDR CNRS RSD - Pôle ResCom

- Ongoing participation (since 2006)
  Communication networks, working groups of GDR ASR/RSD, CNRS (https://gdr-rsd.cnrs.fr/pole_rescom). Hervé Rivano is member of the scientific committee of ResCom.

9.2.3. EquipEx

- SenseCity
  We have coordinated the participation of several Inria teams to the SenseCity EquipEx. Within the SenseCity project, several small reproductions of 1/3rd scale city surroundings will be built under a climatically controlled environment. Micro and nano sensors will be deployed to experiment on smart cities scenarios, with a particular focus on pollution detection and intelligent transport services. Agora will have the opportunity to test some of its capillary networking solutions in a very realistic but controlled urban environment. A proof of concept test site has been built in 2015. We have deployed an experiment on low cost sensor network for vehicle detection and one on atmospheric pollution sensor calibration. The operational site is built, the information system is operational since April 2018.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

- Herve Rivano is member of European COST action CA18204 - Dynamics of placemaking and digitization in Europe´s cities on behalf of Ecole Urbaine de Lyon and Labex IMU.

  Program: Interreg Med

  - Project acronym: ESMARTCITY
  - Project title: Enabling Smarter City in the MED Area through Networking
  - Duration: 02/2018 - 07/2020
  - Coordinator: Abruzzo Region, Italy
  - Other partners: ARIC and RWG (Greece), APEGR (Spain), RAIS (Bosnia and Herzegovina), ENA (Portugal), MCM and PoliMi (Italy), Capergies (France)
  - Abstract: The project has its primary objective in improving the innovation capacity of MED cities by creating innovation ecosystems, which involve actors of the quadruple helix (Citizens, Businesses Operators, Research, Universities and Public Authorities), and in applying the Smart City concept, which utilizes digital and energy saving technologies to allow better services for the citizen with less impact on the environment, producing furthermore new employability and living scenarios. To achieve this goal, the project envisages the pilot testing of the Smart City concept to provide specific services to citizens in the field of intelligent urban districts, energy efficiency of buildings and smarter public lighting.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- **University of Waterloo, ON, Canada**. Joint publications and visits to/from the group of Prof. Catherine Rosenberg.
- **Digital Catapul, London, UK**. Collaboration around LoRa experiments with Dr. Ramona Marfievici.
- **CNR-IEIIT, Turin, Italy**. Joint publications and projects with Dr. Marco Fiore.
- **Trento University, Italy**. Collaboration around routing for IoT networks with the group of Prof. Gian Pietro Picco.
- **Rice University**. Collaboration around network deployment and data assimilation for air quality monitoring with the group of Prof. Edward W. Knightly.
- **University of Edinburgh, UK**. Joint publications and visits to/from the group of Dr. Paul Patras.
- **Biskra University, Algeria**. Joint publications and visits from Prof. Abdelmalik Bachir.

9.4.2. Participation in Other International Programs

9.4.2.1. PHC Campus France

- **University College Cork, Ireland**. PHC Ulysses (2019-2021) on real-world characterisation of long range wireless newtorks, a collaboration with Khaled Abdelfadeel.
- **INPT Rabat, Morocco**. PHC Toubkal (2019-2021) on efficient data collection for smart building and smart city applications, a collaboration with the group of Prof. Loubna Echabbi.
- **University of Cluj-Napoca, Romania**. PHC DRONEM (2017-2019) on monitoring using connected fleet of drones, a collaboration with the group of Prof. Gabriela Czibula.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Abdelmalik Bachir, Professor, Biskra University, Algeria: visiting professor at INSA Lyon (november, 2019).
- Ravi Mazumdar, Waterloo University, Canada, visiting scientist at INSA Lyon (february, 2019).
- Priscilla Solis, Professor, Brasilia University, Brazil, visiting the Agora team to prepare a sabbatical.

9.5.1.1. Internships

- Sami Abdelatif, PhD student, Biskra University, Algeria: visiting professor at INSA Lyon (november, 2019).

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Mihai Popescu visited the group of Prof. Gabriela Czibula, at University of Cluj-Napoca, Romania (2 periods of 1 month duration: April and July 2019).
- Fabrice Valois visited Prof. Catherine Rosenberg, University of Waterloo, Canada (6 weeks between January and March 2019).

ALPINES Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

GIS, Géosciences franciliennes: scientific collaboration network between ten public institutions from the Paris (Ile-de-France) region, focused on natural resources and environment. The project-team Alpines is a member.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. B3DCMB

ANR Decembre 2017 - Novembre 2021 This project is in the area of data analysis of cosmological data sets as collected by contemporary and forthcoming observatories. This is one of the most dynamic areas of modern cosmology. Our special target are data sets of Cosmic Microwave Background (CMB) anisotropies, measurements of which have been one of the most fruitful of cosmological probes. CMB photons are remnants of the very early evolution of the Universe and carry information about its physical state at the time when the Universe was much younger, hotter and denser, and simpler to model mathematically. The CMB has been, and continue to be, a unique source of information for modern cosmology and fundamental physics. The main objective of this project is to empower the CMB data analysis with novel high performance tools and algorithms superior to those available today and which are capable of overcoming the existing performance gap. Partners: AstroParticules et Cosmologie Paris 7 (PI R. Stompor), ENSAE Paris Saclay.

9.2.1.2. ANR Cine-Para

October 2015 - September 2019, Laura Grigori is Principal Coordinator for Inria Paris. Funding for Inria Paris is 145 Keuros. The funding for Inria is to combine Krylov subspace methods with parallel in time methods. Partners: University Pierre and Marie Curie, J. L. Lions Laboratory (PI Y. Maday), CEA, Paris Dauphine University, Paris 13 University.

9.2.1.3. Non-local DD

ANR appel à projet générique October 2015 - September 2020

This project in scientific computing aims at developing new domain decomposition methods for massively parallel simulation of electromagnetic waves in harmonic regime. The specificity of the approach that we propose lies in the use of integral operators not only for solutions local to each subdomain, but for coupling subdomains as well. The novelty of this project consists, on the one hand, in exploiting multi-trace formalism for domain decomposition and, on the other hand, considering optimized Schwarz methods relying on Robin type transmission conditions involving quasi-local integral operators.

9.2.1.4. Soilμ-3D

ANR appel à projet générique October 2015 - april 2019

In spite of decades of work on the modeling of greenhouse gas emission such as CO2 and N2O and on the feedback effects of temperature and water content on soil carbon and nitrogen transformations, there is no agreement on how these processes should be described, and models are widely conflicting in their predictions. Models need improvements to obtain more accurate and robust predictions, especially in the context of climate change, which will affect soil moisture regime.

The goal of this new project is now to go further using the models developed in MEPSOM to upscale heterogeneities identified at the scale of microbial habitats and to produce macroscopic factors for biogeochemical models running at the field scale.

To achieve this aim, it will be necessary to work at different scales: the micro-scale of pores (μm) where the microbial habitats are localized, the meso-scale of cores at which laboratory measurements on CO2 and N2O fluxes can be performed, and the macro-scale of the soil profile at which outputs are expected to predict greenhouse gas emission. The aims of the project are to (i) develop new descriptors of the micro-scale 3D soil architecture that explain the fluxes measured at the macro-scale, (ii) Improve the performance of our 3D pore scale models to simulate both micro-and meso- scales at the same time. Upscaling methods like "homogeneization" would help to simulate centimeter samples which cannot be achieved now. The reduction of the computational time used to solve the diffusion equations and increase the number of computational units, (iii) develop new macro-functions describing the soil micro-heterogeneity and integrate these features into the field scale models.

9.2.1.5. Muffin

ANR appel à projet générique 2019.

S. Hirstoaga and P.-H. Tournier are members of the project MUFFIN, whose objective is to explore and optimize original computational scenarios for multi-scale and high dimensional transport codes, with priority applications in plasma physics. Several approximation methods are planed to be developed. It is at the frontier of computing and numerical analysis and intends to reduce the computational burden in the context of intensive calculation. Principal Investigator: B. Després (Sorbonne University).

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. NLAFET (197)

Title: Parallel Numerical Linear Algebra for Future Extreme-Scale Systems

Programm: H2020

Duration: November 2015 - April 2019

Coordinator: UMEÅ Universitet

Partners:

Science and Technology Facilities Council (United Kingdom)

Computer Science Department, UmeåUniversitet (Sweden)

Mathematics Department, The University of Manchester (United Kingdom)

Inria, Alpines group

Inria contact: Laura Grigori

The NLAFET proposal is a direct response to the demands for new mathematical and algorithmic approaches for applications on extreme scale systems, as identified in the FETHPC work programme and call. This project will enable a radical improvement in the performance and scalability of a wide range of real-world applications relying on linear algebra software, by developing novel architecture-aware algorithms and software libraries, and the supporting runtime capabilities to achieve scalable performance and resilience on heterogeneous architectures. The focus is on a critical set of fundamental linear algebra operations including direct and iterative solvers for dense and sparse linear systems of equations and eigenvalue problems. Achieving this requires a co-design effort due to the characteristics and overwhelming complexity and immense scale of such systems. Recognized experts in algorithm design and theory, parallelism, and auto-tuning will work together to explore and negotiate the necessary tradeoffs. The main research objectives are: (i) development of novel algorithms that expose as much parallelism as possible, exploit heterogeneity, avoid communication bottlenecks, respond to escalating fault rates, and help meet emerging power constraints; (ii) exploration of advanced scheduling strategies and runtime systems focusing on the extreme scale and strong scalability in multi/many-core and hybrid environments; (iii) design and evaluation of novel strategies and software support for both offline and online auto-tuning. The validation and dissemination of results will be done by integrating new software solutions into challenging scientific applications in materials science, power systems, study of energy solutions, and data analysis in astrophysics. The deliverables also include a sustainable set of methods and tools for cross-cutting issues such as scheduling, auto-tuning, and algorithm-based fault tolerance packaged into open-source library modules.

9.3.1.2. ERC Synergy grant EMC2

Title: Extreme-scale Mathematically-based Computational Chemistry (EMC2)

Programm: ERC

Duration: September 2019 - August 2025

PIs: E. Cances (ENPC), L. Grigori (Inria), Y. Maday (Sorbonne University), J. P. Piquemal (Sorbonne University)

Molecular simulation is one of the most dynamic areas of scientific computing. Its field of application is very broad, ranging from theoretical chemistry and drug design to materials science and nanotechnology. Its importance in modern science has been acknowledged by two Nobel Prizes (Kohn & Pople in 1998; Karplus, Levitt & Warshel in 2013). It is also a gold mine of exciting problems for mathematicians and computer scientists.

Molecular simulation can be used as a virtual microscope to study more or less complex molecules with atomic-scale space-time resolution. It can also be used as a tool for computer-aided design (CAD) and the engineering of new molecules, materials and nano-devices.

However, molecular simulation still has important limitations. In particular, the simulation of very large molecular systems, or smaller systems in which electrons interact strongly with each other, remains out of reach today. Overcoming these limitations is extremely difficult. This requires joint breakthroughs in several disciplines, and can, in our opinion, only be achieved through an intensive multidisciplinary effort such as those made possible by ERC-Synergy-type funding.

Our objective is to overcome some of the current limitations in this field and to provide academic communities and industrial companies with new generation, dramatically faster and quantitatively reliable molecular simulation software, to enable those communities to address major technological and societal challenges of the 21st century (in health, energy, and the environment, for example).

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- J. Demmel, UC Berkeley, USA
- M. Grote, Université de Bâle, Suisse
- F. Assous, Israel
- K.-M. Perfekt, Reading, UK
- T. Chacon, Seville, Spain

9.5. International Research Visitors

9.5.1. Visits to International Teams

9.5.1.1. Research Stays Abroad

- Visit of Laura Grigori to the group of J. Demmel at U.C. Berkeley, july-august 2019.

AVALON Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. CPER

Participants: Thierry Gautier, Laurent Lefèvre, Christian Perez.

The LECO experimental platform is a new medium size scientific instrument deployed in Grenoble in 2018 and in Lyon in 2019. It was funded by the CPER 2015-2020 LECO++ to investigate research related to BigData and HPC.

8.1.2. Action Exploratoire Inria: EXODE

Participant: Thierry Gautier.

In biology, the vast majority of systems can be modeled as ordinary differential equations (ODEs). Modeling more finely biological objects leads to increase the number of equations. Simulating ever larger systems also leads to increasing the number of equations. Therefore, we observe a large increase in the size of the ODE systems to be solved. A major lock is the limitation of ODE numerical resolution software (ODE solver) to a few thousand equations due to prohibitive calculation time. The AEx ExODE tackles this lock via 1) the introduction of new numerical methods that will take advantage of the mixed precision that mixes several floating number precisions within numerical methods, 2) the adaptation of these new methods for next generation highly hierarchical and heterogeneous computers composed of a large number of CPUs and GPUs. For the past year, a new approach to Deep Learning has been proposed to replace the Recurrent Neural Network (RNN) with ODE systems. The numerical and parallel methods of ExODE will be evaluated and adapted in this framework in order to improve the performance and accuracy of these new approaches.

8.2. National Initiatives

8.2.1. Inria Large Scale Initiative

8.2.1.1. DISCOVERY, DIStributed and COoperative management of Virtual EnviRonments autonomouslY, 4 years, 2015-2019

Participants: Maverick Chardet, Jad Darrous, Christian Perez.

To accommodate the ever-increasing demand for Utility Computing (UC) resources, while taking into account both energy and economical issues, the current trend consists in building larger and larger Data Centers in a few strategic locations. Although such an approach enables UC providers to cope with the actual demand while continuing to operate UC resources through centralized software system, it is far from delivering sustainable and efficient UC infrastructures for future needs.

The DISCOVERY initiative aims at exploring a new way of operating Utility Computing (UC) resources by leveraging any facilities available through the Internet in order to deliver widely distributed platforms that can better match the geographical dispersal of users as well as the ever increasing demand. Critical to the emergence of such locality-based UC (LUC) platforms is the availability of appropriate operating mechanisms. The main objective of DISCOVERY is to design, implement, demonstrate and promote the LUC Operating System (OS), a unified system in charge of turning a complex, extremely large-scale and widely distributed infrastructure into a collection of abstracted computing resources which is efficient, reliable, secure and at the same time friendly to operate and use.

To achieve this, the consortium is composed of experts in research areas such as large-scale infrastructure management systems, network and P2P algorithms. Moreover two key network operators, namely Orange and RENATER, are involved in the project.

By deploying and using such a LUC Operating System on backbones, our ultimate vision is to make possible to host/operate a large part of the Internet by its internal structure itself: A scalable set of resources delivered by any computing facilities forming the Internet, starting from the larger hubs operated by ISPs, government and academic institutions, to any idle resources that may be provided by end-users.

8.2.1.2. HAC SPECIS, High-performance Application and Computers, Studying PErformance and Correctness In Simulation, 4 years, 2016-2020

Participants: Dorra Boughzala, Idriss Daoudi, Thierry Gautier, Laurent Lefèvre, Frédéric Suter.

Over the last decades, both hardware and software of modern computers have become increasingly complex. Multi-core architectures comprising several accelerators (GPUs or the Intel Xeon Phi) and interconnected by high-speed networks have become mainstream in HPC. Obtaining the maximum performance of such heterogeneous machines requires to break the traditional uniform programming paradigm. To scale, application developers have to make their code as adaptive as possible and to release synchronizations as much as possible. They also have to resort to sophisticated and dynamic data management, load balancing, and scheduling strategies. This evolution has several consequences:

First, this increasing complexity and the release of synchronizations are even more error-prone than before. The resulting bugs may almost never occur at small scale but systematically occur at large scale and in a non deterministic way, which makes them particularly difficult to identify and eliminate.

Second, the dozen of software stacks and their interactions have become so complex that predicting the performance (in terms of time, resource usage, and energy) of the system as a whole is extremely difficult. Understanding and configuring such systems therefore becomes a key challenge.

These two challenges related to correctness and performance can be answered by gathering the skills from experts of formal verification, performance evaluation and high performance computing. The goal of the HAC SPECIS Inria Project Laboratory is to answer the methodological needs raised by the recent evolution of HPC architectures by allowing application and runtime developers to study such systems both from the correctness and performance point of view.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. Energy oriented Centre of Excellence for computing applications (EoCoE-II)

Participants: Thierry Gautier, Christian Perez.

Program: H2020 RIA european project, call H2020-INFRAEDI-2018-1

Project acronym: EoCoE-II

Project title: Energy oriented Centre of Excellence for computing applications

Duration: 2018-2021

Coordinator: CEA

Other partners: CEA, FZJ, ENEA, BSC, CNRS, Inria, CERFACS, MPG, FRAUNHOFER, FAU, CNR, UNITN, PSNC, ULB, UBAH, CIEMAT, IFPEN, DDN, RWTH, UNITOV

Abstract: Europe is undergoing a major transition in its energy generation and supply infrastructure. The urgent need to halt carbon dioxide emissions and prevent dangerous global temperature rises has received renewed impetus following the unprecedented international commitment to enforcing the 2016 Paris Agreement on climate change. Rapid adoption of solar and wind power generation by several EU countries has demonstrated that renewable energy can competitively supply significant fractions of local energy needs in favourable conditions. These and other factors have combined to create a set of irresistible environmental, economic and health incentives to phase out power generation by fossil fuels in favour of decarbonized, distributed energy sources. While the potential of renewables can no longer be questioned, ensuring reliability in the absence of constant conventionally powered baseload capacity is still a major challenge.

The EoCoE-II project will build on its unique, established role at the crossroads of HPC and renewable energy to accelerate the adoption of production, storage and distribution of clean electricity. How will we achieve this? In its proof-of-principle phase, the EoCoE consortium developed a comprehensive, structured support pathway for enhancing the HPC capability of energy-oriented numerical models, from simple entry-level parallelism to fully-fledged exascale readiness. At the top end of this scale, promising applications from each energy domain have been selected to form the basis of 5 new Energy Science Challenges in the present successor project EoCoE-II that will be supported by 4 Technical Challenges

8.3.1.2. PRACE 6th Implementation Phase Project (PRACE6-IP)

Participants: Marcos Dias de Assunção, Laurent Lefèvre, Christian Perez.

Program: H2020 RIA european project, call H2020-INFRAEDI-2018-1

Project acronym: PRACE-6IP

Project title: PRACE 6th Implementation Phase Project

Duration: May 2019-Dec 2021

Coordinator: FZJ

Other partners: HLRS, LRZ, GENCI, CEA, CINES, CNRS, IDRIS, Inria, EPCC, BSC, CESGA, CSC, ETH-CSCS, SURFsara, KTH-SNIC, CINECA, PSNC, CYFRONET, WCNS, UiOsingma2, GRNET, UC-LCA, Univ MINHO, ICHEC, UHEM, CASTORCm NCSA, IT4I-VSB, KIFU, UL, CCSAS, CENAERO, Univ Lux, GEANT

Abstract: PRACE, the Partnership for Advanced Computing is the permanent pan-European High Performance Computing service providing world-class systems for world-class science. Systems at the highest performance level (Tier-0) are deployed by Germany, France, Italy, Spain and Switzerland, providing researchers with more than 17 billion core hours of compute time. HPC experts from 25 member states enabled users from academia and industry to ascertain leadership and remain competitive in the Global Race. Currently PRACE is finalizing the transition to PRACE 2, the successor of the initial five year period. The objectives of PRACE-6IP are to build on and seamlessly continue the successes of PRACE and start new innovative and collaborative activities proposed by the consortium. These include: assisting the development of PRACE 2; strengthening the internationally recognised PRACE brand; continuing and extend advanced training which so far provided more than 36 400 person·training days; preparing strategies and best practices towards Exascale computing, work on forward-looking SW solutions; coordinating and enhancing the operation of the multi-tier HPC systems and services; and supporting users to exploit massively parallel systems and novel architectures. A high level Service Catalogue is provided. The proven project structure will be used to achieve each of the objectives in 7 dedicated work packages. The activities are designed to increase Europe's research and innovation potential especially through: seamless and efficient Tier-0 services and a pan-European HPC ecosystem including national capabilities; promoting take-up by industry and new communities and special offers to SMEs; assistance to PRACE 2 development; proposing strategies for deployment of leadership systems; collaborating with the ETP4HPC, CoEs and other European and international organisations on future architectures, training, application support and policies. This will be monitored through a set of KPIs.

8.4. International Initiatives

8.4.1. Inria International Labs

8.4.1.1. Joint Laboratory for Extreme Scale Computing (JLESC) (2014-2023)

Participants: Thierry Gautier, Christian Perez.

Partners: NCSA (US), ANL (US), Inria (FR), Jülich Supercomputing Centre (DE), BSC (SP), Riken (JP).

The purpose of the Joint Laboratory for Extreme Scale Computing (JLESC) is to be an international, virtual organization whose goal is to enhance the ability of member organizations and investigators to make the bridge between Petascale and Extreme computing. The founding partners of the JLESC are Inria and UIUC. Further members are ANL, BSC, JSC and RIKEN-AICS.

JLESC involves computer scientists, engineers and scientists from other disciplines as well as from industry, to ensure that the research facilitated by the Laboratory addresses science and engineering's most critical needs and takes advantage of the continuing evolution of computing technologies.

Inria@EastCoast

Associate Team involved in the International Lab:

8.4.1.2. SUSTAM

Title: Sustainable Ultra Scale compuTing, dAta and energy Management

International Partner (Institution - Laboratory - Researcher):

Start year: 2017

See also: http://avalon.ens-lyon.fr/sustam

The SUSTAM associate team will focus on the joint design of a multi-criteria orchestration framework dealing with resources, data and energy management in an sustainable way. The SUSTAM associated team will enable a long-term collaboration between the Inria Avalon team and the Rutgers Discovery Informatics Institute (RDI2) from Rutgers University (USA).

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Carlos Henrique Cardonha, IBM Research Brazil, from Jun 2019 until Jul 2019.

Jean-Philippe Aboumou, SAHAM Life Insurance, from Oct 2019.

8.5.1.1. Internships

Ibrahim Jouwad, M2, *Optimisation de la migration d'un ensemble de machines virtuelles dans un datacentre à l'aide d'un graphe d'états*

Laurent Turpin, M2, *Formalisation de paramètres, evaluation de performance et auto-configuration d'une application HPC en mémoire partagée : application au simulateur Aevol*

Josee Alvine Kouamen, M2, *Prise en main d'une infrastructure cloud et Big data pour l'analyse des fraudes a la simbox*

Zakaria Fraoui, *Distributed Stream Processing in the Edge: The Internet of Things Usecase*

Mohamed Hamnache, PFE, *Optimisation d'un environnement de calculs distribués pour la bio-informatique*

Alice Andres, M1, *Cloud vs Edge: fighting for energy !*

Adrien Berthelot, M1, *Revisiting low tech IT protocols*

Pierre Jacquot, L3, *Analysis of DDFacet/KillMS pipeline*

Marouane Azzouz, IUT, *Mode clients/serveur pour le projet CartomENSia*

COAST Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Region Grand Est TV Paint (2017–2019)

Participants: Claudia-Lavinia Ignat [contact], Gérald Oster, Cédric Enclos.

Partners: TVPaint Development, Inria

Website: https://www.tvpaint.com/

This is a project in collaboration with TVPaint Development financed by Region Grand Est. It is a follow-up of a project in collaboration with TVPaint Development financed by Region Lorraine from 2016 to 2017.

The goal is to contribute to the creation of a collaborative system dedicated to manage the production of animated movies. This system has to manipulate a large amount of data in a safe and secure manner. Based on the previously proposed architecture and prototype, this project intends to design and implement a commercial product. In the framework of this project, we bring our expertise in data management, business process management, distributed systems and collaborative systems.

9.2. National Initiatives

9.2.1. OpenPaas NG (2015–2019)

Participants: Claudia-Lavinia Ignat, François Charoy [contact], Gérald Oster, Olivier Perrin, Jean-Philippe Eisenbarth, Matthieu Nicolas, Mohammed Riyadh Abdmeziem, Victorien Elvinger, Quentin Laporte Chabasse, Hoai-Le Nguyen, Hoang Long Nguyen.

Partners: Linagora, XWiki, Nexedi, Université de Lorraine, LIX.

Website: http://www.open-paas.org/

This project is funded by BpiFrance and involves French industrial leaders in open-source software development (Linagora, Nexedi, XWiki) and academic partners in collaborative work (Coast team) and recommender systems (DaScim team, LIX). The goal of the project is to develop next generation of cloud enabled virtual desktop based on an Enterprise Social Network to provide advanced collaborative and recommendation services. Coast is responsible for the work package dedicated to the design of the peer-to-peer collaborative middleware. In this context, we bring our expertise on data replication for collaborative data in peer-to-peer environments and on trust and access control and identity management in distributed collaborative information systems.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

Weihai Yu, The Arctic University of Norway, did his sabbatical year in the period September 1, 2018 - August 31, 2019 in the Coast team. He worked on the formalisation of undo with CRDTs.

9.3.2. Research Stays Abroad

François Charoy was invited by Heiko Ludwig to spend 3 month (March-May 2019) at IBM Almaden Research Center in San Jose,CA. He worked on P2P Federated Learning. A replication protocol has been designed that is under evaluation thanks to a shared internship. It also led to an ANR submission on the topic with a french company.

François Charoy was invited by Akhil Kumar to spend 6 weeks at Penn State University to collaborate to on a long transaction protocol implementation on a permissioned blockchain. This work is based on previous work done in the Coast project-team. It is also ongoing and has led to the submission of a project to a proposal submission with a local startup.

COATI Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. SNIF, 2018-2021

Participants: David Coudert, Frédéric Giroire, Nicolas Nisse, Stéphane Pérennes.

Program: Innovation project of IDEX UCA$^{\text{JEDI}}$.

Project acronym: SNIF

Project title: Scientific Networks and IDEX Funding

Duration: September 2018 - August 2021

Coordinator: Patrick Musso

Other partners: GREDEG, SKEMA, I3S (SigNet) and Inria (COATI), all from UCA.

Abstract: Scientific collaboration networks play a crucial role in modern science. This simple idea underlies a variety of initiatives aiming to promote scientific collaborations between different research teams, universities, countries and disciplines. The recent French IDEX experience is one of them. By fostering competition between universities and granting few of them with a relatively small amount of additional resources (as compare to their global budget), public authorities aim to encourage them to deeply reshape the way academic activities are organized in order to significantly increase the quality of their research, educational programs and innovative activities. The development of new collaboration networks is one of the factors at the heart of this global reorganization. Promoting new international and/or interdisciplinary collaborations is supposed to increase researchers' productivity and industry partnerships. This project aims to question the validity of this line of thought.

9.2. National Initiatives

9.2.1. DGA/Inria Brainside, 2019-2023

Participants: Francesco d'Amore, Emanuele Natale.

Program: DGA/Inria

Project acronym: Brainside

Project title: Algorithms for simplifying neural networks

Duration: October 2019 - March 2023

Coordinator: Emanuele Natale

Other partners: Inria Paris, EP GANG

Abstract: The widespread use of neural networks on devices with computationally-low capabilities, demands for lightweight and energy-efficient networks. Despite such need, and despite the strategies employed to prevent overfitting by removing a substantial part of their edges, the question of how to reduce their size in terms of the number of neurons appears largely unexplored. The aim of the project is to investigate algorithmic procedures to reduce the size of neural networks, in order to improve the speed with which they can be evaluated and to shed light on how much information about the computational problem at hand can be encoded within neural networks of small size.

9.2.2. ANR-17-CE22-0016 MultiMod, 2018-2022

Participants: Mohammed Amine Ait Ouahmed, Ali Al Zoobi, David Coudert, Nicolas Nisse, Michel Syska.

Program: ANR

Project acronym: MultiMod

Project title: Scalable routing in Multi Modal transportation networks

Duration: January 2018 - December 2022

Coordinator: David Coudert

Other partners: Inria Paris, EP GANG; team CeP, I3S laboratory; SME Instant-System; SME Benomad

Abstract: The MultiMod project addresses key algorithmic challenges to enable the fast computation of personalized itineraries in large-scale multi-modal public transportation (PT) networks (bus, tram, metro, bicycle, etc.) combined with dynamic car-pooling. We will use real-time data to propose itineraries with close to real travel-time, and handle user-constraints to propose personalized itineraries. Our main challenge is to overcome the scalability of existing solutions in terms of query processing time and data-structures space requirements, while including unplanned transportation means (car-pooling), real-time data, and personalized user constraints. The combination of car-pooling and PT network will open-up areas with low PT coverage enable faster itineraries and so foster the adoption of car-pooling. We envision that the outcome of this project will dramatically enhanced the mobility and daily life of citizens in urban areas.

Web: https://project.inria.fr/multimod/

9.2.3. PICS DISCO

Program: PICS

Project acronym: DISCO

Project title: DIsjoint Structures and Coverings in Oriented graphs

Duration: January 2018 -December 2020.

Coordinator: Stéphane Bessy (LIRMM)

Other partners: CNRS LIRMM (Montpellier), Syddansk universitet (Odense, Danemark)

Abstract: Directed graphs (digraphs) are much less understood than undirected graphs. Many, seemingly very simple questions remain unsolved for digraphs while the analogous problem for undirected graphs is trivial. At the same time digraphs are a very important modelling tool for practical applications and so a better undestanding of their structure is important. The purpose of DISCO is to advance knowledge on fundamental problems on digraphs, including splitting a digraph into smaller pieces with given properties, problems regarding disjoint paths and trees, finding small certificates for given properties, such as strong spanning subdigraphs with few arcs. The later is important for speeding up certain algorithms.

Through a concerted effort we expect to obtain important results which will lead to a better undestanding of fundamental questions about the structure of digraphs. The participants will meet regularly both in France and in Denmark to work on carefully selected problems.

9.2.4. GDR Actions

9.2.4.1. GDR RSD, ongoing (since 2006)

Members of COATI are involved in the working group RESCOM (*Réseaux de communications*) of GDR RSD, CNRS (http://gdr-rsd.cnrs.fr/pole_rescom). In particular, David Coudert is co-chair of this working group since 2017.

We are also involved in the working group "Energy" of GDR RSD (http://gdr-rsd.cnrs.fr/action_green). In particular, Frédéric Giroire is co-hair of this working group.

9.2.4.2. GDR IM, ongoing (since 2006)

Members of COATI are involved in the working group "Graphes" of GDR IM, CNRS. (http://gtgraphes.labri.fr/). In particular, Frédéric Havet is member of the steering committee.

9.2.4.3. GDR MADICS, ongoing (since 2017)

Members of COATI are involved in the working group GRAMINEES (GRaph data Mining in Natural, Ecological and Environnemental Sciences) of GDR MADICS (Masses de Données, Informations et Connaissances en Sciences). (http://www.madics.fr/actions/actions-en-cours/graminees/).

9.3. International Initiatives

9.3.1. Inria Associate Teams Not Involved in an Inria International Labs

9.3.1.1. EfDyNet

Title: Efficient Dynamic Resource Allocation in Networks

International Partner (Institution - Laboratory - Researcher):

Concordia University (Canada) - Department of Electrical Engineering - Brigitte Jaumard

Start year: 2019

See also: https://team.inria.fr/coati/projects/efdynet/

Networks are evolving rapidly in two directions. On the one hand, new network technologies are developed for different layers, and in particular flexible optical technologies (enabling to allocate a fraction of the optical spectrum rather than a fixed wavelength), Software Defined Networks, and Network Function Virtualization. On the other hand, the traffic patterns evolve and become less predictable due to the increase of cloud and mobile traffic. In this context, there are new possibilities and needs for dynamic resource allocations. We will study this problem mainly in two directions: network reconfiguration and the allocation of virtualized resources. The associated team will build on an already fruitful collaboration between COATI and Concordia. The two teams address design and management optimization problems in networks (WDM, wireless, SDN) with complementary tools and expertise.

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

Apart from formal collaboration COATI members maintain strong connections with the following international teams, with regular visits of both sides.

Universidade Federal do Ceará (Fortaleza, Brazil), ParGO team;

Universidade Estadual do Ceará (Fortaleza, Brazil), Prof. Leonardo Sampaio;

Univ. of Southern Denmark (Odense, Denmark), Prof. Jørgen Bang-Jensen.

9.3.3. Participation in Other International Programs

9.3.3.1. International Initiatives

GALOP

Program: STICAmSud

Title: Graphs ALgorithms for Optimization Problems

International Partners (Institution - Laboratory - Researcher):

Universidad Diego Portales (Chile) - Facultad de Ingeniería y Ciencias - Karol Suchan

Universidade Federal do Ceará (Brazil) - ParGo team - Julio Araujo

Duration: 2019 - 2020

Start year: 2019

See also: https://team.inria.fr/coati/projects/sticamsud-galop/
This project aims at allowing to continue the fruitful and long-standing collaboration between Inria and UFC and between Inria and UAI. Another goal is to reinforce the collaboration between UFC and UAI that has been recently initiated. Our goal is to study the Computational Complexity of several important problems arising in networks (routing, resources assignment...). In particular, we will focus on the computation of metric or structural properties and parameters of large networks (e.g., transportation and social networks...). We plan to design efficient exact algorithms for solving these problems or to theoretically prove that such algorithms cannot exist. In the latter case, we will then design approximation algorithms, or prove that none exists. In all cases, we aim at implementing our algorithms and use them on real-world instances such as large road networks or huge social networks.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Hossein Baktash: Sharif Institute of Technology, Tehran, Iran. July 15 - September 15, 2019.
- Joergen Bang-Jensen: Southern Denmark University, Odense, Denmark, January 7-11 2019.
- Brigitte Jaumard: Concordia University, Montréal, Québec, Canada. June 17-28 and December 7-21, 2019.
- Malgorzata Sulkowska: Faculty of Fundamental Problems of Technology, Wroclaw University of Science and Technology, Wroclaw, Poland. September 23-27th, 2019.
- Karol Suchan: Universidad Diego Portales, Santiago, Chile. December 8-22th, 2019.
- Julio-Cesar Silva Araújo: Universidad do Ceara, Fortaleza, Brazil. December 5-28th, 2019.
- Karol Maia de Oliveira: Universidad do Ceara, Fortaleza, Brazil. December 5-28th, 2019.
- Claudia Linhares Sales: Universidad do Ceara, Fortaleza, Brazil. December 5-28th, 2019.
- Leonardo Sampaio Rocha: Universidad do Ceara, Fortaleza, Brazil. until June 2019.
- Xavier Defago: Tokyo Institute of Technology, Tokyo, Japan. January 7-11, 2019.
- Takako Kodate: Tokyo Woman's Christian University, Tokyo, Japan. March 18-31, 2019.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

- Julien Bensmail :

  Indian Statistical Institute, Kolkata, India. January 26-February 9, 2019.
  Universidade Federal do Ceará, Fortaleza, Brazil. May 4-May 17, 2019.
  Xidian University, Xi'an, China. August 31-September 14, 2019.
  Northwestern Polytechnical University, Xi'an, China. October 19-November 2, 2019.
- David Coudert :

  Concordia University, Montréal, Québec, Canada. July 12-27, 2019.
- Adrien Gausseran :

  Concordia University, Montréal, Québec, Canada. September 2 - December 2, 2019.
- Frédéric Giroire :

  Concordia University, Montréal, Québec, Canada. October 8-18th, 2019.
- Joanna Moulierac :

  Concordia University, Montréal, Québec, Canada. October 8-18th, 2019.
- Emanuele Natale :

  Max Planck Institute for Informatics, Sarrebruck, Germany. January 19 - February 28, 2019.
  University of Melbourne, Melbourne, Australia & University of Otago, Dunedin, New Zealand. October 1-30, 2019.
  University of Rome Tor Vergata, Rome, Italy. 1 November 2019 - 31 January 2020.
- Nicolas Nisse :

  Univ. Federal do Ceara, Fortaleza, Brazil, May 4-18th, 2019.
  Xidiang University, Xi'an, China. September 1-15th, 2019.

CTRL-A Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Grenoble Alpes Cybersecurity Institute Cross-Disciplinary Project of the Idex

The Grenoble Alpes Cybersecurity Institute aims at undertaking ground-breaking interdisciplinary research in order to address cybersecurity and privacy challenges. Our main technical focus is on low-cost secure elements, critical infrastructures, vulnerability analysis and validation of large systems, including practical resilience across the industry and the society.

In Ctrl-A, it is currently funding two “alternance” student positions and a PhD position might be provided in September 2020 and supervised by Stephane Mocanu.

9.2. National Initiatives

9.2.1. ANR HPeC

HPeC is an ANR project on Self-Adaptive, Energy Efficient High Performance Embedded Computing, with a UAV case study (http://hpec.fr/). The Coordinator is Lab-STICC / MOCS (Lorient / Brest), and the duration: 42 month from october 2015. Others Partners are: UBO, U. Clermont-Ferrand, InPixal.

In Ctrl-A, it has been funding a post-doc position, hired in Grenoble and co-advised with Lorient : Soguy Gueye. The work will be continued with a post-doc hired in Lorient : Erwan Moreac. A PhD based in Brest, Chabha Hireche, is co-advised by Stéphane Mocanu.

9.2.2. ANR Sacade

The ANR ASTRID Sacade project is funded by DGA. Stéphane Mocanu is in charge of several workpackages including a demonstrator. An expert engineer position is funded for the implementation of attack/defense scenarios in SCADA.

9.2.3. IRT Nanoelec Pulse program

The Pulse program aims the development for SCADA cybersecurity demonstrators. It has funded a Master grant in 2019 and two master grants in 2020. A PhD position was also approved for September 2020 and it will be co-supervised by Stéphane Mocanu

9.2.4. Informal National Partners

We have contacts with colleagues in France, in addition to the cooperation mentioned before, and with whom we are submitting collaboration projects, co-organizing events and workshops, etc. They feature : Avalon Inria team in Lyon (Ch. Perez, L. Lefevre, E. Caron), LIP6 (J. Malenfant), Scales Inria team in Sophia-Antipolis (L. Henrio), LIRRM in Montpellier (A. Gamatié, K. Godary, D. Simon), IRISA/Inria Rennes (J. Buisson, J.L. Pazat, ...), Telecom Paris-Tech (A. Diaconescu, E. Najm), LAAS (Thierry Monteil), LURPA ENS Cachan (J.M. Faure, J.J. Lesage).

9.2.5. Informal National Industrial Partners

We have ongoing discussions with several industrial actors in our application domains, some of them in the framework of cooperation contracts, other more informal: Eolas/Business decision (G. Dulac, I. Saffiedine), ST Microelectronics (V. Bertin), Schneider Electric (C. El-Kaed, P. Nappey, M. Pitel).

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: ECSEL

Project acronym: CPS4EU

Project title: Cyber Physical Systems for Europe

Duration: july 2019 - june 2022

Coordinator: VALEO

Other partners: 38 participants

Abstract: CPS4EU proposes to address technical issues and organizational issues in an integrated way. Hence, CPS4EU promotes a high level of sharing, so that an operational ecosystem, with adequate skills and expertise all along the value chain can enable, at the end of the project, the European industry to lead strategic markets based on CPS technologies.

In this project, the Ctrl-A team is involved in WP4 and WP9 mainly, on topics of Software Architectures for Self-Adaptive systems in CPS, and our main industrial collaboration is with RTE.

9.4. International Initiatives

9.4.1. Inria International Labs

We participate in the jLESC, Joint Laboratory for Extreme Scale Computing, with partners Inria, the University of Illinois, Argonne National Laboratory, Barcelona Supercomputing Center, Jülich Supercomputing Centre and RIKEN AICS.

We participated to the 9th Workshop of the JLESC at Knoxville, TE, USA, in April 2019, and visited ANL in Chicago.

We started a cooperation with Argonne National Labs, on Improving the performance and energy efficiency of HPC applications using autonomic computing techniques.

https://jlesc.github.io/projects/energy_autonomic/

We are also exploring possibilities on the topic of integrating FPGAs in HPC grids, with a participation in a workshop at FPT 18.

https://collab.cels.anl.gov/display/HPCFPGA/HPC-FPGA

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

We have ongoing relations with international colleagues in the emerging community on our topic of control for computing e.g., in Sweden at Lund (K.E. Arzen, M. Maggio), Mälardalen (A. Papadopoulos) and Linnaeus Universities (D. Weyns, N. Khakpour), in the Netherlands at CWI/leiden University (F. Arbab), in the U.K. at Liverpool U. (N. Berthier), in China at Heifei University (Xin An), in Italy at University Milano (C. Ghezzi, A. Leva), in the USA at Ann Arbor University (S. Lafortune) and UMass (P. Shenoy, E. Cecchet).

DANTE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Idex Lyon ACADEMICS

Participants: Paulo Gonçalves, Rémi Gribonval, Marion Foare, Amélie Barbe, Gaetan Frusque.

The project brings together a **consortium of 4 teams from Laboratories of Université de Lyon** (UdL) and will form a working group with complementary expertise in machine learning (deep learning, statistical learning, data mining), in data science (complex data analysis, adaptive and/or data-driven methods, network science) and in the studies of climate modeling and of computational social science. It comprises:

- Laboratoire Informatique du Parallélisme (LIP): P. Gonçalves (PI), M. Karsai (PI for Comp. Social Sc.)
- Laboratoire de Physique (LP): P. Borgnat (Coordinator), F. Bouchet (PI for Climate)
- Laboratoire Hubert Curien (LabHC), Université Jean Monnet: M. Sebban (PI)
- Laboratoire d'InfoRmatique en Images et Systèmes d'information (LIRIS): C. Robardet (PI)

The **impacts** of the project will stem from the efficiency of our proposed methods to learn from complex and dynamic data, and if so, **future applications** will naturally follow in many areas: social science and study of social interactions, climate and environmental science but also in technological networks, neuroscience with the study of brain networks and more generally in any domain where effective dynamical models of complex situations are to be learned from data. All these situations go beyond the current classical applicative frameworks of ML (time measurements, 2D images, or texts) and compel us to work out a major scientific breakthrough.

9.1.2. ISI Torino / Dante

Participant: Márton Karsai [correspondant].

Duration of the project: **October 2016 - October 2020**.

This project involves M. Karsai and L. Gauvin (ISI Torino) and funded by the IXXI Complex System Institute. The purpose of this project is to investigate the presence and the importance of higher-order correlations in dynamical networks. As the first attempt to address this problem we applied autoencoder, a recent representation using deep neural networks, on modelled and small-scale real temporal networks. However, since the results were trivial on the modelled network and not convincing on the real one we decided to take a different approach during the second phase of the project. We involved an ISI PhD student Maddalena Toricelli, to work out a method for temporal network embedding. Our idea is to extend the node2vec representation of static networks for time-varying structures, by using a local random walk to explore the structural-temporal neighbourhood of a node. Based on such local information we can effectively propose an embedding, which captures the temporal and structural properties of nodes in a temporal network.

9.1.3. FIL PerfWiFi

Participants: Guérin-Lassous Isabelle [correspondant], Grünblatt Rémy.

Duration of the project: **January 2019 - December 2020**.

The goal of the project **PerfWiFi** is to set up a Wi-Fi experimental platform that will be, in the future, open to interested researchers. This platform consists in devices (cards, routers) implementing the last versions of Wi-Fi (Wi-Fi 5 and Wi-Fi 6) and with different chipsets from different manufacturers. This platform will also be interconnected to a fleet of UAVs equipped with Wi-Fi interfaces. The Wi-Fi devices are chosen to be as open as possible in order to have a large set of possibilities in terms of parameterization of the Wi-Fi parameters.

In 2019, a first version of the platform has been set up along with a set of software tools to automatically launch Wi-Fi experiments. The first experiments can monitor, during a long period, all the possible Wi-Fi channels and their medium use ratio. We intend to provide these data via an open website.

9.1.4. FIL ALIENOR

Participant: Begin Thomas [correspondant].

Duration of the project: **January 2019 - December 2020**.

The goal of ALIENOR (ArtificiaL IntElligence-assisted NetwORks) is to develop an approach to dynamically select adequate values for the IEEE 802.11 parameters related to the Rate Adaptation (RA) mechanism to the WLAN context. The search for an adequate setting for the RA parameters is made complex due to the vast number of parameters (e.g., the used amendment of 802.11, the channel transmission rate, the number of competing nodes, the Frame Error Rate (FER), the offered load, and the transport protocol to name a few) that may affect a WLAN behavior.

In ALIENOR, we propose to explore a new approach to determine an adequate setting of the RA parameters using a data-driven approach based on techniques of Machine Learning (ML) in Artificial Intelligence (AI). Our approach consists of three stages. First, we will build a large dataset of measurements that will serve as the training set. Second, we will use ML techniques to discover a function that fits the mapping between the dataset output and the inputs. Lastly, WLAN devices will embed and use this learned function to predict (approximately) what will be their attained throughput under various possible settings of their RA, and then select their best option.

9.1.5. ENS Lyon project Vehicular project

Participants: Begin Thomas [correspondant], Guérin Lassous Isabelle, Busson Anthony.

Duration of the project: **January 2017 - December 2020**.

The goal of this project is to design new performance tools to improve the sharing of communication resources in vehicular networks. In particular, we focus on the use case of delivering a Video on Demand service to vehicles traveling along a highway. Through the development of a simple and yet accurate performance modeling approach, we were able to demonstrate the feasibility of using IEEE 802.11p to deliver video content to vehicles. Our work also underlines the benefit of blocking the lowest transmission rates for the sake of a collective gain in terms of attained throughput and interruption time in the video playback. This somehow surprising property derives from the well-established performance anomaly of 802.11-based networks.

9.2. National Initiatives

9.2.1. ANR DataRedux

Participants: Paulo Gonçalves [correspondant], Rémi Gribonval, Marion Foare.

Duration of the project: **February 2020 - January 2024**.
DataRedux puts forward an innovative framework to reduce networked data complexity while preserving its richness, by working at intermediate scales ("mesoscales"). Our objective is to reach a fundamental breakthrough in the theoretical understanding and representation of rich and complex networked datasets for use in predictive data-driven models. Our main novelty is to define network reduction techniques in relation with the dynamical processes occurring on the networks. To this aim, we will develop methods to go from data to information and knowledge at different scales in a human-accessible way by extracting structures from high-resolution, diverse and heterogeneous data. Our methodology will involve the identification of the most relevant subparts of time-resolved datasets while remapping the remaining parts of the system, the simultaneous structural-temporal representations of time-varying networks, the development of parsimonious data representations extracting meaningful structures at mesoscales ("mesostructures"), and the building of models of interactions that include mesostructures of various types. Our aim is to identify data aggregation methods at intermediate scales and new types of data representations in relation with dynamical processes, that carry the richness of information of the original data, while keeping their most relevant patterns for their manageable integration in data-driven numerical models for decision making and actionable insights.

9.2.2. ANR Darling

Participants: Paulo Gonçalves [correspondant], Rémi Gribonval, Marion Foare.

Duration of the project: **February 2020 - January 2024**.
This project meets the compelling demand of developing a unified framework for distributed knowledge extraction and learning from graph data streaming using in-network adaptive processing, and adjoining powerful recent mathematical tools to analyze and improve performances. The project draws on three major parallel directions of research: network diffusion, signal processing on graphs, and random matrix theory which DARLING aims at unifying into a holistic dynamic network processing framework. Signal processing on graphs has recently provided a comprehensive set of basic instruments allowing for signal on graph filtering or sampling, but it is limited to static signal models. Network diffusion on the opposite inherently assumes models of time varying graphs and signals, and has pursued the path of proposing and understanding the performance of distributed dynamic inference on graphs. Both areas are however limited by their assuming either deterministic graph or signal models, thereby entailing often inflexible and difficult-to-grasp theoretical results. Random matrix theory for random graph inference has taken a parallel road in explicitly studying the performance, thereby drawing limitations and providing directions of improvement, of graph-based algorithms (e.g., spectral clustering methods). The ambition of DARLING lies in the development of network diffusion-type algorithms anchored in the graph signal processing lore, rather than heuristics, which shall systematically be analyzed and improved through random matrix analysis on elementary graph models. We believe that this original communion of as yet remote areas has the potential to path the pave to the emergence of the critically needed future field of dynamical network signal processing.

9.2.3. Equipex FIT (Futur Internet of Things)

Participant: Éric Fleury [correspondant].

Duration of the project: **February 2011 - December 2019**.
FIT was one of 52 winning projects in the Equipex research grant program. It will set up a competitive and innovative experimental facility that brings France to the forefront of Future Internet research. FIT benefits from 5.8 million euro grant from the French government. The main ambition is to create a first-class facility to promote experimentally driven research and to facilitate the emergence of the Internet of the future.

9.2.4. ANR SoSweet

Participant: Márton Karsai [correspondant].

Duration of the project: **November 2015 - November 2019**.

The SoSweet project focuses on the synchronic variation and the diachronic evolution of the variety of French used on Twitter. The recent rise of novel digital services opens up new areas of expression which support new linguistic behaviours. In particular, social medias such as Twitter provide channels of communication through which speakers/writers use their language in ways that differ from standard written and oral forms. The result is the emergence of new varieties of languages. The main goal of SoSweet is to provide a detailed account of the links between linguistic variation and social structure in Twitter, both synchronically and diachronically. Through this specific example, and aware of its bias, we aim at providing a more detailed understanding of the dynamic links between individuals, social structure and language variation and change.

9.2.5. ANR DylNet

Participant: Márton Karsai [correspondant].

Duration of the project: **September 2016 - September 2020**.

The DylNet project aims to observe and to characterise the relationships between childhood sociability and oral-language learning at kindergarten. With a view to this, it takes an multidisciplinary approach combining work on language acquisition, sociolinguistics, and network science. It will be implemented by following all the children (≈ 220) and teaching staff in one kindergarten over a 3-year period. The use of wireless proximity sensors will enable collection of social contacts throughout the study. The data on sociability will be linked to the results of language tests and recordings of verbal interactions used to follow the children's progress on both a psycholinguistic level (lexicon, syntax, pragmatics) and a sociolinguistic level (features showing belonging to a social group). The aim is to better understand the mechanisms of adaptation and integration at work when young children first come into contact with the school context.

9.2.6. Inria PRE LIAISON

Participant: Márton Karsai [correspondant].

Duration of the project: **November 2017 - December 2019**.

This project implements unsupervised deep learning approaches to infer correlations/patterns that exist between dynamic linguistic variables, the mesoscopic and dynamic structure of the social network, and their socio-economic attributes. This interdisciplinary project is positioned at the crossroads of Natural Language Processing (NLP), Network Science, Data Science and Machine Learning.

More precisely, we develop a joint feature-network embedding, named AN2VEC (Attributed Network to Vector), which ultimately aims at disentangling the information shared by the structure of a network and the features of its nodes. Building on the recent developments of Graph Convolutional Networks (GCN), we use a multitask GCN Variational Autoencoder where different dimensions of the generated embeddings can be dedicated to encoding feature information, network structure, or shared feature-network information separately. This method thus defines a range of models whose performance in embedding a given data set varies depending with the allocation of dimensions. By exploring the behaviour of these models on synthetic data sets having different levels of feature-network correlation, we show (i) that embeddings relying on shared information perform better than the corresponding reference with unshared information, and (ii) that this performance gap increases with the correlation between network and feature structure, thus confirming that our embedding is able to capture joint information of structure and features.

9.2.7. HOTNET - IXXI

Participant: Márton Karsai [correspondant].

Duration of the project: **January 2019 - December 2021**.

The purpose of the HOTNet (Higher-order representation of temporal networks) project is to develop a pipeline for the embedding of temporal networks that captures higher order correlations relevant for dynamical processes. We propose to detach from the straightforward representations of networks — as successions of static networks — by focusing on representations that better reflects the higher-order neighbourhood and temporal paths. To project plans to develop a framework that learns from this representation an embedding sufficient to estimate the outcome of spreading processes that might take place on top of the original network.

This is a small-scale collaborative project funded by the IXXI Complex System Institute to foster collaborations between MK and Laetitia Gauvin (ISI Torino) for the period of 2019-2021.

9.2.8. Inria & HCERES

Participant: Éric Guichard [correspondant].

Bilateral project on the evolution of the Multi/inter-disciplinary of SHS.

An increasing number of researchers in SHS has the desire to develop new researches with computer scientists or mathematicians because they want to apply new methodologies (according to various or numerous data) or to develop older ones, which can now be easily implemented online. Some also develop a reflexion on their discipline, with the idea that epistemological questions are revitalized by the internet. This reality invite them to discuss with philosophers or with other SHS scientists who have the same intuition (eg: cartography, visualisation).

The project is hence to measure these new forms or inter-multi-disciplinarity. The main source will be the publications of all academics of French SHS laboratories, to find out who writes a paper with somebody of a different discipline and/or laboratories. All data are anonymized,

9.2.9. Inria IPL BetterNet

Participant: Éric Guichard.

An Observatory to Measure and Improve Internet Service Access from User Experience.

BetterNet aims at building and delivering a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. In this Inria Project Lab, we will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks with a particular focus on geography and cartography.

9.3. International Initiatives

9.3.1. Participation in Other International Programs

9.3.1.1. International Initiatives

MOTIf

Title: Mobile phone sensing of human dynamics in techno-social environment

International Partners (Institution - Laboratory - Researcher):

Universidad de Buenos Aires (Argentina) - Instituto de Cálculo - Alejo Salles

Universidade Federal de Minas Gerais (Brazil) - Jussara M. Almeida

Duration: 2018 - 2019

Start year: 2018

Information and Communication Technology (ICT) is becoming increasingly social, as demonstrated by the multitude of emerging technologies and technology platforms that facilitate social interactions, taking place as communication via telephone, text message, email, online social networks etc. At the same time, our social activities are increasingly embedded in the ICT environments that enable and enhance our ability to transact, share experiences, and maintain social relationships. One of the best ways to explore these developments is through the mining and analysis of data, which are collected through mobile phones and allow us to investigate how individuals act when embedded in a technology-enabled environment. Unlimited access to a wide range of mobile applications and services may change our way to gain information, to communicate, or even to behave in different contextual places like home, work, or anywhere else. Thus understanding individual activity patterns and the source of decisions behind them is moreover important for the design of future services and to estimate the demand on the infrastructure. The MOTIf project builds on the analysis and modeling of geo-localized temporally detailed but fully anonymised mobile phone call networks. These datasets allow us to address the two scientific objectives about spatiotemporal patterns of service usage of anonymised individuals to learn when, where, and what people are doing; and about the fine-grained sociodemographic structure of society and its effect on the the individual social behaviour. In other words our goal in general is to understand how individuals behave in a dynamic techno-social environment.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Jaqueline Faria has been a long term visitor in the DANTE team as a visiting PhD student from the PUC Minas University of Belo Horizonte (Brazil). Her stay between May-December was supported by the CAPES.

- Alexandre Brandwajn from University of California, Santa Cruz (USA) has been a visiting Professor in the DANTE team between Feb and Mar 2019.
- Dorsaf Ghozlani, PhD student at Ecole Nationale d'Ingénieurs de Tunis, has been a visitor in the Dante team from April to July 2019.

9.4.1.1. Internships

- Maxime De Freitas, Télécom Physique Strasbourg, from Jun 2019 until Aug 2019.
- Julien Alamelle, Université Claude Bernard Lyon 1, from Oct 2019 until Dec 2019.
- Juan Pablo Astudillo, Universitat Politècnica de Catalunya, PhD, from Apr 2019 until Jul 2019.
- Simon Fernandez, Master 2 student, ENS Lyon, from February 2019 until June 2019.
- Paul Grangette, Master 2 student, Université Claude from November 2019 to July 2020 (work-study contract).

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

- Christophe Crespelle is on leave with a Marie Sklodowska-Curie Grant from EU. He is currently at the University of Bergen (Norway) until February 1st, 2020.

DATAMOVE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- **ANR grant GRECO (2017-2020).** Resource manager for cloud of things. Coordinator: Quarnot Computing. Partners: Quarnot Computing, Grenoble-INP, Inria.
- **ANR grant Energumen (2018-2022).** Resource management: malleable jobs for a better use of the resources along with energy optimization. Coordinator: Denis Trystram. Partners: Grenoble-INP, IRIT, Sorbonne Université.

9.1.2. Competitivity Clusters

- **FUI IDIOM (2018-2020)**. Monitoring and optimization of I/Os. Coordinator DDN Storage. Partners: DDN Storage, Criteo, Quarnot, QuasarDB, CEA, Université de Bretagne Occidentale, Telecom SudParis, Inria (DataMove).

9.1.3. Inria

- Inria PRE COSMIC (exploratory research project), 2017-2019. Photovoltaic Energy Management for Distributed Cloud Platforms. Myriads, DataMove.
- Inria IPL HPC-BigData (2018-2021). Convergence between HPC, Big Data and AI. Coordinator: Bruno Raffin. Partners: the Inria teams Zenith, Kerdata, Datamove, Tadaam, SequeL, Parietal, Tau, and the external partners ATOS, ANL, IBPC, ESI-Group. See https://project.inria.fr/hpcbigdata/

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

- **H2020 EoCoE-II (2019-2021)**
  - Energy oriented Center of Excellence on HPC.
  - H2020 RIA european project, call H2020-INFRAEDI-2018-1.
  - PI: CEA.
  - Partners: CEA, FZL, ENEA, BSC, CNRS, Inria, CERFACS, Max-Planck-Gesellschaft, FRAUNHOFER, FAU, CNR, UNITN, PSNC, ULB, UBAH, CIEMAT, IFPEN, DDN. Datamove is leading the WP5 (Ensemble Runs)
  - Summary: The EoCoE-II project will build on its unique, established role at the crossroads of HPC and renewable energy to accelerate the adoption of production, storage and distribution of clean electricity. How will we achieve this? In its proof-of-principle phase, the EoCoE consortium developed a comprehensive, structured support pathway for enhancing the HPC capability of energy-oriented numerical models, from simple entry-level parallelism to fully-fledged exascale readiness. At the top end of this scale, promising applications from each energy domain have been selected to form the basis of 5 new Energy Science Challenges:
    * Wind turbine modelling, from detailed understanding single turbine dynamics to flow across entire wind farms in complex terrain;
    * Energy Meteorology, where probabilistic forecasting is needed to predict the production efficiency of solar and wind parks and their impact on energy trading across the grid;

* Design and study of new energy materials for photovoltaic cells, batteries and super-capacitors;
* Water for energy to manage geothermal and hydro-power including the influence of climate change on these resources;
* And fusion for energy, where the mandatory kinetic modelling of plasma turbulence and transport from the core to the edge of complex tokamak magnetic geometries requires exascale resources.

9.2.2. Collaborations in European Programs, Except FP7 & H2020

- Program: SKŁODOWSKA-CURIE ACTIONS - Individual Fellowship
- Project acronym: DAMA
- Project title: Extreme-Scale Data Management
- Duration: November 2018 - October 2020
- Coordinator: Bruno Raffin
- Followship Recipient: Francieli Zanon Boito.
- Abstract: This project is concerned with the I/O challenges that arise from the convergence between these two different paradigms. It is clear data analytics tools cannot simply replace their typical storage solutions for the HPC I/O stack, centered on the abstraction of files and powered by a parallel file system, because their workload is not well suited for that and would observe poor performance. Moreover, the separated storage infrastructure breaks the data affinity idea in which they are built upon. Finally, even among traditional HPC applications there is a need to minimize data movement, as it imposes high latency and increases energy consumption.

9.3. International Initiatives

9.3.1. Inria International Labs

9.3.1.1. JLESC

- Title: Joint Laboratory for Extreme-Scale-Computing.
- International Partners:
  - University of Illinois at Urbana Champaign (USA)
  - Argonne National Laboratory (USA),
  - Barcelona Supercomputing Center (Spain),
  - Jülich Supercomputing Centre (Germany)
  - Riken Advanced Institute for Computational Science (Japan)
- Start year: 2009
- See also: https://jlesc.github.io/
- The purpose of the Joint Laboratory for Extreme Scale Computing is to be an international, virtual organization whose goal is to enhance the ability of member organizations and investigators to make the bridge between Petascale and Extreme computing. The JLESC organizes a workshop every 6 months DataMove participates to. DataMove developed several collaborations related to in situ processing with Tom Peterka group (ANL) , the Argo exascale operating system with Swann Perarnau (ANL).

9.3.2. Inria Associate Teams Not Involved in an Inria International Labs

9.3.2.1. UNIFY

- Title: Intelligent Unified Data Services for Hybrid Workflows Combining Compute-Intensive Simulations and Data-Intensive Analytics at Extreme Scales

- Partners:
  - Inria teams: KerData, DataMove
  - Argonne National Lab (Tom PETERKA)
- Duration: 2019-2021

9.3.3. Participation in Other International Programs

9.3.3.1. STIC AmSud SAQED

- Title: Scalable Approximate Query Evaluation on Document Inverted Files for GPU based Big-Data Applications
- International Partner:
  - Universidad Nacional de San Luis - UNSL, Argentina
  - Universidad de Santiago de Chile - USACH, Chile
  - Universidade Federal de São Carlos - UFSCAR, Brazil
- Duration: 2019-2021
- Develop efficient and scalable approximate search and document similarity evaluation on large datasets based on document inverted files using high performance computing and GPUs.

9.3.3.2. LICIA

- Title: International Laboratory in High Performance and Ubiquitous Computing
- International Partner (Institution - Laboratory - Researcher):
  - UFRGS (Brazil)
- Duration: Funded by CNRS in 2011-2018, by Univ Grenoble Alpes for 2019-2020.
- See also: http://licia-lab.org/
- The LICIA is an Internacional Laboratory and High Performance and Ubiquitous Computing born in 2011 from the common desire of members of Informatics Institute of the Federal University of Rio Grande do Sul and of Laboratoire d'Informatique de Grenoble to enhance and develop their scientific parternship that started by the end of the 1970. LICIA is an Internacional Associated Lab of the CNRS, a public french research institution. It has support from several brazilian and french research funding agencies, such as CNRS, Inria, ANR, European Union (from the french side) and CAPES, CNPq, FAPERGS (from the Brazilian side). DataMove is deeply involved in the animation of LICIA.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Professor visit: Alfredo Goldman, Professor at Universidade de São Paulo, visited Datamove from June to July 2019.

DELYS Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

7.1.1.1. AdeCoDS (2019–2023)

Title: Programming, verifying, and synthesizing Adequately-Consistent Distributed Systems (AdeCoDS).

Members: Université de Paris (project leader), Sorbonne-Université LIP6, ARM, Orange.

Funding: The total funding of AdeCoDS from ANR is 523 471 euros, of which 162 500 euros for Delys.

Objectives The goal of the project is to provide a framework for programming distributed systems that are both correct and efficient (available and performant). The idea is to offer to developers a programming framework where it is possible, for a given application, (1) to build implementations that are correct under specific assumptions on the consistency level guaranteed by the infrastructure (e.g., databases and libraries of data structures), and (2) to discover in a systematic way the different trade-offs between the consistency level guaranteed by the infrastructure and the type and the amount of synchronization they need to use in their implementation in order ensure its correctness. For that, the project will develop a methodology based on combining (1) automated verification and synthesis methods, (2) language-based methods for correct programming, and (3) techniques for efficient system design.

7.1.1.2. ESTATE - (2016–2021)

Members: LIP6 (DELYS, project leader), LaBRI (Univ. de Bordeaux); Verimag (Univ. de Grenoble).

Funding: ESTATE is funded by ANR (PRC) for a total of about 544 000 euros, of which 233 376 euros for DELYS.

Objectives: The core of ESTATE consists in laying the foundations of a new algorithmic framework for enabling Autonomic Computing in distributed and highly dynamic systems and networks. We plan to design a model that includes the minimal algorithmic basis allowing the emergence of dynamic distributed systems with self-* capabilities, *e.g.*, self-organization, self-healing, self-configuration, self-management, self-optimization, self-adaptiveness, or self-repair. In order to do this, we consider three main research streams:

(i) building the theoretical foundations of autonomic computing in dynamic systems, (ii) enhancing the safety in some cases by establishing the minimum requirements in terms of amount or type of dynamics to allow some strong safety guarantees, (iii) providing additional formal guarantees by proposing a general framework based on the Coq proof assistant to (semi-)automatically construct certified proofs.

The coordinator of ESTATE is Franck Petit.

7.1.1.3. RainbowFS - (2016–2020)

Members: LIP6 (DELYS, project leader), Scality SA, CNRS-LIG, Télécom Sud-Paris, Université Savoie-Mont-Blanc.

Funding: is funded by ANR (PRC) for a total of 919 534 euros, of which 359 554 euros for DELYS.

Objectives: RainbowFS proposes a "just-right" approach to storage and consistency, for developing distributed, cloud-scale applications. Existing approaches shoehorn the application design to some predefined consistency model, but no single model is appropriate for all uses. Instead, we propose tools to co-design the application and its consistency protocol. Our approach reconciles the conflicting requirements of availability and performance vs. safety: common-case operations are designed to be asynchronous; synchronisation is used only when strictly necessary to satisfy the application's integrity invariants. Furthermore, we deconstruct classical consistency models into orthogonal primitives that the developer can compose efficiently, and provide a number of tools for quick, efficient and correct cloud-scale deployment and execution. Using this methodology, we will develop an entreprise-grade, highly-scalable file system, exploring the rainbow of possible semantics, and we demonstrate it in a massive experiment.

The coordinator of RainbowFS is Marc Shapiro.

7.1.2. LABEX

7.1.2.1. SMART - (2012–2019)

Members: ISIR (Sorbonne Univ./CNRS), LIP6 (Sorbonne Univ./CNRS), LIB (Sorbonne Univ./INSERM), LJLL (Sorbonne Univ./CNRS), LTCI (Institut Mines-Télécom/CNRS), CHArt-LUTIN (Univ. Paris 8/EPHE), L2E (Sorbonne Univ.), STMS (IRCAM/CNRS).

Funding: Sorbonne Universités, ANR.

Description: The SMART Labex project aims globally to enhancing the quality of life in our digital societies by building the foundational bases for facilitating the inclusion of intelligent artifacts in our daily life for service and assistance. The project addresses underlying scientific questions raised by the development of Human-centered digital systems and artifacts in a comprehensive way. The research program is organized along five axes and DELYS is responsible of the axe "Autonomic Distributed Environments for Mobility."

The project involves a PhD grant of 100 000 euros over 3 years.

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

7.2.1.1. LightKone

Title: Lightweight Computation for Networks at the Edge

Programm: H2020-ICT-2016-2017

Duration: January 2017 - December 2019

Coordinator: Université Catholique de Louvain

Partners:

Université Catholique de Louvain (Belgium)

Technische Universitaet Kaiserslautern (Germany)

INESC TEC - Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciencia (Portugal)

Faculdade de Ciencias E Tecnologiada Universidade Nova de Lisboa (Portugal)

Universitat Politecnica De Catalunya (Spain)

Scality (France)

Gluk Advice B.V. (Netherlands)

Inria contact: Marc Shapiro

The goal of LightKone is to develop a scientifically sound and industrially validated model for doing general-purpose computation on edge networks. An edge network consists of a large set of heterogeneous, loosely coupled computing nodes situated at the logical extreme of a network. Common examples are networks of Internet of Things, mobile devices, personal computers, and points of presence including Mobile Edge Computing. Internet applications are increasingly running on edge networks, to reduce latency, increase scalability, resilience, and security, and permit local decision making. However, today's state of the art, the gossip and peer-to-peer models, give no solution for defining general-purpose computations on edge networks, i.e., computation with shared mutable state. LightKone will solve this problem by combining two recent advances in distributed computing, namely synchronisation-free programming and hybrid gossip algorithms, both of which are successfully used separately in industry. Together, they are a natural combination for edge computing. We will cover edge networks both with and without data center nodes, and applications focused on collaboration, computation, and both. Project results will be new programming models and algorithms that advance scientific understanding, implemented in new industrial applications and a startup company, and evaluated in large-scale realistic settings.

7.3. International Initiatives

7.3.1. Participation in Other International Programs

7.3.1.1. Spanish research ministry project

Title: BFT-DYNASTIE - Byzantine Fault Tolerance: Dynamic Adaptive Services for Partitionable Systems

French Partners: Labri, Irisa, LIP6

International Partners (Institution - Laboratory - Researcher):

University of the Basque Country UPV - Spain, EPFL - LSD - Switzerland, Friedrich-Alexander-Universitat Erlangen-Nurenberg - Deutschland, University of Sydney - Australia

Duration: 2017–2019

The project BFT-DYNASTIE is aimed at extending the model based on the alternation of periods of stable and unstable behavior to all aspects of fault-tolerant distributed systems, including synchrony models, process and communication channel failure models, system membership, node mobility, and network partitioning. The two main and new challenges of this project are: the consideration of the most general and complex to address failure model, known as Byzantine, arbitrary or malicious, which requires qualified majorities and the use of techniques form the security area; and the operation of the system in partitioned mode, which requires adequate reconciliation mechanisms when two partitions merge.

7.3.1.2. Spanish research ministry project

Title: BFT-DYNASTIE - Byzantine Fault Tolerance: Dynamic Adaptive Services for Partitionable Systems

French Partners: Labri, Irisa, LIP6

International Partners (Institution - Laboratory - Researcher):

University of the Basque Country UPV - Spain, EPFL - LSD - Switzerland, Friedrich-Alexander-Universitat Erlangen-Nurenberg - Deutschland, University of Sydney - Australia

Duration: 2017–2019

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7.3.1.3. STIC Amsud

Title: ADMITS - Architecting Distributed Monitoring and Analytics for IoT in Disaster Scenarios

International Partners (Institution - Laboratory - Researcher):

Universidad Diego Portales and Universidad Tecnica Federico Santa Maria (Chile)

Universidade Federal de Uberlandia, Universidade Federal do Rio Grande do Norte and Instituto Federal Sul-Rio-Grandense (Brazil)

Universidad de la Republica (Uuruguay)

Duration: 2019 - 2020

Start year: 2019

Develop algorithms, protocols and architectures to enable a decentralized distributed computing environment to provide support for failure monitoring and data analytics in Internet-of-Things (IoT) disaster scenarios.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

- AMOZARRAIN Ugaitz, PhD Student, University of San Sebastian (Spain), Feb. 2019 - Mar. 2019
- CORREA Leonardo, PhD Student, Federal University of Rio Grande do Sul (Brazil), Jan 2019 - Oct. 2019
- GOUVEIA LIMA Luan Teylo, PhD Student, UFF (Brazil), Sep. 2019-Mar. 2020
- PELC Andrzej, Professor, Université du Québec en Outaouais (Canada), Sep. 2019 - Oct. 2019
- DIEUDONNE Yoann, Associate Professor, Amiens Univ., Sep. 2019-Oct. 2019
- LONG Darrell, Professor, Univ. California Santa Cruz (USA), Feb. 2019 - Mar. 2019
- PARIS Jehan-François, Professor, University of Houston (USA), Feb. 2019 - Mar. 2019

7.4.2. Visits to International Teams

Marc Shapiro spent three weeks visiting Technical University Kaiserslautern during the Spring.

Luciana Arantes and Pierre Sens have been invited for 10 days at New-York University Shanghai

Luciana Arantes visited the network team at Pontifical Catholic University of Rio de Janeiro - PUC (Brazil)

Luciana Arantes and Pierre Sens visited the computer science department at Universidade Federal Fluminense - UFF (Brazl)

DIANA Project-Team

8. Partnerships and Cooperations

8.1. Inria Internal Funding

8.1.1. IPL Betternet

Participants: Giuilio Grassi, Imane Taibi, Chadi Barakat.
The DIANA team is part of the Inria Project Lab BetterNet (http://project.inria.fr/betternet/). Within this lab, Inria is funding the PhD of Imane Taibi who is hosted by the Dionysos team in Rennes and is co-supervied by Chadi Barakat from the DIANA project-team and Gerardo Rubino and Yassine Hadjadj-Aoul from the DIONYSOS project-team. The PhD of Imane Taibi started on the 1st of November 2017. Further in 2018, Inria funded a PostDoc position to supervise the experiments planned within the IPL and develop the data analysis part. This PostDoc position is occupied by Giulio Grassi who is co-supervised by Chadi Barakat from the Diana project-team and Renata Teixeira from the MIMOVE project-team. Giulio Grassi started on October 1st, 2018 and is currently located in Paris.

8.2. Regional Initiatives

8.2.1. ElectroSmart

Participants: Arnaud Legout, Mondi Ravi, David Migliacci, Abdelhakim Akodadi, Yanis Boussad.

The ElectroSmart project benefits form the following fundings:

- a 39 months engineering position from the UCN@Sophia Labex for the 2016-2019 period (Ravi Mondi was hired on this position)
- 30KEuros from Academy 1 of UCAJedi
- a two years engineering position from an Inria ADT for 2017/2019 (Abdelhakim Akodadi)
- a 18 months business developer from Inria ATT for june 2017-june 2019 (David Migliacci)
- a 3 years 2017/2020 Ph.D. thesis from Academy 1 of UCAJedi (Yanis Boussad)
- 12 months business developper from Inria ATT for june 2019 - mai 2020 (David Migliacci)
- 12 months engineer from Inria ATT for june 2019 - mai 2020 (Mondi Ravi)

8.2.2. D2D Indoor

Participants: Chadi Barakat, Zeineb Guizani.
This project is joint with the NFCOM startup in Nice, specialized in the development of new services for mobile phones. The project aims at leveraging mobile to mobile communications for offloading the cellular infrastructure, and targets a solution based on algorithms previously developed in the DIANA project-team (BitHoc and HBSD) to achieve networking in a sparse scenario following the multi-hop communication principle. The project got a funding for one year engineer from the Labex UCN@SOPHIA. Zeineb Guizani has worked on this project from July 2018 to May 2019 and has proposed an architecture based on NDN-opp to support such communications.

8.3. National Initiatives

8.3.1. ANR

- **ANR JCJC DET4ALL** (2019-2021): Modern factories and industrial system massively rely on cyber physical systems with digital communications (e.g., to allow collaborative robots, for data analytics...). However, industrial networks are still mostly managed and conceived as collections of independent communicating units instead of one unified piece of software.

  The reason why the shift of paradigm did not occur yet to industrial digital communication networks is because industrial processes generally impose strong determinism and real-time constraints. As a result, industrial networks have a propensity of being physically segregated to contain potential malfunctions and simplify conception.

  With the DET4ALL project, we will apply the concept of network programmability to the world of industrial communicating systems. To that aim, we will construct and prove the essential building blocks that will allow to virtualise industrial networks:

  - algorithms to automatically provision the various components constituting industrial networks;
  - Domain Specific Languages (DSLs) to specify real-time communication schemes;
  - mechanisms to update on-the-fly the production infrastructures without service degradation.

  The impact of the DET4ALL project goes beyond technological advances; it will also bring a new vision on what production tools can become, namely agile systems in perpetual evolution.
- **ANR FIT** (2011-2019): FIT (Future Internet of Things) aims at developing an experimental facility, a federated and competitive infrastructure with international visibility and a broad panel of customers. It will provide this facility with a set of complementary components that enable experimentation on innovative services for academic and industrial users. The project will give French Internet stakeholders a means to experiment on mobile wireless communications at the network and application layers thereby accelerating the design of advanced networking technologies for the Future Internet. FIT is one of 52 winning projects from the first wave of the French Ministry of Higher Education and Research's Equipements of Excellence (Equipex) research grant programme. The project will benefit from a 5.8 million euro grant from the French government. Other partners are UPMC, IT, Strasbourg University and CNRS. The project was extended for one year and will end in december 2019. See also http://fit-equipex.fr/.
- **ANR BottleNet** (2016-2019): BottleNet aims to deliver methods, algorithms, and software systems to measure Internet Quality of Experience (QoE) and diagnose the root cause of poor Internet QoE. This goal calls for tools that run directly at users' devices. The plan is to collect network and application performance metrics directly at users' devices and correlate it with user perception to model Internet QoE, and to correlate measurements across users and devices to diagnose poor Internet QoE. This data-driven approach is essential to address the challenging problem of modeling user perception and of diagnosing sources of bottlenecks in complex Internet services. ANR BottleNet will lead to new solutions to assist users, network and service operators as well as regulators in understanding Internet QoE and the sources of performance bottleneck.

8.4. European Initiatives

8.4.1. FP7 & H2020 Projects

- Program: FP7 FIRE programme
- Project acronym: Fed4Fire+
- Project title: Federation for FIRE Plus

- Duration: January 2017 - December 2021
- Coordinator: iMinds (Belgium)
- Other partners: 20 european partners including IMEC (Belgium), UPMC (Fr), Fraunhofer (Germany), TUB (Germany), etc.
- Web site: http://www.fed4fire.eu/
- Abstract: The Fed4FIRE+ project has the objective to run and further improve Fed4FIRE as best-in-town federation of experimentation facilities for the Future Internet Research and Experimentation initiative. Federating a heterogeneous set of facilities covering technologies ranging from wireless, wired, cloud services and open flow, and making them accessible through common frameworks and tools suddenly opens new possibilities, supporting a broad range of experimenter communities covering a wide variety of Internet infrastructures, services and applications. Fed4FIRE+ will continuously upgrade and improve the facilities and include technical innovations, focused towards increased user satisfaction (user-friendly tools, privacy-oriented data management, testbed SLA and reputation, experiment reproducibility, service-level experiment orchestration, federation ontologies, etc.). It will open this federation to the whole FIRE community and beyond, for experimentation by industry and research organisations, through the organization of Open Calls and Open Access mechanisms. The project will also establish a flexible, demand-driven framework which allows test facilities to join during the course of its lifetime by defining a set of entry requirements for new facilities to join and to comply with the federation. FIRE Experimental Facilities generate an ever increasing amount of research data that provides the foundation for new knowledge and insight into the behaviour of FI systems. Fed4FIRE+ will participate in the Pilot on Open Research Data in Horizon 2020 to offer open access to its scientific results, to the relevant scientific data and to data generated throughout the project's lifetime. Fed4FIRE+ will finally build on the existing community of experimenters, testbeds and tool developers and bring them together regularly (two times a year) in engineering conferences to have maximal interaction between the different stakeholders involved.

8.5. International Initiatives

8.5.1. Inria Associate Teams Involved in an Inria International Lab

8.5.1.1. DrIVE

Title: DrIVE: Distributed Intelligent Vehicular Environment - Enabling ITS through programmable networks

Inria International Lab: **Inria@SiliconValley**

International Partners (Institution - Laboratory - Researcher):

UniCamp (Brazil) - Department of Computer Engineering and Industrial Automation - Mateus Augusto Silva Santos

UNICAMP (Brazil) - Department of Computer Engineering and Industrial Automation - Christian Esteve Rothenberg

UC Santa Cruz (USA) - Department of Computer Science and Engineering- Katia Obraczka

Start year: 2018

See also: https://team.inria.fr/diana/drive-associated-team/

Transportation systems are part of our society's critical infrastructure and are expected to experience transformative changes as the Internet revolution unfolds. The automotive industry is a notable example: it has been undergoing disruptive transformations as vehicles transition from traditional unassisted driving to fully automated driving, and eventually to the self-driving model. Communication technology advancements such as support for vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) communication have been one of the key enablers of next generation transportation services, also known as Intelligent Transport Systems (ITS). However, ITS services and applications pose significant challenges to the underlying communication and network infrastructure due to their stringent low latency, reliability, scalability, and geographic decentralization requirements. The DrIVE associated team proposal aims at addressing such challenges by: (1) developing a programmable network control plane that will dynamically adjust to current environment conditions and network characteristics to support ITS' scalability, quality of service (QoS), and decentralization requirements, and (2) applying the proposed distributed network control plane framework to ITS applications, such as road hazard warning, autonomous- and self-driving vehicles, and passenger-centric services (e.g., infotainment and video streaming).

8.6. International Research Visitors

8.6.1. Visits of International Scientists

Mark Crovella, Professor at Boston University, visited us in March 2019 and gave a talk at Forum Numerica of Université Côte d'Azur. Mark is currently collaborating with Chadi Barakat on network-wide anomaly detection within the IPL BetterNet.

8.6.2. Internships

Houssam Elbouanani

Date: from March 2019 to August 2019

Institution: Ubinet Master 2 program at Université Côte D'Azur

Supervisors: Chadi Barakat and Guillaume Urvoy-Keller

Subject: Measurement as a Service in modern Data Centers

Anas Errahali

Date: from March 2019 to August 2019

Institution: Ubinet Master 2 program at Université Côte D'Azur

Supervisosr: Walid Dabbous and Thierry Turletti

Subject: Enhancing geolocation accuracy in LoRa Low Power Wide Area Networks

Youssef Rachid

Date: from March 2019 to August 2019

Institution: Ubinet Master 2 program at Université Côte D'Azur

Supervisor: Arnaud Legout

Subject: Exploring bias in the YouTube recommendation system.

Tareq Si Salem

Date: from March 2019 to August 2019

Institution: Ubinet Master 2 program at Université Côte D'Azur

Supervisor: Arnaud Legout

Subject: Identifying exposure profiles of Electrosmart users.

8.6.3. Visits to International Teams

Mohamed Naoufal Mahfoudi spent six months (october 2018, March 2019) PhD internship in University of California at San Diego in Professor Xinyu Zhang team. During this period he worked on a new passive localization system based on deep learning.

Tingting Yuan spent a 3-week visit at UNICAMP, Brazil, in the context of the DrIVE associated team (Oct 21 – Nov 8, 2019).

DIONYSOS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- Yann Busnel is a member of the ONCOSHARe project (ONCOlogy bigdata SHARing for Research) funded by Brittany and Pays de la Loire regions, with 280.000 k€ for 24 months.
- Bruno Sericola continues to work on the analysis of fluid queues with Fabrice Guillemin from Orange Labs in Lannion, France.

9.2. National Initiatives

ANR

- Yassine Hadjadj-Aoul, Sofiene Jelassi and Gerardo Rubino are participating at 20% of their time to the IRT BCOM granted by the ANR.
- Yann Busnel is a member of the two following projects: INSHARE granted by the ANR (ANR-15-CE19-0024) and BigClin granted by the LabEx CominLabs (ANR-10-LABX-07-01).

IPL (Inria Project Lab) BetterNet

Yassine Hadjadj-Aoul, Gerardo Rubino and Bruno Tuffin are members of the IPL (Inria Project Lab) BetterNet: An Observatory to Measure and Improve Internet Service Access from User Experience, 2016-2020.

BetterNet aims at building and delivering a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. In this Inria Project Lab, we will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks. Our observatory can be defined as a vantage point, where: 1) tools, models and algorithms/heuristics will be provided to collect data, 2) acquired data will be analyzed, and shared appropriately with scientists, stakeholders and civil society, and 3) new value-added services will be proposed to end-users.

Inria Exploratory Action SNIDE We are leading of the Inria Exploratory Action SNIDE (Search Non neutratlIty DEtection) 2019-2023, involving Dionysos and MIMR (Grenoble).

Search engines play a key role to access content and are accused to bias their results to favor their own services among others. This has led to the sensitive search neutrality debate, similar to the network neutrality debate currently discussed on the role of ISPs. Our goal in this project is to develop and apply a methodology aiming at highlighting a bias and quantifying its impact.

An initial version of our meta-engine (which will be further develop by incorporating outlier detection tests) can be found at https://snide.irisa.fr/.

9.3. European Initiatives

- Bruno Sericola continues to work on the analysis of fluid queues with Marie-Ange Remiche from the university of Namur in Belgium.
- Gerardo Rubino has a long collaboration with Sebastián Basterrech at the VSB-Technical University of Ostrava, Czech Republic, on Machine Learning.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

We keep a long collaboration in research with the CalPoly at Pomona, USA, on the transient analysis of Markovian models.

9.4.2. Participation in Other International Programs

9.4.2.1. Ecos Sud program

Project "Masc"

Title: Mathematical Algorithms for Semantic Cognition

International Partner (Institution - Laboratory - Researcher):

Universidad de la República (Uruguay) - Biophysics - Eduardo Mizraji, Jorge Graneri

Universidad de la República (Uruguay) - Computer science - Pablo Rodríguez-Bocca

Duration: 2018 – 2020

Start year: 2018

MASC is a three-year project (code U17E03) with the Faculty of Sciences of the university of the Republic, in Uruguay, on the application of mathematical modeling tools to a better understanding of a cognitive disease called semantic dementia. This involves Prof. Eduardo Mizraji and Jorge Graneri, a PhD student whose co-advisors are Prof. Mizraji and G. Rubino from Dionysos, plus Pablo Rodríguez Bocca, from the Engineering Faculty of the university of the Republic. Our contribution to this project is around the use of mathematical tools applied to the analysis of cognition pathologies.

9.4.2.2. Math and Stic AmSud programs

Project "RareDep"

Title: Rare events analysis in multi-component systems with dependent components

International Partner (Institution - Laboratory - Researcher):

Universidad Adolfo Ibañez (Chile) - Faculty of Engineering and Sciences - Javiera Barrera

Universidad de la República Uruguay (Uruguay) - Computer Science - Héctor Cancela

Universidade Federal de Pernambuco (Brazil) - Mathematics - Pablo Martín Rodríguez

Duration: 2019 – 2020

Start year: 2019

See also: http://mansci-web.uai.cl/raredep/RareDep/Welcome.html

The RareDep project focus on developing new techniques addressing two central elements for the improvement of the available tools for risk analysis of complex systems. One is the case of rare events, occurring both in performance and in dependability evaluation of systems modeled as made of many components. Rare events preclude the use of Monte Carlo techniques when the event of interest has a small probability of occurring, and specific methods are necessary, with many open problems in the area. Independence is the usual assumption when building models (more precisely, in almost all works in the field make this assumption), but we know that the assumption is almost never satisfied. We often are constrained by the necessity of assuming independent components in order to be able to use the available methods. In RareDep, we intend to address both problems simultaneously. This needs to develop new variance reduction techniques, for instance in the Importance Sampling family, or in the Splitting one, to be able to exploit data concerning dependencies between the components of the models. This will be built on top of our accumulated experience in the Monte Carlo area (and related fields, such as Quasi-Monte Carlo, numerical integration, etc.), and a starting effort to begin the exploration of what happens when we relax the omnipresent independence hypothesis. We will also explore what happens if we consider new ideas (several coming from the participants of the proposal) for defining new metrics in some specific areas. In these cases, everything is to be done: procedures to deal with rare events, modeling techniques to deal with dependencies between the system's components, and then, both issues at the same time. Our main application area will concern different types of modern networks (in communications, or in energy distribution, for instance).

Project “ACCON”

Title: Algorithms for the Capacity Crunch problem in Optical Networks

International Partner (Institution - Laboratory - Researcher):

Universidad de la República Uruguay (Uruguay) - Computer Science - Héctor Cancela

UTFSM (Chile) - Télématica - Reinaldo Vallejos

Universidad de Valparaiso (Chile) - Computer Science - Marta Barría

Duration: 2019 – 2020

Start year: 2019

See also: http://accon.elo.usm.cl/

The rapid increase in demand for bandwidth from existing networks has caused a growth in the use of telecommunications technologies, especially WDM optical networks. So far, communication technologies have been able to meet the bandwidth demand. Nevertheless, this decade researchers have anticipated a coming “Capacity Crunch” potential problem associated with these networks. It refers to fact that the transmission capacity limit on optical fibers is close to be reached in the near future. It is then urgent to make the current network architectures evolve, in order to satisfy the relentless exponential growth in bandwidth demand. In other words, the performance bottleneck for optical infrastructures is concentrated around this limiting situation, and the most efficient way of preparing the future of these fundamental technological systems that support the backbone of the Internet is to focus on solving the related management problems. In the previously described scientific context, the ACCON project has a main scientific goal: the development of new strategies capable to provide better resource management techniques to face the threat of the Capacity Crunch. To this end, we will explore the utilization of different analytical techniques to evaluate the performance of several network architecture paradigms, in order to assess their viability in the near future. This will provide us the needed insight leading to finding new strategies for efficiently managing the network resources, and consequently, to contribute addressing this coming Capacity Crunch problem.

9.4.2.3. PHC Ulysses

Project “AFFINE”

Title: Achieving Energy Efficient Communication in Future Networks by Supporting Multi-Access Edge Computing in Internet of Things (IoT)

International Partners (Institution - Laboratory - Researcher):

University College Dublin (Ireland) - Computer Science - Lina Xu

Duration: 1 year

Start year: January 2019

Yassine Hadjadj-Aoul and Lina Xu received a grant from the PHC Ulysses (for French-Irish collaboration). The aim of this project is to improve the energy efficiency for data transmission and communication in IoT networks and therefore to reduce electricity consumption and CO_2 emissions.

Yann Busnel has taken part in several events to develop Indo-French collaborations, notably within the framework of Campus France. In particular, he led the round table on Artificial Intelligence and Mathematics at the Knowledge Summit 2 in Lyon in October 2019, in the presence of the Minister, Frédérique Vidal.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

We have received the following international scientists:

- M. Nakayama (New Jersey Institute of Technology, USA): one week in July 2019.
- DanHua ShangGuan (Institute of Applied Physics and Computational Mathematics, Beijing, China), one month in September 2019.
- Vamsi Bulusu from VJTI Mumbai visited us for 4 months between August and Novembre 2019.
- Jorge Graneri (Sep.–Oct.) and Eduardo Mizraji (Sep.), UDELAR, Uruguay, in the context of the MASC project.
- Nicolás Jara, UTFSM, Chile, Dec., in the context of the ACCON project.
- Franco Robledo, UDELAR, Uruguay, in Feb.

DIVERSE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. PEC – Pôle d'Excellence Cyber

- Coordinator: Université de Rennes 1
- Dates: 2016-2019
- Abstract: Formal and Executable Specification of domain-specific language families.

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. VaryVary ANR JCJC

- Coordinator: Mathieu Acher
- DiverSE, Inria/IRISA Rennes
- Dates: 2017-2021
- Abstract: Most modern software systems (operating systems like Linux, Web browsers like Firefox or Chrome, video encoders like x264 or ffmpeg, servers, mobile applications, etc.) are subject to variation or come in many variants. Hundreds of configuration options, features, or plugins can be combined, each potentially with distinct functionality and effects on execution time, memory footprint, etc. Among configurations, some of them are chosen and do not compile, crash at run time, do not pass a test suite, or do not reach a certain performance quality (e.g., energy consumption, security). In this JCJC ANR project, we follow a thought-provocative and unexplored direction: We consider that the variability boundary of a software system can be specialized and should vary when needs be. The goal of this project is to provide theories, methods and techniques to make vary variability. Specifically, we consider machine learning and software engineering techniques for narrowing the space of possible configurations to a good approximation of those satisfying the needs of users. Based on an oracle (e.g., a runtime test) that tells us whether a given configuration meets the requirements (e.g., speed or memory footprint), we leverage machine learning to retrofit the acquired constraints into a variability that can be used to automatically specialize the configurable system. Based on a relative small number of configuration samples, we expect to reach high accuracy for many different kinds of oracles and subject systems. Our preliminary experiments suggest that varying variability can be practically useful and effective. However, much more work is needed to investigate sampling, testing, and learning techniques within a variety of cases and application scenarios. We plan to further collect large experimental data and apply our techniques on popular, open-source, configurable software (like Linux, Firefox, ffmpeg, VLC, Apache or JHipster) and generators for media content (like videos, models for 3D printing, or technical papers written in LaTeX).

8.2.2. DGA

8.2.2.1. LangComponent (CYBERDEFENSE)

- Coordinator: DGA
- Partners: DGA MI, Inria
- Dates: 2019-2022

- Abstract: in the context of this project, DGA-MI and the Inria team DiverSE explore the existing approaches to ease the development of formal specifications of domain-Specific Languages (DSLs) dedicated to paquet filtering, while guaranteeing expressiveness, precision and safety. In the long term, this work is part of the trend to provide to DGA-MI and its partners a tooling to design and develop formal DSLs which ease the use while ensuring a high level of reasoning.

8.2.3. Cominlabs

8.2.3.1. PROFILE

- Coordinator: Université de Rennes 1
- Partners: Inria, Université de Rennes 2
- Dates: 2016-2019
- Abstract: The PROFILE project brings together experts from law, computer science and sociology to address the challenges raised by online profiling, following a multidisciplinary approach. More precisely, the project will pursue two complementary and mutually informed lines of research: (i) Investigate, design, and introduce a new right of opposition into the legal framework of data protection to better regulate profiling and to modify the behavior of commercial companies towards being more respectful of the privacy of their users; (ii) Provide users with the technical means they need to detect stealthy profiling techniques as well as to control the extent of the digital traces they routinely produce. As a case study, we focus on browser fingerprinting, a new profiling technique for targeted advertisement. The project will develop a generic framework to reason on the data collected by profiling algorithms, to uncover their inner workings, and make them more accountable to users. PROFILE will also propose an innovative protection to mitigate browser fingerprinting, based on the collaborative reconfiguration of browsers.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. H2020 ICT-10-2016 STAMP

- Coordinator: Inria Rennes
- Other partners: ATOS, ActiveEon, OW2, TellU, Engineering, XWiki, TU Delft, SINTEF
- Dates: 2016-2019
- Abstract: Leveraging advanced research in automatic test generation, STAMP aims at pushing automation in DevOps one step further through innovative methods of test amplification. It reuse existing assets (test cases, API descriptions, dependency models), in order to generate more test cases and test configurations each time the application is updated. Acting at all steps of development cycle, STAMP techniques aim at reducing the number and cost of regression bugs at unit level, configuration level and production stage.

  STAMP raises confidence and foster adoption of DevOps by the European IT industry. The project gathers 3 academic partners with strong software testing expertise, 5 software companies (in: e-Health, Content Management, Smart Cities and Public Administration), and an open source consortium. This industry-near research addresses concrete, business-oriented objectives. All solutions are open source and developed as microservices to facilitate exploitation, with a target at TRL 6.

8.3.2. Collaborations with Major European Organizations

SINTEF, ICT (Norway): Model-driven systems development for the construction of distributed, heterogeneous applications. We collaborate since 2008 and are currently in two FP7 projects together.

Université du Luxembourg, (Luxembourg): Models runtime for dynamic adaptation and multi-objective elasticity in cloud management; model-driven development.

KTH, the Royal Institute of Technology (Sweden): continuous software testing, perturbation and diversification.

McGill University (Canada): language reuse, model composition, and models for sustainability.

CWI (The Netherlands): language engineering.

JKU Linz (Austria): model analysis and Model-Based DevOps.

RWTH Aachen (Germany): models for industry 4.0

8.4. International Initiatives

8.4.1. Inria International Labs

IIL CWI-Inria

Associate Team involved in the International Lab:

8.4.1.1. ALE

- Title: Agile Language Engineering
- International Partner (Institution - Laboratory - Researcher):
  - CWI (Netherlands) Tijs van der Storm
- Start year: 2017
- See also: http://gemoc.org/ale/
- Software engineering faces new challenges with the advent of modern software-intensive systems such as complex critical embedded systems, cyber-physical systems and the Internet of things. Application domains range from robotics, transportation systems, defense to home automation, smart cities, and energy management, among others. Software is more and more pervasive, integrated into large and distributed systems, and dynamically adaptable in response to a complex and open environment. As a major consequence, the engineering of such systems involves multiple stakeholders, each with some form of domain-specific knowledge, and with an increasingly use of software as an integration layer.

  Hence more and more organizations are adopting Domain Specific Languages (DSLs) to allow domain experts to express solutions directly in terms of relevant domain concepts. This new trend raises new challenges about designing DSLs, evolving a set of DSLs and coordinating the use of multiple DSLs for both DSL designers and DSL users.

  ALE will contribute to the field of Software Language Engineering, aiming to provide more agility to both language designers and language users. The main objective is twofold. First, we aim to help language designers to leverage previous DSL implementation efforts by reusing and combining existing language modules. Second, we aim to provide more flexibility to language users by ensuring interoperability between different DSLs and offering live feedback about how the model or program behaves while it is being edited (aka. live programming/modeling).

8.4.2. Inria International Partners

8.4.2.1. Informal International Partners

- Université de Montréal (Canada)
- McGill University (Canada)
- University of Alabama (USA)
- University of Lancaster (UK)
- University of Namur (Belgium)
- Universita degli Studi di Cagliari (Italy)
- Università degli Studi dell'Aquila (Italy)

- JKU Linz (Austria)
- TU Wien (Austria)
- Michigan State University (MSU)
- RWTH Aachen University (Germany)
- KTH (Sweden)

8.4.3. Participation in Other International Programs

The GEMOC studio has been sustained through the creation of a Research Consortium at the Eclipse Foundation.

8.4.3.1. International initiative GEMOC

The GEMOC initiative (cf. http://www.gemoc.org) is an open and international initiative launched in 2013 that coordinate research partners worldwide to develop breakthrough software language engineering (SLE) approaches that support global software engineering through the use of multiple domain-specific languages. GEMOC members aim to provide effective SLE solutions to problems associated with the design and implementation of collaborative, interoperable and composable modeling languages.

The GEMOC initiative aims to provide a framework that facilitates collaborative work on the challenges of using of multiple domain-specific languages in software development projects. The framework consists of mechanisms for coordinating the work of members, and for disseminating research results and other related information on GEMOC activities. The framework also provides the required infrastructure for sharing artifacts produced by members, including publications, case studies, and tools.

The governance of the GEMOC initiative is provided by the Advisory Board. The role of the Advisory Board is to coordinate the GEMOC work and to ensure proper dissemination of work products and information about GEMOC events (e.g., meetings, workshops).

Benoit Combemale is a GEMOC co-founder and currently acts as principal coordinator of the GEMOC initiative. Benoit Combemale and Jean-Marc Jézéquel are part of the Advisory Board, and 9 DIVERSE members are part of the GEMOC initiative.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Yves Le Traon, Professor at the University of Luxembourg, visited the team in June, July and October 2019.
- Nelly Bencomo, Lecturer in Computer Science Aston University, UK, visited the team from October 2019 to June 2020.
- Martin Montperrus, Professor at KTH, Sweden, visited the team in December 2019.
- Nicolas Harrand, PhD Student at KTH, Sweden, visited the team in December 2019.
- Paul Temple, postdoc at University de Namur, visited the team in February 2019.
- Thomas Degueule, postdoc at CWI, visited the team in December 2019
- Alfonso Pierantonio, Associate Professor at Università degli Studi dell'Aquila, visited the team in June 2019
- Mark van den Brand, Professor at Eindhoven University of Technology, visited the team in June 2019

8.5.2. Visits to International Teams

- Pierre JeanJean visited CWI for 1 week in December 2019 in the context of the Associated Team ALE.
- Benoit Combemale made several short visits at CWI in the context of the Associated Team ALE, visited McGill University in June 2019, and visited TU Eindhoven in November 2019.
- Olivier Barais made several short visits at KTH in the context of a collaboration with Prof Monperrus and Prof Baudry.
- Djamel E. Khelladi made a one week research visit in December 2019 to the DIRO laboratory at University of Montreal, Canada.

DYOGENE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Laboratory of Information, Networking and Communication Sciences (LINCS)

Dyogene participates in LINCS https://www.lincs.fr, a research centre co-founded by Inria, Institut Mines-Télécom, UPMC and Alcatel-Lucent Bell Labs (currently Nokia Bell Labs) dedicated to research and innovation in the domains of future information and communication networks, systems and services.

9.1.2. PGMO

Dyogene participates in the PGMO (Gaspard Monge Program for Optimization, operations research, and their interactions with data science) via the project a 2 year project "Distributed control of flexible loads" funded through the ICODE/IROE call. This is a collaborative project between University Paris-Sud (PI: Gilles Stoltz) and Inria (PI: Ana Busic).

9.2. National Initiatives

9.2.1. GdR GeoSto

Members of Dyogene participate in Research Group GeoSto (Groupement de recherche, GdR 3477) http://gdr-geostoch.math.cnrs.fr/ on Stochastic Geometry led by and David Coupier [Université de Valenciennes].

This is a collaboration framework for all French research teams working in the domain of spatial stochastic modeling, both on theory development and in applications.

9.2.2. GdR RO

Members of Dyogene participate in GdR-RO (Recherche Opérationelle; GdR CNRS 3002), http://gdrro.lip6.fr/, working group COSMOS (Stochastic optimization and control, modeling and simulation), lead by A. Busic and E. Hyon (LIP 6); http://gdrro.lip6.fr/?q=node/78

9.2.3. ANR JCJC PARI

Probabilistic Approach for Renewable Energy Integration: Virtual Storage from Flexible Loads. The project started in January 2017. PI — A. Bušić. This project is motivated by current and projected needs of a power grid with significant renewable energy integration. Renewable energy sources such as wind and solar have a high degree of unpredictability and time variation, which makes balancing demand and supply challenging. There is an increased need for ancillary services to smooth the volatility of renewable power. In the absence of large, expensive batteries, we may have to increase our inventory of responsive fossil-fuel generators, negating the environmental benefits of renewable energy. The proposed approach addresses this challenge by harnessing the inherent flexibility in demand of many types of loads. The objective of the project is to develop decentralized control for automated demand dispatch, that can be used by grid operators as ancillary service to regulate demand-supply balance at low cost. We call the resource obtained from these techniques virtual energy storage (VES). Our goal is to create the necessary ancillary services for the grid that are environmentally friendly, that have low cost and that do not impact the quality of service (QoS) for the consumers. Besides respecting the needs of the loads, the aim of the project is to design local control solutions that require minimal communications from the loads to the centralized entity. This is possible through a systems architecture that includes the following elements: i) local control at each load based on local measurements combined with a grid-level signal; ii) frequency decomposition of the regulation signal based on QoS and physical constraints for each class of loads.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. NEMO

NEMO, NEtwork MOtion https://cordis.europa.eu/project/id/788851, https://project.inria.fr/ercnemo is an ERC Advanced Grant (2019 – 2024, PI François Baccelli). It is an inter-disciplinary proposal centered on network dynamics. The inter-disciplinarity spans from communication engineering to mathematics, with an innovative interplay between the two. NEMO's aim is to introduce dynamics in stochastic geometry. General mathematical tools combining stochastic geometry, random graph theory, and the theory of dynamical systems will be developed. NEMO will leverage interactions of Inria with Ecole Normale Supérieure on the mathematical side, and with Nokia Bell Labs and Orange on the engineering side. In March 2019, an inaugural workshop *Processus ponctuels et graphes aléatoires unimodulaires*https://project.inria.fr/ercnemo/fr/presentation was organized at Inria Paris.

9.3.2. Collaborations with Major European Organizations

Partner: VITO (Belgium); https://vito.be/en.

Co-advising of PhD student I. Shilov. Started: Nov 2019. Topic: "Algorithmic Games and Distributed Learning for Peer-to-Peer Energy Trading". PhD scholarship by VITO.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- University of Florida; Collaborations with Prof Sean Meyn (ECE), Associate Prof Prabir Barooah (MAE), and the PhD students: A. Devraj (ECE), A. Coffman (MAE), N. Cammardella (ECE), J. Mathias (ECE).
- Sharif University, Tehran; Collaborations with O. Mirsadeghi.
- UC Berkeley; Collaborations with V. Anantharam.
- Indian Statistical Institute (ISI), Bangalore; Collaborations with Yogeshwaran D.

9.4.2. Participation in Other International Programs

9.4.2.1. Indo-French Center of Applied Mathematics

IFCAM Project "Geometric statistics of stationary point processes" B. Błaszczyszyn and Yogeshwaran D. from Indian Statistical Institute (ISI), Bangalore, have got in 2018 the approval from Indo-French Centre for Applied Mathematics (IFCAM), for their joint project on "Geometric statistics of stationary point processes" for the period 2018–2021. Yogeshwaran D. was visiting Dyogene for two weeks in March and November 2019.

9.4.2.2. Microsoft Research-Inria collaboration

Microsoft Research-Inria collaboration: Laurent Massoulié heads the Microsoft Research-Inria Joint Centre, and also participates to the "Distributed Machine Learning" project of the Joint Centre, together with Francis Bach (Inria), Sébastien Bubeck and Lin Xiao (MSR Redmond), and PhD student Hadrien Hendrikx.

9.4.2.3. Inria International Chairs

IIC- MEYN Sean

Title: Distributed Control and Smart Grid

International Partner (Institution - Laboratory - Researcher):

University of Florida (United States) - Department of Electrical and Computer Engineering - Sean Meyn

Duration: 2019 – 2023

Start year: 2019

See also: https://www.inria.fr/sites/default/files/2019-12/HoldersChairesInt_EN.pdf

TOPIC: “Distributed Control and Smart Grid”

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Ali Khezeli [School of Mathematical Sciences, Tehran, Iran],
- Christian Hirsch [Bernoulli Institute, University of Groningen,
- David Métivier [Los Alamos National Laboratory, USA]
- Deepjyoti Deka [Los Alamos National Laboratory, USA]
- Guenter Last [Karlsruhe Institute of Technology, Germany],
- Hermann Thorisson [University of Islande],
- Holger Keeler [University of Melbourne, Australia] ,
- Hrvoje Pandžić [University of Zagreb, Croatia]
- Itai Benjamini [Weizmann Institute of Science, Rehovot, Israel],
- Joe Yukich [Lehigh University, Bethelem, PA, USA],
- Josu Doncel [University of the Basque Country, Spain],
- Lucas Pereira [Técnico Lisboa, Portugal]
- Miklós Abért [MTA Renyi Institute, Budapest, Hungary],
- Mir-Omid Haji-Mirsadeghi [Sharif University, Tehran, Iran],
- Natasa Dragovic [The University of Texas at Austin, TX, USA],
- Nelson Antunes [University of Faro, Portugal],
- Venkatachalam Anantharam [University of California, Berkeley, CA USA],
- Yogeshwaran D. [ISI, Bangalore, India],

9.5.1.1. Internships

- Bastien Dubail [École Normale Supérieure de Lyon],
- Emmanuel Kravitzch [Inria],
- Erwan Pichon [Inria].
- Ge Jin [Inria],
- Maxence Lefort [Inria].

9.5.2. Visits to International Teams

- C. Fricker: University of Faro, Portugal (one week).

9.5.2.1. Research Stays Abroad

- A.Busic: program participant (5 weeks in total) of “The mathematics of energy systems”, Isaac Newton Institute for Mathematical Sciences, Cambridge, UK. Spring 2019, https://www.newton.ac.uk/event/mes

EASE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Chantier 3.0

Coordinator: JM. Bonnin

Starting: Jan 2019; Ending : Dec 2021

Partners: Agemos, YoGoKo, IMT Atlantique

Abstract: Co-founded by "Région Bretagne" Chantier 3.0 is a "PME Project" aiming at increasing safety of workers in construction sites and road works. In these scenarios, vehicles represent a danger for the workers. Knowing the position of the vehicles and workers, it is possible to alert workers who are located in a safety perimeter around the vehicles. The project addresses the challenges of 1) precise localisation with low or medium cost wearable devices and 2) of dynamically setting up a reliable communication network in harsh environments mixing indoor and outdoor conditions. The key technologies used to solve theses issues include: fusion of localisation data (GPS, acceleration integration, location anchors, angle of arrival and time of flight of radio signals), opportunistic short range broadcast communications, ITS communication protocols and system integration. EASE brings it expertise in all of theses domains in order to enhance the reliability of the system, to make it affordable and to pave the way for its standardisation.

8.2. National Initiatives

SCOOP@F part 2

Coordinator: JM. Bonnin

Starting: Jan 2016; Ending: Dec 2019

Partners: MEDE, Renault, PSA, IMT Atlantique

Abstract: SCOOP@F is a Cooperative ITS pilot deployment project that intends to connect approximately 3000 vehicles with 2000 kilometers of roads. It consists of 5 specific sites with different types of roads: Ile-de-France, "East Corridor" between Paris and Strasbourg, Brittany, Bordeaux and Isère. SCOOP@F is composed of SCOOP@F Part 1 from 2014 to 2015 and SCOOP@F Part 2 from 2016 to 2019. Its main objective is to improve the safety of road transport and of road operating staff during road works or maintenance. The project includes the validations of Cooperative ITS services in open roads, cross border tests with other EU Member States (Spain, Portugal and Austria) and development of a hybrid communication solution (3G-4G/ITS G5). We are involved in the project to study the security and privacy properties of the hybrid architecture that allow to use non dedicated communication networks (WiFi, 5G) as well as the vehicular dedicated communication technologies (G5). The second phase of SCOOP will end up in 2019. As a partner of the InDiD consortium, we proposed a follow up for this project to the EC for the period 2020-2023.

InDiD

Coordinator: JM. Bonnin

Starting: mid 2019; Ending: Dec 2023

Partners: 20+ French partners including cities (Paris, Grenoble...), road operators, transport operators, academics (incl. IMT Atlantique) and industrials

Abstract: InDiD is one of 13 French projects out of 148 European projects selected by the European Commission within the framework of the last Connecting Europe Facility (CEF) call for proposals. The project benefits from a co-funding rate of 50% on behalf of the European Union. It follows the Smart Cooperative Transport Systems projects SCOOP@F, C-ROADS France and InterCor. The project aims at expanding the coverage of use cases deployed in previous projects (emergency braking, accident, work...) and develop new use cases dealing with urban area, but also use cases of increased perception for autonomous vehicle. In addition, it deals with high definition digital mapping of the infrastructure. Connectivity along with mapping shape the digital infrastructure of tomorrow, an essential addition to the physical infrastructure. InDiD aims at continuing the deployment of Cooperatives Intelligent Transport Systems on new road experimentation sites in order to expand the services coverage offered by the infrastructure. Pilot sites are located on 4 main French geographic areas, on the Mediterranean side, in the south-west area, at the centre and in the north of France.

TAGRI

Coordinator: P. Couderc

Starting: Nov 2019; Ending: Nov 2020

Abstract: Tagri is a 12 months innovation action supported by a CominLabs grant, started on 2019-11-01 and ending on October 2020. It follows up the previous Pervasive_RFID project, a joint Inria - IETR collaboration. Tagri aims at developing an operational UHF RFID solution for agricultural applications where tags are used as a pervasive storage to track important data related to the production. Tagri is using the RFID research facility from Pervasive_RFID project to study the behavior and performance level of UHF RFID in the context of agricultural applications, which is new as the the standard RFID technology used in farming is LF based: historically, LF was selected because it was reliable for bio-tags attached to animal, and the driver application for RFID in smart farming was breeding. A new research engineer, Alexis Girard, has integrated the team in November 2019 on this project.

8.3. International Research Visitors

8.3.1. Informal International Partners

Three years ago we initiated a collaboration with Valerie Gay and Christopher Lawrence (UTS / Australia) on adapting smart spaces for eHealth applications. We continued the collaboration and Jean-Marie Bonnin visited UTS last August. He participated in the definition of research IoT infrastructure for a new maternity clinic dedicated to aboriginal community. The goal was to design an efficient research infrastructure to study how pervasive technologies could be used to adapt the environment to the people. To prepare this visit, Christopher Lawrence came in France and visit the team in March 2019.

8.3.2. Visits of International Scientists

Christopher Lawrence, Associate Professor, University of Technology Sydney, visited the team in March/April 2019.

EVA Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Inria Project Labs, Exploratory Research Actions and Technological Development Actions

- IPL SPARTA
- ATT SmartMarina, 2019. Help transfer the technology of the SmartMarina project to startup Falco. Keoma Brun-Laguna is lead.
- ADT 6TiSCH, 2018-2020. Benchmark the performance of 6TiSCH under realistic scenarios, through experimentaion using the OpenTestbed. Tengfei Chang is lead.
- ADT DASMU (Distributed Adaptive Scheduling for MUltichannel Wireless Sensor Networks), 2018-2019. DASMU focuses on a distributed scheduling algorithm which relies on realistic assumptions, does not require complex computation, is valid for any traffic load, is adaptive and compliant with the standardized protocols used in the 6TiSCH working group at IETF. First results have been obtained and an intensive simulation campaign made with the 6TiSCH simulator has provided comparative performance results. Our proposal, called YSF, outperforms MSF, the 6TiSCH Minimal Scheduling Function, in terms of end-to-end latency and end-to-end packet delivery ratio. Thanks to this ADT, Yasuyuki Tanaka has joined the EVA team for two years.

9.1.2. ANR

- The GeoBot FUI project (https://geobot.fr/) is one of the most innovative, challenging and fun projects around wireless localization in the world today. It applies true innovation to a real-world problem, with a clear target application (and customer) in mind. The GeoBot partners are building a small robot (think of a matchbox-sized RC car) that will be inserted into a gas pipe, and move around it to map the location of the different underground pipes. Such mapping is necessary to prevent gas-related accidents, for example during construction. At the end of the project, this solution will be commercialized and used to map the network of gas pipe in France, before being used in worldwide. Each partner is in charge of a different aspect of the problem: robotics, analysis of the inertial data, visualization, etc. Inria is in charge of the wireless part. We will be equipping the robot with a wireless chip(set) in order to (1) communicate with the robot as it moves about in the pipes while standing on the surface, and (2) discover the relative location of the robot w.r.t. a person on the surface. Inria is evaluating different wireless technologies, benchmarking around ranging accuracy and capabilities to communicate. We start from off-the-shelf kits from different vendors and build a custom board, benchmark it, and integrate it with the other partners of the project.

9.1.3. Other collaborations

- EVA has a collaboration with Orange Labs. **Thomas Watteyne** supervises the PhD of Mina Rady, which happens under a CIFRE agreement with Orange Labs.
- EVA has a collaboration with Vedecom. **Paul Muhlethaler** supervises Fouzi Boukhalfa's PhD funded by Vedecom. This PhD aims at studying low latency and high reliability vehicle-to-vehicle communication to improve roads safety.
- EVA has an ongoing collaboration with SODEAL company, which runs the Cap d'Agde marina, as part of Falco startup.
- EVA has an ongoing collaboration with SELOR company, which runs the Lorient marinas, as part of the Falco startup.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

The H2020 following project is ongoing:

- H2020 SPARTA, Jan 2019 – December 2020.

9.2.2. Collaborations in European Programs, Except FP7 & H2020

Inria-EVA has collaboration in 2018 with ETSI (the European Telecommunications Standards Institute) to organize the F-Interop 6TiSCH 2 Interop Event on 2-4 February 2018 in Paris.

9.3. International Initiatives

9.3.1. Inria Associate Teams Not Involved in an Inria International Labs

9.3.1.1. REALMS

- Title: Real-Time Real-World Monitoring Systems
- International Partner (Institution - Laboratory - Researcher):
  - University of California Berkeley (United States) - Civil and Environmental Engineering - Steven Glaser
  - University of Michigan (United States) - Civil and Environmental Engineering - Branko Kerkez
- Start year: 2015
- See also: http://glaser.berkeley.edu et http://www-personal.umich.edu/~bkerkez/
- The Internet of Things revolution prompted the development of new products and standards; The IEEE 802.15.4e (2012) standard introduced the Time Synchronized Channel Hoping (TSCH) which can provide end-to-end reliability of 99.999 % and an energy autonomy of many years. This exceptional performance prompted the IETF to create the 6TISCH working group to standardize the integration of TSCH networks in the Internet. While the first experimental data have highlighted the great robustness of these networks, there is no data of a real network, accessible in real time, on a large scale and over a long period. Such data is needed to better model network performance and produce better products and standards. The teams of Professors Glaser and Kerkez are successfully deploying such networks to study mountain hydrology, monitor water quality and manage rainwater in urban environments. A model is missing to assist in the deployment and operation of these networks, as well as to monitor an operational network.

9.3.2. Inria International Partners

9.3.2.1. Declared Inria International Partners

Inria-EVA has a long-standing Memorandum of Understanding with the OpenMote company (http://www.openmote.com/), which runs until 2020. OpenMote emerged as a spin-off of the OpenWSN project, co-led by **Thomas Watteyne** and Prof. Xavier Vilajosana, Professor at the Open University of Catalonia and Chief Technical Officer at OpenMote.

The collaboration has been ongoing since 2012 and at the time of writing has resulted in:

- Joint academic publications, including 7 journal articles, 1 letter, 1 book chapter, 5 conference papers, 2 tutorials and invited talks.
- Joint standardization activities, in particular in the IETF 6TiSCH working group, co-chaired by **Thomas Watteyne** and for which Prof. Xavier Vilajosana is a key contributor. This activity has resulted in the joint participation in 12 IETF face-to-face meetings, joint participation in over 100 audioconferences, co-authorship of 3 Internet-Drafts and joint organization of 2 interop events.
- Joint software development, as both institutions closely collaborate in the maintenance, development, promotion and research along the OpenWSN project, including the development of the protocol stack, the integration of novel hardware technologies, the support to the community and the participation in standardization activities and interoperability events.

This MOU is NOT a commitment of funds by any party.

9.3.2.2. Informal International Partners

The Inria-EVA team collaborates extensively with Prof. Pister's group at UC Berkeley on the OpenWSN and Smart Dust projects. This activity translated into several members of the Pister team visiting Inria-EVA and vice-versa in 2018.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

1. **Martina Brachmann (RISE, Sweden)** (November 2019) working on TSCH on the RISE: Current Research and Future Directions in Networked Embedded Systems with Thomas Watteyne, Malisa Vucinic, Tengfei Chang
2. **Ana Laura Diedrichs (UTN, Argentina)** (Oct-Nov 2019) working on WirelessWine with Thomas Watteyne, Keoma Brun-Laguna
3. **Prof Leila Seidane Azouz** 1-30 October 2019 working with **Pascale Minet** and **Paul Muhlethaler** on wireless networks.
4. **Prof Ruben Milocco** visited EVA from 1-30 October 2019 working with **Pascale Minet** on evaluation of data center performance and **Paul Muhlethaler** on wireless network relaying.
5. **Prof. Diego Dujovne (UDP, Chile)** (July 2019) working on WirelessWine with Thomas Watteyne
6. **Prof. Branko Kerkez (U. Michigan)** (May 2019) working on REALMS associate team with Thomas Watteyne
7. **Mikolaj Chwalisz (TU Berlin)** (May 2019) working on Towards efficient coexistence of IEEE 802.15.4e TSCH and IEEE 802.11 Collaboration with Tengfei Chang, Thomas Watteyne

9.4.1.1. Internships

1. Amy Hane, Intern, from Sep 2019 until Dec 2019
2. Camilo Andres Lopez Lopez, Intern, from May 2019 until Aug 2019
3. Ba Hai Le, Intern, Apr-Aug 2019
4. Victor Kenichi Nascimento Kobayashi,Intern, from May 2019 until Aug 2019
5. Sharut Gupta, Intern, from May 2019 until July 2019
6. Miguel Landry Foko Sindjoung, Intern, from Mar 2019 until Jun 2019.

9.4.1.2. Research Stays Abroad

- **Thomas Watteyne** spent the month of August 2019 at UC Berkeley, working with Prof. Glaser on the SnowHow project, and with Prof. Pister on Smart Dust and OpenWSN.
- Tengfei Chang spent June 2019 in California working with Prof. Pister working on Smart Dust UC Berkeley.

FOCUS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

- DCore (Causal debugging for concurrent systems) is a 4-years ANR project that started on March 2019. The overall objective of the project is to develop a semantically well-founded, novel form of concurrent debugging, which we call "causal debugging". Causal debugging will comprise and integrate two main engines: (i) a reversible execution engine that allows programmers to backtrack and replay a concurrent or distributed program execution and (ii) a causal analysis engine that allows programmers to analyze concurrent executions to understand why some desired program properties could be violated. Main persons involved: Lanese, Medic.
- REPAS (Reliable and Privacy-Aware Software Systems via Bisimulation Metrics) is an ANR Project that started on October 2016 and that will finish on October 2020. The project aims at investigating quantitative notions and tools for proving program correctness and protecting privacy. In particular, the focus will be put on bisimulation metrics, which are the natural extension of bisimulation to quantitative systems. As a key application, we will develop a mechanism to protect the privacy of users when their location traces are collected. Main persons involved: Dal Lago, Gavazzo, Sangiorgi.
- COCAHOLA (Cost models for Complexity Analyses of Higher-Order Languages) is an ANR Project that started on October 2016 and that finished on October 2019. The project aims at developing complexity analyses of higher-order computations. The focus is not on analyzing fixed programs, but whole programming languages. The aim is the identification of adequate units of measurement for time and space, i.e. what are called *reasonable* cost models. Main persons involved: Dal Lago, Martini.
- PROGRAMme ("What is a program? Historical and philosophical perspectives"), is an ANR project started on October 2017 and that will finish on October 2022; PI: Liesbeth De Mol (CNRS/Université de Lille3). The aim of this project is to develop a coherent analysis and pluralistic understanding of "computer program" and its implications to theory and practice. Main person involved: Martini.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

- BEHAPI (Behavioural Application Program Interfaces) is an European Project H2020-MSCA-RISE-2017, running in the period March 2018 - February 2022. The topic of the project is behavioural types, as a suite of technologies that formalise the intended usage of API interfaces. Indeed, currently APIs are typically flat structures, i.e. sets of service/method signatures specifying the expected service parameters and the kind of results one should expect in return. However, correct API usage also requires the individual services to be invoked in a specific order. Despite its importance, the latter information is either often omitted, or stated informally via textual descriptions. The expected benefits of behavioural types include guarantees such as service compliance, deadlock freedom, dynamic adaptation in the presence of failure, load balancing etc. The project aims to bring the existing prototype tools based on these technologies to mainstream programming languages and development frameworks used in industry.
- ICT COST Action IC1405 (Reversible computation - extending horizons of computing). Initiated at the end of April 2015 and with a 4-year duration, this COST Action studies reversible computation and its potential applications, which include circuits, low-power computing, simulation, biological modeling, reliability and debugging. Reversible computation is an emerging paradigm that extends the standard forwards-only mode of computation with the ability to execute in reverse, so that computation can run backwards as naturally as it can go forwards.

  Main persons involved: Lanese (vice-chair of the action).

9.2.2. Collaborations with Major European Organizations

We list here the cooperations and contacts with other groups, without repeating those already listed in previous sections.

- ENS Lyon (on concurrency models and resource control). Contact person(s) in Focus: Dal Lago, Martini, Sangiorgi. Some visit exchanges during the year, in both directions. A joint PhD (Adrien Durier).
- University of Innsbruck (on termination and complexity analysis of probabilistic programs). Contact person(s) in Focus: Avanzini. Some short visits during the year.
- University of Southern Denmark (on service-oriented computing). Contact person(s) in Focus: Gabbrielli, Lanese, Zavattaro.
- Universitat Politecnica de Valencia, Spain (on reversibility for Erlang). Contact person(s) in Focus: Lanese. Some visit exchanges during the year, in both directions.
- Laboratoire d'Informatique, Université Paris Nord, Villetaneuse (on implicit computational complexity). Contact person(s) in Focus: Dal Lago, Martini.
- Institut de Mathématiques de Luminy, Marseille (on lambda-calculi, linear logic and semantics). Contact person(s) in Focus: Dal Lago, Martini.
- Team PPS, IRIF Lab, University of Paris-Diderot Paris 7 (on logics for processes, resource control). Contact person(s) in Focus: Dal Lago, Martini, Sangiorgi. Some short visits in both directions during the year.
- IRILL Lab, Paris (on models for the representation of dependencies in distributed package based software distributions). Contact person(s) in Focus: Gabbrielli, Zavattaro. Some short visits in both directions during the year.
- IMDEA Software, Madrid (G. Barthe) (on implicit computational complexity for cryptography). Contact person(s) in Focus: Dal Lago. Some visits during the year.

9.3. International Initiatives

9.3.1. Inria Associate Teams Not Involved in an Inria International Lab

9.3.1.1. CRECOGI

Title: Concurrent, Resourceful and Effectful Computation by Geometry of Interaction

International Partner (Institution - Laboratory - Researcher):

Kyoto (Japan) - Research Institute for Mathematical Sciences - Naohiko Hoshino

Start year: 2018

See also: http://crecogi.cs.unibo.it

The field of denotational semantics has successfully produced useful compositional reasoning principles for program correctness, such as program logics, fixed-point induction, logical relations, etc. The limit of denotational semantics was however that it applies only to high-level languages and to extensional properties. The situation has changed after the introduction of game semantics and the geometry of interaction (GoI), in which the meaning of programs is formalized in terms of movements of tokens, through which programs "talk to" or "play against" each other, thus having an operational flavour which renders them suitable as target language for compilers. The majority of the literature on GoI and games only considers sequential functional languages. Moreover, computational effects (e.g. state or I/O) are rarely taken into account, meaning that they are far from being applicable to an industrial scenario. This project's objective is to develop a semantic framework for concurrent, resourceful, and effectful computation, with particular emphasis on probabilistic and quantum effects. This is justified by the greater and greater interest which is spreading around these two computation paradigms, motivated by applications to AI and by the efficiency quantum parallelism induces.

9.3.2. Participation in Other International Programs

Focus has taken part in the creation of the Microservices Community (http://microservices.sdu.dk/), an international community interested in the software paradigm of Microservices. Main aims of the community are: i) sharing knowledge and fostering collaborations about microservices among research institutions, private companies, universities, and public organisations (like municipalities); ii) discussing open issues and solutions from different points of view, to create foundations for both innovation and basic research.

U. Dal Lago is "Partner Investigator" in the project "Verification and analysis of quantum programs", whose Chief Investigator is Prof Yuan Feng, University of Technology Sydney. The project is funded by the Australian Research Council.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

The following researchers have visited Focus for short periods; we list them together with the title of the talk they have given during their stay, or the topic discussed during their stay.

- Ornela Dardha (University of Glasgow) and Laura Bocchi (University of Kent): collaboration within BehAPI RISE H2020 project, September 2019.
- Guilhem Jaber (University of Nantes): "Game semantics for higher-order functions with state", December 2019.
- Naohiko Hoshino, April 2019 and October 2019.
- Gilles Barthe, May 2019.
- Boaz Barak, July 2019.
- Francesco Dagnino, "Generalizing Inference Systems by Corules", November 2019.

9.4.1.1. Sabbatical programme

Simone Martini has been Fellow at the Collegium - Lyon Institute for Advanced Studies, since September 2018 and until June 2019 https://collegium.universite-lyon.fr.

9.4.1.2. Research Stays Abroad

- Ugo Dal Lago has spent overall a few weeks in Japan: RIMS (Kyoto) and NII (Tokyo), as part of ongoing collaborations with Naohiko Hoshino and Shin-ya Katsumata.
- Ivan Lanese has visited Xibis Limited and University of Leicester, UK (in particular Irek Ulidowski and Emilio Tuosto) from 3/7/2019 to 2/8/2019, to work on choreographies, and the University of Torun, Poland (in particular Lukasz Mikulski and Kamila Barylska), from 13/8/2019 to 29/8/2019, to work on reversible Petri nets.
- Cosimo Laneve and Gianluigi Zavattaro have spent overall a few weeks in Malta visit to Prof. Adrian Francalanza at the University of Malta within the BehAPI RISE H2020 project.
- Michael Lodi has visited Prof. Tim Bell and the Computer Science Education Research Group at the Department of Computer Science and Software Engineering, University of Canterbury, Christchurch, New Zealand, from 26th of October 2018 to 17th of April 2019, as part of his Ph.D. course.

FUN Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. StoreConnect

Participants: Nathalie Mitton [contact person], Valeria Loscri, Antonio Costanzo, Ibrahim Amadou.

Title: StoreConnect

Type: FUI

Duration: September 2016 - October 2018

Coordinator: NEOSENSYS

Others partners: Inria FUN, SPIRALS and STARS, TeVolys, Ubudu, Smile, STIME, Leroy Merlin

The aim of StoreConnect is to provide French large retailers with efficient and powerful tools in the in-store customer interaction.

8.1.2. LumiCAR

Participants: Valeria Loscri [contact person], Antonio Costanzo, Meysam Mayahi.

Title: LumiCAR

Type: ISITE

Duration: October 2019 - October 2021

Vehicle-to-Vehicle and Vehicle-RSU (Roadside Units) communication (V2X) has become a very active topic of research in recent years as it appears to be a means of improving road safety and make effective and timely intervention of road safety actors. To date, most research activities are based on the use of conventional radio frequency (RF) technology. However, faced with multiple constraints, these vehicular communications are not always effective. In the LumiCar project we will base the V2X communication mainly on the Visible Light Communication (VLC) technology and we will focus on the coexistence of the VLC with other technologies. VLC has already started to work in other indoor applications such as connected stores for geolocation of customers. The properties offered by light (speed, directional, controlled containment ...) suggest that VLC technology is more suitable for vehicular communications and can effectively meet the needs of a reliable, robust and with increasing flow to consider new applications such as virtual reality in future cars. In addition, VLC technology can be recognized as a "green" technology because it is based on the exploitation of LEDs and lamps already used for lighting and visibility. It is therefore a question of optimizing the use (by the transmission of information) of an energy already consumed.

8.2. National Initiatives

8.2.1. Exploratory Action

8.2.1.1. Ethicam

Participants: Valeria Loscri [contact person], Carola Rizza.

Duration: October 2019 - October 2022

The evolution of the Internet of Things (IoT) towards the Internet of Everything (IoE) paradigm represents an important and emerging research direction, capable to connect and interconnect massive number of heterogeneous nodes, both inanimate and living entities, encompassing molecules, nanosensors, vehicles and people. This new paradigm demands new engineering communication solutions to overcome miniaturization and spectrum scarcity. Novel pervasive communication paradigms will be conceived by the means of a cutting edge multidisciplinary research approach integrating (quasi) particles (e.g. phonons) and specific features of the (meta)material (e.g. chirality) in the design of the communication mechanisms. In particular, by the means of the meta-materials, it would be possible to control the propagation environment. More specifically, through this paradigm it will be possible to manipulate not only the desired signals, but also the interfering signals.

8.2.2. ADT

8.2.2.1. Catimex

Participants: Matthieu Berthome, Nathalie Mitton [contact person], Julien Vandaele.

Duration: September 2017 -June 2019

Coordinator: Inria FUN

The purpose of this project is to foster research transfer in IoT from ADT members to their industrial partners by widening experimental features and PoC realization. It is lead in closed partnership with Inria Chile and Université of Strasbourg.

8.2.3. Equipements d'Excellence

8.2.3.1. FIT

Participants: Nathalie Mitton [contact person], Julien Vandaele, Matthieu Berthome.

Title: Future Internet of Things

Type: EquipEx

Duration: March 2010 - December 2019

Coordinator: UPMC

See also: http://fit-equipex.fr/

Abstract: FIT (Future Internet of Things) aims to develop an experimental facility, a federated and competitive infrastructure with international visibility and a broad panel of customers. It will provide this facility with a set of complementary components that enable experimentation on innovative services for academic and industrial users. The project will give French Internet stakeholders a means to experiment on mobile wireless communications at the network and application layers thereby accelerating the design of advanced networking technologies for the Future Internet. FIT is one of 52 winning projects from the first wave of the French Ministry of Higher Education and Research's "Equipements d'Excellence" (Equipex) research grant program. Coordinated by Professor Serge Fdida of UPMC Sorbonne Universités and running over a nine-year period, the project will benefit from a 5.8 million euro grant from the French government.

8.3. European Initiatives

8.3.1. H2020 Projects

8.3.1.1. VESSEDIA

Participants: Rehan Malak, Nathalie Mitton, Allan Blanchard [contact person].

Title: Verification Engineering of Safety and Security Critical Dynamic Industrial Applications

Program: H2020

Duration: January 2017 - Dec. 2019

Coordinator: Technikon Forschungs und Planungsgesellschaft MBH (TEC)

The VESSEDIA project will bring safety and security to many new software applications and devices. In the fast evolving world we live in, the Internet has brought many benefits to individuals, organizations and industries. With the capabilities offered now (such as IPv6) to connect billions of devices and therefore humans together, the Internet brings new threats to the software developers and VESSEDIA will allow connected applications to be safe and secure. VESSEDIA proposes to enhance and scale up modern software analysis tools, namely the mostly open-source Frama-C Analysis platform, to allow developers to benefit rapidly from them when developing connected applications. At the forefront of connected applications is the IoT, whose growth is exponential and whose security risks are real (for instance in hacked smart phones). VESSEDIA will take this domain as a target for demonstrating the benefits of using our tools on connected applications. VESSEDIA will tackle this challenge by 1) developing a methodology that allows to adopt and use source code analysis tools efficiently and produce similar benefits than already achieved for highly-critical applications (i.e. an exhaustive analysis and extraction of faults), 2) enhancing the Frama-C toolbox to enable efficient and fast implementation, 3) demonstrating the new toolbox capabilities on typical IoT (Internet of Things) applications including an IoT Operating System (Contiki), 4) developing a standardization plan for generalizing the use of the toolbox, 5) contributing to the Common Criteria certification process, and 6) defining a label "Verified in Europe" for validating software products with European technologies such as Frama-C. This project yields to set of publications in 2019: [17], [18], [35].

8.3.1.2. CyberSANE

Participants: Valeria Loscri, Nathalie Mitton [contact person], Edward Staddon.

Title: Cyber Security Incident Handling, Warning and Response System for the European Critical Infrastructures

Program: H2020

Duration: September 2019 - September 2022

CyberSANE aims to enhance the security and resilience of Critical Information Infrastructures (CIIs) by providing a dynamic collaborative, warning and response system supporting and guiding security officers and operators (e.g. Incident Response professionals) to recognize, identify, dynamically analyze, forecast, treat and respond to advanced persistent threats (APTs) and handle their daily cyber incidents utilizing and combining both structured data (e.g. logs and network traffic) and unstructured data (e.g. data coming from social networks and dark web).

In achieving that aim, CyberSANE will introduce a holistic and privacy-aware approach in handling security incidents, addressing the complexity of these nets consisting of cyber assets hosted in cross-border, heterogeneous Critical Information Infrastructures (CIs). Moreover, CyberSANE is fully in-line with relevant regulations (such as the GDPR and NIS directive), which requires organizations to increase their preparedness, improve their cooperation with each other, and adopt appropriate steps to manage security risks, report and handle security incidents.

8.4. International Initiatives

8.4.1. Inria International Labs

8.4.1.1. Agrinet

Participants: Christian Salim, Brandon Foubert, Nathalie Mitton [contact person].

Title: Agrinet

International Partner (Institution - Laboratory - Researcher): Stellenbosch University, South Africa, Riaan Wolhuter

Type: LIRIMA Associate team

Duration: 2017-2020

See also: https://team.inria.fr/agrinet/

The current drought and limited water resources in many parts of Southern Africa and beyond, already have a significant impact on agriculture and hence, food production. Sustainable food security depends upon proper plant and crop management respectful of soils and natural re- sources, such as water. This includes very important South African farming areas, such as the Western Cape and Northern Cape. In France, agriculture is also hugely important. Not just nationally, but also in Europe. The system proposed can be applied to a variety of crops. The economic- and social consequences are profound and any contribution towards more efficient farming within increasingly onerous natural constraints, should be a priority. To address these constraints, we propose to develop a flexible, rapidly deployable, biological/agricultural data acquisition platform and associated machine learning algorithms to create advanced agricultural monitoring and management techniques, to improve crop management and use of natural resources. The project also addresses an industry with very high socioeconomic impact.

Publications issued from that project in 2019 are: [12], [16].

8.4.2. Inria International Partners

8.4.2.1. Declared Inria International Partners

Université Mediterranea di Reggio Calabria (UNIC) (Italy): The objective of this collaboration is the design of an innovative architecture that enables autonomic and decentralized fruition of the services offered by the network of smart objects in many heterogeneous and dynamic environments, such that is independent of the network topology, in a reliable and flexible way. The result is an 'ecosystem' of self-organized and self-sustained objects, capable of making data and services available to the users wherever and whenever required, thus supporting the fruition of an 'augmented' reality thanks to a new environmental and social awareness.

8.4.2.2. Informal International Partners

Anna-Maria Vegni from Roma Tre University, Italy: The purpose of this collaboration is to study alternative communication paradigms and investigate their limitations and different effects on performances. In this framework, joint publications have been obtained, among them in 2019 [23], [33], [15], [24], [32].

8.4.3. Participation in Other International Programs

8.4.3.1. International Initiatives

CroMo

Title: Crowd data in the mobile cloud

International Partner (Institution - Laboratory - Researcher):

Universidade Federal do Rio de Janeiro (Brazil) - GTA Laboratory - Luis Henrique Costa

Duration: 2015 - 2019

Start year: 2015

CroMo's main goal is to investigate alternatives to efficiently offload multiple data collected from mobile users to the cloud. To achieve this goal, CroMo will focus on three complementary objectives:

- Objective 1 (Data acquisition): In a wireless environment, data can be sourced at a multitude of wireless devices. Hence, the first objective of this project is to identify the most relevant information from all the data available by using local criteria. The notion of local can be concerned with a single wireless device or a set of nearby wireless devices. The goal is to only send relevant data to the cloud or to assign a higher priority to it.
- Objective 2 (Data transmission): The large-scale sensing system forces massive transmission to the cloud. Hence, transmitting the data in a reliable and timely fashion is the purpose of this second objective.
- Objective 3 (Data computation): Mobile clouds must be available for wireless users to receive and process data. Hence, the cloud infrastructure must be efficient enough to process data from users in a efficient fashion. The third objective of this project is to evaluate cloud availability and to propose performance improvements for data computation. Such improvements are concerned with cloud infrastructure adaptation according to users' demands.

In this context, our project is original and ambitious. Indeed, compared to other studies in wireless networking, our project is focused on a global approach from raw data acquisition to information creation at the mobile cloud infrastructure.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Several researchers have visited our group in 2019, mainly from our partner universities but not only:

- Gewu Bu, LIP6, France, January 2019
- Noura Mares, University of Sfax, Tunisia, from June 2019 until July 2019
- Marco Di Renzo, Centrale Supelec, France, August 2019
- Riaan Wolhuter, Stellenbosch University, South Africa, September 2019

GANG Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR DESCARTES

Participants: Carole Gallet Delporte, Hugues Fauconnier, Pierre Fraigniaud, Adrian Kosowski, Laurent Viennot.

Cyril Gavoille (U. Bordeaux) leads this project that grants 1 Post-Doc. H. Fauconnier is the local coordinator (This project began in October 2016).

Despite the practical interests of reusable frameworks for implementing specific distributed services, many of these frameworks still lack solid theoretical bases, and only provide partial solutions for a narrow range of services. We argue that this is mainly due to the lack of a generic framework that is able to unify the large body of fundamental knowledge on distributed computation that has been acquired over the last 40 years. The DESCARTES project aims at bridging this gap, by developing a systematic model of distributed computation that organizes the functionalities of a distributed computing system into reusable modular constructs assembled via well-defined mechanisms that maintain sound theoretical guarantees on the resulting system. DESCARTES arises from the strong belief that distributed computing is now mature enough to resolve the tension between the social needs for distributed computing systems, and the lack of a fundamentally sound and systematic way to realize these systems.

8.1.2. ANR MultiMod

Participants: Adrian Kosowski, Laurent Viennot.

David Coudert (Sophia Antipolis) leads this project. L. Viennot coordinates locally. The project began in 2018.

The MultiMod project aims at enhancing the mobility of citizens in urban areas by providing them, through a unique interface enabling to express their preferences, the most convenient transportation means to reach their destinations. Indeed, the increasing involvement of actors and authorities in the deployment of more responsible and cost-effective logistics and the progress made in the field of digital technology have made possible to create synergies in the creation of innovative services for improving the mobility in cities. However, users are faced with a number of solutions that coexist at different scales, providing complementary information for the mobility of users, but that make very complex to find the most convenient itinerary at a given time for a specific user. In this context, MultiMod aims at improving the mobility of citizens in urban areas by proposing contextualized services, linking users, to facilitate multimodal transport by combining, with flexibility, all available modes (planned/dynamic carpooling, public transport (PT), car-sharing, bicycle, etc.).

We consider the use of carpooling in metropolitan areas, and so for short journeys. Such usage enables itineraries that are not possible with PT, allows for opening up areas with low PT coverage by bringing users near PT (last miles), and for faster travel-time when existing PT itineraries are too complex or with too low frequency (e.g., one bus per hour). In this context, the application must help the driver and the passenger as much as possible. In particular, the application must propose the meeting-point, indicate the driver the detour duration, and indicate the passenger how to reach this meeting-point using PT. Here, the time taken by drivers and passengers to agree becomes a critical issue and so the application must provide all needed information to quickly take a decision (i.e., in one click).

In addition, the era of Smart City gathers many emerging concepts, driven by innovative technological players, which enables the exploitation of real-time data (e.g., delay of a bus, traffic jam) made available by the various actors (e.g., communities in the framework of Open Data projects, users via their mobile terminals, traffic supervision authorities). In the MultiMod project, we will use these rich sources of data to propose itineraries that are feasible at query-time. Our findings will enable the design of a mobility companion able not only to guide the user along her journey, including when and how to change of transportation mean, but also to propose itinerary changes when the current one exceeds a threshold delay. The main originality of this project is thus to address the problem of computing itineraries in large-scale networks combining PT, carpooling and real-time data, and to satisfy the preferences of users. We envision that the outcome of this project will significantly improve the daily life of citizens.

The targeted metropolitan area for validating our solutions is Ile-de-France. Indeed, Instant-System is currently developing the new application “Vianavigo lab” which will replace the current “Vianavigo” application for the PT network of Ile-de-France. Our findings will therefore be tested at scale and eventually be integrated and deployed in production servers and mobile applications. The smaller networks of Bordeaux and Nice will be used to perform preliminary evaluations since Instant System already operates applications in these cities (Boogi Nice, Boogi Bordeaux). An important remark is that new features and algorithms can contractually be deployed in production every 4 months, thus enabling Instant System to measure and challenge the results of the MultiMod project in continue. This is a chance for the project to maximize its impact.

8.1.3. ANR FREDDA

Participants: Carole Gallet Delporte, Hugues Fauconnier, Pierre Fraigniaud.

Arnaud Sangnier (IRIF, Univ Paris Diderot) leads this project that grants 1 PhD. (This project began in October 2017).

Distributed algorithms are nowadays omnipresent in most systems and applications. It is of utmost importance to develop algorithmic solutions that are both robust and flexible, to be used in large scale applications. Currently, distributed algorithms are developed under precise assumptions on their execution context: synchronicity, bounds on the number of failures, etc. The robustness of distributed algorithms is a challenging problem that has not been much considered until now, and there is no systematic way to guarantee or verify the behavior of an algorithm beyond the context for which it has been designed. We propose to develop automated formal method techniques to verify the robustness of distributed algorithms and to support the development of robust applications. Our methods are of two kinds: statically through classical verification, and dynamically, by synthesizing distributed monitors, that check either correctness or the validity of the context hypotheses at runtime.

8.1.4. ANR Distancia

Participants: Pierre Charbit, Michel Habib, Laurent Viennot.

Victor Chepoi (Univ. Marseille) leads this project. P. Charbit coordinates locally. The project began in early-2018.

The theme of the project is Metric Graph Theory, and we are concerned both on theoretical foundations and applications. Such applications can be found in real world networks. For example, the hub labelling problem in road networks can be directly applied to car navigation applications. Understanding key structural properties of large-scale data networks is crucial for analyzing and optimizing their performance, as well as improving their reliability and security. In prior empirical and theoretical studies researchers have mainly focused on features such as small world phenomenon, power law degree distribution, navigability, and high clustering coefficients. Although those features are interesting and important, the impact of intrinsic geometric and topological features of large-scale data networks on performance, reliability and security is of much greater importance. Recently, there has been a surge of empirical works measuring and analyzing geometric characteristics of real-world networks, namely the Gromov hyperbolicity (called also the negative curvature) of the network. It has been shown that a number of data networks, including Internet application networks, web networks, collaboration networks, social networks, and others, have small hyperbolicity.

Metric graph theory was also indispensable in solving some open questions in concurrency and learning theory in computer science and geometric group theory in mathematics. Median graphs are exactly the 1–skeletons of CAT(0) cube complexes (which have been characterized by Gromov in a local-to-global combinatorial way). They play a vital role in geometric group theory (for example, in the recent solution of the famous Virtual Haken Conjecture). Median graphs are also the domains of event structures of Winskel, one of the basic abstract models of concurrency. This correspondence is very useful in dealing with questions on event structures.

Many classical algorithmic problems concern distances: shortest path, center and diameter, Voronoi diagrams, TSP, clustering, etc. Algorithmic and combinatorial problems related to distances also occur in data analysis. Low-distortion embeddings into l1-spaces (theorem of Bourgain and its algorithmical use by Linial et al.) were the founding tools in metric methods. Recently, several approximation algorithms for NP-hard problems were designed using metric methods. Other important algorithmic graph problems related to distances concern the construction of sparse subgraphs approximating inter-node distances and the converse, augmentation problems with distance constraints. Finally, in the distributed setting, an important problem is that of designing compact data structures allowing very fast computation of inter- node distances or routing along shortest or almost shortest paths. Besides computer science and mathematics, applications of structures involving distances can be found in archeology, computational biology, statistics, data analysis, etc. The problem of characterizing isometric subgraphs of hypercubes has its origin in communication theory and linguistics. . To take into account the recombination effect in genetic data, the mathematicians Bandelt and Dress developed in 1991 the theory of canonical decompositions of finite metric spaces. Together with geneticists, Bandelt successfully used it over the years to reconstruct phylogenies, in the evolutional analysis of mtDNA data in human genetics. One important step in their method is to build a reduced median network that spans the data but still contains all most parsimonious trees. As mentioned above, the median graphs occurring there constitute a central notion in metric graph theory.

With this project, we aim to participate at the elaboration of this new domain of Metric Graph Theory, which requires experts and knowledge in combinatorics (graphs, matroids), geometry, and algorithms. This expertise is distributed over the members of the consortium and a part of the success of our project it will be to share these knowledges among all the members of the consortium. This way we will create a strong group in France on graphs and metrics.

8.1.5. ANR HOSIGRA

Participants: Pierre Charbit, Michel Habib.

This project starting in early-2018, led by Reza Naserasr, explores the connection between minors and colorings, exploiting the notion of signed graphs. With the four colour theorem playing a central role in development of Graph Theory, the notions of minor and coloring have been branded as two of the most distinguished concepts in this field. The geometric notion of planarity has given birth to the theory of minors among others, and coloring have proven to have an algebraic nature through its extension to the theory of graph homomorphisms. Great many projects have been completed on both subjects, but what remains mostly a mystery is the correlation of the two subjects. The four color theorem itself, in slightly stronger form, claims that if a complete graph on five vertices cannot be formed by minor operation from a given graph, then the graph can be homomorphically mapped into the complete graph on four vertices (thus a 4-coloring). Commonly regarded as the most challenging conjecture on graph theory, the Hadwiger conjecture claims that five and four in this theorem can be replaced with n and $n-1$ respectively for any value of n. The correlation of these two concepts has been difficult to study, mainly for the following reason: While the coloring or homomorphism problems roots back into intersections of odd-cycles, the minor operation is irrelevant of the parity of cycles. To overcome this barrier, the notion of signed graphs has been used implicitly since 1970s when coloring results on graphs with no odd-K4 is proved, following which a stronger form of the Hadwiger conjecture, known as Odd Hadwiger conjecture, was proposed by P. Seymour and B. Gerards, independently. Being a natural subclass of Matroids and a superclass of graphs, the notion of minor of signed graphs is well studied and many results from graph minor are either already extended to signed graphs or it is considered by experts of the subject. Observing the importance, and guided by some earlier works, in particular that of B.

Guenin, we then started the study of algebraic concepts (coloring and homomormphisms) for signed graphs. Several results have been obtained in the past decade, and this project aims at exploring more of this topic.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

Amos Korman has an ERC Consolidator Grant entitled "Distributed Biological Algorithms (DBA)", started in May 2015. This project proposes a new application for computational reasoning. More specifically, the purpose of this interdisciplinary project is to demonstrate the usefulness of an algorithmic perspective in studies of complex biological systems. We focus on the domain of collective behavior, and demonstrate the benefits of using techniques from the field of theoretical distributed computing in order to establish algorithmic insights regarding the behavior of biological ensembles. The project includes three related tasks, for which we have already obtained promising preliminary results. Each task contains a purely theoretical algorithmic component as well as one which integrates theoretical algorithmic studies with experiments. Most experiments are strategically designed by the PI based on computational insights, and are physically conducted by experimental biologists that have been carefully chosen by the PI. In turn, experimental outcomes will be theoretically analyzed via an algorithmic perspective. By this integration, we aim at deciphering how a biological individual (such as an ant) "thinks", without having direct access to the neurological process within its brain, and how such limited individuals assemble into ensembles that appear to be far greater than the sum of their parts. The ultimate vision behind this project is to enable the formation of a new scientific field, called algorithmic biology, that bases biological studies on theoretical algorithmic insights.

8.2.2. LIA Struco

Pierre Charbit is director of the LIA STRUCO, which is an Associated International Laboratory of CNRS between IÚUK, Prague, and IRIF, Paris. The director on the Czech side is Pr. Jaroslav Nešetřil. The primary theme of the laboratory is graph theory, more specifically: sparsity of graphs (nowhere dense classes of graphs, bounded expansion classes of graphs), extremal graph theory, graph coloring, Ramsey theory, universality and morphism duality, graph and matroid algorithms and model checking.

STRUCO focuses on high-level study of fundamental combinatorial objects, with a particular emphasis on comprehending and disseminating the state-of-the-art theories and techniques developed. The obtained insights shall be applied to obtain new results on existing problems as well as to identify directions and questions for future work.

One of the main goals of STRUCO is to provide a sustainable and reliable structure to help Czech and French researchers cooperate on long-term projects, disseminate the results to students of both countries and create links between these students more systematically. The chosen themes of the project indeed cover timely and difficult questions, for which a stable and significant cooperation structure is needed. By gathering an important number of excellent researchers and students, the LEA will create the required environment for making advances, which shall be achieved not only by short-term exchanges of researchers, but also by a strong involvement of Ph. D students in the learning of state-of-the-art techniques and in the international collaborations.

STRUCO is a natural place to federate and organize these many isolated collaborations between our two countries. Thus, the project would ensure long-term cooperations and allow young researchers (especially PhD students) to maintain the fruitful exchanges between the two countries in the future years, in a structured and federated way.

8.3. International Initiatives

8.3.1. Inria Associate Teams Not Involved in an Inria International Labs

Carole Delporte-Gallet and Hugues Fauconnier are members of the Inria-MEXICO Equipe Associée LiDiCo (At the Limits of Distributed Computability, https://sites.google.com/site/lidicoequipeassociee/).

8.3.2. Inria International Partners

8.3.2.1. Informal International Partners

Ofer Feinerman (Physics department of complex systems, Weizmann Institute of Science, Rehovot, Israel), is a team member in Amos Korman's ERC project DBA. This collaboration has been formally established by signing a contract between the CNRS and the Weizmann Institute of Science, as part of the ERC project.

Rachid Guerraoui (School of Computer and Communication Sciences, EPFL, Switzerland) maintains an active research collaboration with Gang team members (Carole Delporte, Hugues Fauconnier).

Sergio Rajsbaum (UNAM, Mexico) is a regular collaborator of the team, also involved formally in a joint French-Mexican research project (see next subsection).

Boaz Patt-Shamir (Tel Aviv University, Israel) is a regular collaborator of the team, also involved formally in a joint French-Israeli research project (see next subsection).

8.4. International Research Visitors

8.4.1. Visits to International Teams

- Laurent Viennot has visited Archontia Giannopoulou at National and Kapodistrian University of Athens from July 1st to July 7th.
- Michel Habib has visited Prof. M. Chen (Xiamen University of Technology) and Prof. Lin Cheng-Kuan (Fuzhou University) in China, 9-15 december.

HIEPACS Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. HPC-Ecosystem

Participants: Emmanuel Agullo, Olivier Beaumont, Olivier Coulaud, Aurélien Esnard, Lionel Eyraud-Dubois, Mathieu Faverge, Luc Giraud, Abdou Guermouche, Pierre Ramet, Guillaume Sylvand.

Grant: Regional council
Dates: 2018 – 2020
Partners: EPIs STORM, TADAAM from Inria Bordeaux Sud-Ouest, Airbus, CEA-CESTA, INRA
Overview:

Numerical simulation is today integrated in all cycles of scientific design and studies, whether academic or industrial, to predict or understand the behavior of complex phenomena often coupled or multi-physical. The quality of the prediction requires having precise and adapted models, but also to have computation algorithms efficiently implemented on computers with architectures in permanent evolution. Given the ever increasing size and sophistication of simulations implemented, the use of parallel computing on computers with up to several hundred thousand computing cores and consuming / generating massive volumes of data becomes unavoidable; this domain corresponds to what is now called High Performance Computing (HPC). On the other hand, the digitization of many processes and the proliferation of connected objects of all kinds generate ever-increasing volumes of data that contain multiple valuable information; these can only be highlighted through sophisticated treatments; we are talking about Big Data. The intrinsic complexity of these digital treatments requires a holistic approach with collaborations of multidisciplinary teams capable of mastering all the scientific skills required for each component of this chain of expertise.

To have a real impact on scientific progress and advances, these skills must include the efficient management of the massive number of compute nodes using programming paradigms with a high level of expressiveness, exploiting high-performance communications layers, effective management for intensive I / O, efficient scheduling mechanisms on platforms with a large number of computing units and massive I / O volumes, innovative and powerful numerical methods for analyzing volumes of data produced and efficient algorithms that can be integrated into applications representing recognized scientific challenges with high societal and economic impacts. The project we propose aims to consider each of these links in a consistent, coherent and consolidated way.

For this purpose, we propose to develop a unified Execution Support (SE) for large-scale numerical simulation and the processing of large volumes of data. We identified four Application Challenges (DA) identified by the Nouvelle-Aquitaine region that we propose to carry over this unified support. We will finally develop four Methodological Challenges (CM) to evaluate the impact of the project. This project will make a significant contribution to the emerging synergy on the convergence between two yet relatively distinct domains, namely High Performance Computing (HPC) and the processing, management of large masses of data (Big Data); this project is therefore clearly part of the emerging field of High Performance Data Analytics (HPDA).

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. SASHIMI: Sparse Direct Solver using Hierarchical Matrices

Participants: Aurélien Esnard, Mathieu Faverge, Pierre Ramet.

Grant: ANR-18-CE46-0006
Dates: 2018 – 2022

Overview: Nowadays, the number of computational cores in supercomputers has grown largely to a few millions. However, the amount of memory available has not followed this trend, and the memory per core ratio is decreasing quickly with the advent of accelerators. To face this problem, the SaSHiMi project wants to tackle the memory consumption of linear solver libraries used by many major simulation applications by using low-rank compression techniques. In particular, the direct solvers which offer the most robust solution to strategy but suffer from their memory cost. The project will especially investigate the super-nodal approaches for which low-rank compression techniques have been less studied despite the attraction of their large parallelism and their lower memory cost than for the multi-frontal approaches. The results will be integrated in the PaStiX solver that supports distributed and heterogeneous architectures.

8.2.1.2. SOLHARIS: SOLvers for Heterogeneous Architectures over Runtime systems, Investigating Scalability

Participants: Emmanuel Agullo, Olivier Beaumont, Mathieu Faverge, Lionel Eyraud-Dubois, Abdou Guermouche, Pierre Ramet, Guillaume Sylvand.

Grant: ANR-19-CE46-0009
Dates: 2019 – 2023
Overview: The SOLHARIS project aims at addressing the issues related to the development of fast and scalable linear solvers for large-scale, heterogeneous supercomputers. Because of the complexity and heterogeneity of the targeted algorithms and platforms, this project intends to rely on modern runtime systems to achieve high performance, programmability and portability. By gathering experts in computational linear algebra, scheduling algorithms and runtimes, SOLHARIS intends to tackle these issues through a considerable research effort for the development of numerical algorithms and scheduling methods that are better suited to the characteristics of large scale, heterogeneous systems and for the improvement and extension of runtime systems with novel features that more accurately fulfill the requirements of these methods. This is expected to lead to fundamental research results and software of great interest for researchers of the scientific computing community.

8.2.2. FUI

8.2.2.1. ICARUS: Intensive Calculation for AeRo and automotive engines Unsteady Simulations

Participants: Cyril Bordage, Aurélien Esnard.

Grant: FUI-22
Dates: 2016-2020
Partners: SAFRAN, SIEMENS, IFPEN, ONERA, DISTENE, CENAERO, GDTECH, Inria, CORIA, CERFACS.
Overview: Large Eddy Simulation (LES) is an increasingly attractive unsteady modelling approach for modelling reactive turbulent flows due to the constant development of massively parallel supercomputers. It can provide open and robust design tools that allow access to new concepts (technological breakthroughs) or a global consideration of a structure (currently processed locally). The mastery of this method is therefore a major competitive lever for industry. However, it is currently constrained by its access and implementation costs in an industrial context. The ICARUS project aims to significantly reduce them (costs and deadlines) by bringing together major industrial and research players to work on the entire high-fidelity LES computing process by:

- increasing the performance of existing reference tools (for 3D codes: AVBP, Yales2, ARGO) both in the field of code coupling and code/machine matching;
- developing methodologies and networking tools for the LES;
- adapting the ergonomics of these tools to the industrial world: interfaces, data management, code interoperability and integrated chains;
- validating this work on existing demonstrators, representative of the aeronautics and automotive industries.

8.2.3. Inria Project Labs

8.2.3.1. IPL HPC BigData

The goal of the HPC-BigData IPL is to gather teams from the HPC, Big Data and Machine Learning (ML) areas to work at the intersection between these domains. HPC and Big Data evolved with their own infrastructures (supercomputers versus clouds), applications (scientific simulations versus data analytics) and software tools (MPI and OpenMP versus Map/Reduce or Deep Learning frameworks). But Big Data analytics is becoming more compute-intensive (thanks to deep learning), while data handling is becoming a major concern for scientific computing. Within the IPL, we are in particular involved in a tight collaboration with Zenith Team (Montpellier) on how to parallelize and how to deal with memory issues in the context of the training phase of Pl@ntnet (https://www.plantnet.org). Alexis Joly (Zenith) co supervises with Olivier Beaumont the PhD Thesis of Alena Shilova.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. EoCoE-II

Title: Energy oriented Centre of Excellence for computer applications

Program: H2020

Duration: January 2019 - December 2021

Coordinator: CEA

Partners:

- Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)
- Commissariat A L Energie Atomique et Aux Energies Alternatives (France)
- Centre Europeen de Recherche et de Formation Avancee en Calcul Scientifique (France)
- Consiglio Nazionale Delle Ricerche (Italy)
- The Cyprus Institute (Cyprus)
- Agenzia Nazionale Per le Nuove Tecnologie, l'energia E Lo Sviluppo Economico Sostenibile (Italy)
- Fraunhofer Gesellschaft Zur Forderung Der Angewandten Forschung Ev (Germany)
- Instytut Chemii Bioorganicznej Polskiej Akademii Nauk (Poland)
- Forschungszentrum Julich (Germany)
- Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V. (Germany)
- University of Bath (United Kingdom)
- Universite Libre de Bruxelles (Belgium)
- Universita Degli Studi di Trento (Italy)

Inria contact: Bruno Raffin

The Energy-oriented Centre of Excellence (EoCoE) applies cutting-edge computational methods in its mission to accelerate the transition to the production, storage and management of clean, decarbonized energy. EoCoE is anchored in the High Performance Computing (HPC) community and targets research institutes, key commercial players and SMEs who develop and enable energy-relevant numerical models to be run on exascale supercomputers, demonstrating their benefits for low carbon energy technology. The present project will draw on a successful proof-of-principle phase of EoCoE-I, where a large set of diverse computer applications from four such energy domains achieved significant efficiency gains thanks to its multidisciplinary expertise in applied mathematics and supercomputing. During this 2nd round, EoCoE-II will channel its efforts into 5 scientific Exascale challenges in the low-carbon sectors of Energy Meteorology, Materials, Water, Wind and Fusion. This multidisciplinary effort will harness innovations in computer science and mathematical algorithms within a tightly integrated co-design approach to overcome performance bottlenecks and to anticipate future HPC hardware developments. A world-class consortium of 18 complementary partners from 7 countries will form a unique network of expertise in energy science, scientific computing and HPC, including 3 leading European supercomputing centres. New modeling capabilities in selected energy sectors will be created at unprecedented scale, demonstrating the potential benefits to the energy industry, such as accelerated design of storage devices, high-resolution probabilistic wind and solar forecasting for the power grid and quantitative understanding of plasma core-edge interactions in ITER-scale tokamaks. These flagship applications will provide a high-visibility platform for high-performance computational energy science, cross-fertilized through close working connections to the EERA and EUROfusion consortia.

8.3.1.2. PRACE 6IP

Title: PRACE Sixth Implementation Phase (PRACE-6IP) project

Duration: May 2019 - December 2021

Partners: see the following url

Inria contact: Luc Giraud

PRACE, the Partnership for Advanced Computing is the permanent pan-European High Performance Computing service providing world-class systems for world-class science. Systems at the highest performance level (Tier-0) are deployed by Germany, France, Italy, Spain and Switzerland, providing researchers with more than 17 billion core hours of compute time. HPC experts from 25 member states enabled users from academia and industry to ascertain leadership and remain competitive in the Global Race. Currently PRACE is finalizing the transition to PRACE 2, the successor of the initial five year period. The objectives of PRACE-6IP are to build on and seamlessly continue the successes of PRACE and start new innovative and collaborative activities proposed by the consortium. These include: assisting the development of PRACE 2; strengthening the internationally recognised PRACE brand; continuing and extend advanced training which so far provided more than 36 400 person·training days; preparing strategies and best practices towards Exascale computing, work on forward-looking SW solutions; coordinating and enhancing the operation of the multi-tier HPC systems and services; and supporting users to exploit massively parallel systems and novel architectures. A high level Service Catalogue is provided. The proven project structure will be used to achieve each of the objectives in 7 dedicated work packages. The activities are designed to increase Europe's research and innovation potential especially through: seamless and efficient Tier-0 services and a pan-European HPC ecosystem including national capabilities; promoting take-up by industry and new communities and special offers to SMEs; assistance to PRACE 2 development; proposing strategies for deployment of leadership systems; collaborating with the ETP4HPC, CoEs and other European and international organisations on future architectures, training, application support and policies. This will be monitored through a set of KPIs.

8.3.1.3. EOSC-Pillar

Title: Coordination and Harmonisation of National and Thematic Initiatives to support EOSC

Duration: 2019 - 2023

Partners: see the following url

Inria contact: Stefano Zacchiroli

The project aims to support the coordination and harmonization of national initiatives relevant to EOSC in Europe and investigate the option for them to interfederate at a later stage, help integrating initiatives and data/cloud providers through the development of common policies and tools, and facilitate user communities in adopting and using these services and propose new ones born from their scientific domain. To this end, the project will integrate a bottom-up approach (by voicing the requirements and needs expressed by the different scientific communities operating at the national level) and a top-down one (by harmonising the national strategies and translating them in a viable work plan). In the longer term, this is expected to facilitate the design and adoption of common policies and streamline the process of joining EOSC for service providers and user communities while helping populating the EOSC with useful services of wider European interest, based on the real needs and interests of the European scientific communities. In order to maximise this simplification process, the project will collaborate with related regional and thematic initiatives.

8.3.1.4. EXDCI-2

Title: European Extreme Data & Computing Initiative

Duration: 2010 - 2020

Partners: see the following url

Inria contact: Olivier Beaumont

Through the joint action of PRACE and ETP4HPC, EXDCI-2 mobilises the European HPC stakeholders. The project participates in the support of the European HPC Ecosystem with two main goals. First, the development and advocacy of a competitive European HPC Exascale Strategy by supporting the implementation of a common European HPC strategy, open to synergistic areas including High Performance Data Analytics (HPDA) and Artificial Intelligence (AI). Secondly, the coordination of the stakeholder community for European HPC at the Exascale through joint community structuring and synchronisation, such as (i) the development of relationships with other ecosystems including upstream technologies as Big Data (BDVA) (ii) in the context of the upcoming European Data Infrastructure (EDI) a road mapping activity toward future converged HPC, HPDA and AI needs and new services from PRACE users communities and CoE and (iii) the continuation of BDEC activities, for international participation of European stakeholders on the integration from edge computing to HPC, including Data Analytics and AI.

8.4. International Initiatives

8.4.1. Inria International Labs

There is an ongoing reasearch activity with Argonne National Laboratory in the framework of the JLESC International Lab, through a postdoc funded by the DPI, namely Nick Schenkels, who work on data compression techniques in Krylov methods for the solution of large linear systems. The objective is to use agnostic compressor developped at Argonne to compress the basis involved in Krylov methods that have a large memory footprint. The challange is to design algorithm that reduce the memory consumption, hence the energy, while preserving the numerical convergence of the numerical technique.

INDES Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Skini

Skini was used for the production of a musical piece as part of SACEM's "Music Factory" program in collaboration with the *CIRM* in Nice and the *Conservatory of Nice*. This piece was designed, and produced in May at the Nice Conservatory, by 12 years old pupils of the Nucéra secondary school in Nice after a dozen working sessions within the school. This production is followed by a similar project with 14 years old pupils as part of the "Cordé de la résussite" programme run by Inria with the objective of a musical production in spring 2020.

8.2. National Initiatives

8.2.1. ANR CISC

The CISC project (Certified IoT Secure Compilation) is funded by the ANR for 42 months, starting in April 2018. The goal of the CISC project is to provide strong security and privacy guarantees for IoT applications by means of a language to orchestrate IoT applicatoins from the microcontroller to the cloud. Tamara Rezk coordinates this project, and Manuel Serrano, Ilaria Castellani and Nataliia Bielova participate in the project. The partners of this project are Inria teams Celtique, Indes and Privatics, and Collège de France.

8.2.2. ANR PrivaWeb

The PrivaWeb project (Privacy Protection and ePrivacy Compliance for Web Users) is funded by the ANR JCJC program for 48 months, started in December 2018. PrivaWeb aims at developing new methods for detection of new Web tracking technologies and new tools to integrate in existing Web applications that seamlessly protect privacy of users.

Nataliia Bielova coordinates this project.

8.2.3. PIA ANSWER

The ANSWER project (Advanced aNd Secured Web Experience and seaRch) is funded by PIA program for 36 months, starting January 1, 2018. The aim of the ANSWER project is to develop the new version of the http://www.qwant.com search engine by introducing radical innovations in terms of search criteria as well as indexed content and users' privacy. The partners of this project include QWANT and Inria teams Wimmics, Indes, Neo and Diana.

8.3. Inria Internal Funding

8.3.1. IPL SPAI

SPAI (Security Program Analyses for the IoT) is an IPL (Inria Project Lab), with a duration of 4 years, started on April 2018. Members of the Antique, Celtique, Indes, Kairos, and Privatics Inria teams are involved in the SPAI IPL.

SPAI is concerned with the design of program analyses for a multitier language for the Internet of Things (IoT). The programming abstractions will allow us to reason about IoT systems from microcontrollers to the cloud. Relying on the Inria multitier language Hop.js semantics and the current Coq formalizations of JavaScript semantics, we plan to certify these analyses in order to guarantee the impossibility of security properties violations and implement security properties' enforcements by compilation.

8.3.2. AEx DATA4US

DATA4US is a joint project between two teams in Inria Sophia Antipolis and Inria Grenoble - Rhône-Alpes that tackles these interdisciplinary challenges by establishing collaborations with researchers in Law. Members are Nataliia Bielova (INDES) and Cedric Lauradoux (Privatics).

DATA4US will propose a new architecture for exercising access rights that will explain the users whether their data has been legally collected and eventually help contact DPAs for further investigations.

8.3.3. ADT FingerKit

In the context of the Inria ADT call, we are involved in a *FingerKit: a Cloud Platform to Study Browser Fingerprints at Large*, lead by Walter Rudametkin from the Spirals project-team. The funding for a two year engineering position for the 2018-2020 period was obtained and an engineer is hired in Spirals project-team. Nataliia Bielova is part of this project.

8.4. European Initiatives

8.4.1. H2020 Sparta

SPARTA (Strategic Programs for Advanced Research and Technology in Europe) is a novel cybersecurity competence network, with the objective to collaboratively develop and implement top-tier research and innovation actions. Strongly guided by concrete challenges forming an ambitious Cybersecurity Research & Innovation Roadmap, SPARTA will tackle hard innovation challenges, leading the way in building transformative capabilities and forming a world-leading cybersecurity competence network across the EU. Four initial research and innovation programs will push the boundaries to deliver advanced solutions to cover emerging issues, with applications from basic human needs to economic activities, technologies, and sovereignty.

See also: https://www.sparta.eu/

8.4.2. Collaborations in European Programs, Except FP7 & H2020

8.4.2.1. ICT Cost Action IC1405 on Reversible Computation

Program: ICT COST Action IC1405

Project title: Reversible computation - extending horizons of computing

Duration: November 2014 - April 2019

Coordinator: Irek Ulidowski, University of Leicester

Other partners: several research groups, belonging to 23 European countries.

Abstract: Reversible computation is an emerging paradigm that extends the standard mode of computation with the ability to execute in reverse. It aims to deliver novel computing devices and software, and to enhance traditional systems. The potential benefits include the design of reversible logic gates and circuits - leading to low-power computing and innovative hardware for green ICT, new conceptual frameworks and language abstractions, and software tools for reliable and recovery-oriented distributed systems. This was the first European network of excellence aimed at coordinating research on reversible computation.

See also: http://www.revcomp.eu

8.4.2.2. Bilateral PICS project SuCCeSS

Program: CNRS Bilaterial PICS project

Project acronym: SuCCeSS

Project title: Security, Adaptability and time in Communication Centric Software Systems

Duration: June 2016 - June 2019

Coordinator: Cinzia Di Giusto, I3S, Sophia Antipolis

Partners: I3S, Inria, University of Groningen

Abstract: The project SuCCeSS was a CNRS-funded “Projet coopératif” (PICS 07313), involving two French teams in Sophia Antipolis (the MDSC team at the laboratory I3S, acting as coordinator, and the INDES team) and one Dutch team at the University of Groningen. The objective of the project was to study formal models for reliable distributed communication-centric software systems. The project focussed on analysis and validation techniques based on behavioural types, aimed at enforcing various properties (safety, liveness, security) of structured communications.

8.5. International Initiatives

8.5.1. Inria International Partners

8.5.1.1. Informal International Partners

- We are collaborating with Professor of Law, Frederik Zuiderveen Borgesius from the Radbound University Nijmegen and Amsterdam Law School (double affiliation). We are studying General Data Protection Regulation (GDPR) and ePrivacy Regulation and their application to Web tracking technologies.
- We have been collaborating with Prof. Benoit Baudry from KTH Royal Institute of Technology, Sweden and with Pierre Laperdrix from Stony Brook University on the survey of browser fingerprinting technologies.
- We are setting a new collaboration with Dr. Zinaida Benenson from University of Erlangen-Nuremberg, Germany, to study Human Factors in Privacy: in particular, to set up user studies to evaluate their perception and understanding of the cookie banners design and measure the influence of dark patterns on user decisions.
- We are setting a new collaboration with Prof. Martin Johns from TU Braunschweig, Germany, to work on cryptographic primitives to include proof of ownership in browser cookies that would facilitate the exercise of GDRP subject access rights. The is a joint collaboration with Cedric Lauradoux from Privatics.
- We are pursuing our collaboration on session types with Prof. Mariangiola Dezani Ciancaglini from the University of Torino and Prof. Paola Giannini from the University of Piemonte Orientale. This year, this collaboration was extended to Dr. Ross Horne from the University of Luxemburg. We also continue to collaborate with Dr. Jorge Pérez and his PhD student Mauricio Cano, from the University of Groningen, on the integration of session types with synchronous reactive programming.
- We are pursuing our collaboration on reactive programming and on higher contracts for security with Prof. Robby Findler from Northwestern University in Chicago.
- We are pursuing our collaboration with Prof. Marc Feeley from Univerisity of Montréal on the compilation of dynamic languages.

8.5.2. Participation in Other International Programs

8.5.2.1. International Initiatives

DAJA

Title: Detection strategies based on Software Metrics for Multitier JavaScript

International Partners (Institution - Laboratory - Researcher):

Universidad de Chile (Chile), Intelligent Software Construction laboratory (ISCLab) - Alexandre Bergel

Universidad Nacional del Centro de la Provincia de Buenos Aires (Argentina) Computer Science Departement - Santiago Vidal

Duration: 2018 - 2019

Start year: 2018

See also: https://daja-sticamsud.github.io/

JavaScript is the most popular object scripting programming language. It is extensively used conceived only for scripting, it is frequently used in large applications. The rapid adoption of JavaScript has outpaced the Software Engineering community to propose solutions to ensure a satisfactory code quality production. This situation has favored the production of poor quality JavaScript applications: we have found across JavaScript applications a large presence of dead-code (i.e., source code portion that is never used) and code duplications. These symptoms are known to lead to maintenance and performance degradation. Moreover, we have previously analyzed potential security threats to JavaScript applications produced by bad coding practices. The DAJA project will provide methodologies, techniques, and tools to ease the maintenance of software applications written in JavaScript while improving its security.

8.6. International Research Visitors

8.6.1. Visits of International Scientists

- We are collaborating with Cristiana Teixeira Santos from University Toulouse 1-Capitole. Cristiana is a postdoc in Data Protection Law with whom we have been analyzing legal requirements for GDPR consent, and cookie banners in particular. Cristiana has visited us two times in 2019 and will be hired as a postdoc for Inria AEx project DATA4US in 2020.
- As part of our ongoing collaboration on GDPR Subject Access Rights, Cedric Lauradoux has visited us several times in 2019, to expand our existing work [13] and establish new research directions. Cedris is a co-PI for Inria AEx project DATA4US.
- We are collaborating with Prof. Marc Feeley from University of Montréal. For the third consecutive year, M. Feeley has visited us for studying implementation of dynamic languages, and in particular we started a study of the efficient compilation of the Python programming language.
- We are collaborating with Prof. Andrei Sabelfeld from Chalmers University of Technology. A.Sabelfeld has visited us for one month in July 2019 for studying remote timing attackers in the context of IoT frameworks.
- Prof. Robby Findler and his PhD student Spencer Florence visited us in July, where we have organized a mini-workshop during a week, working with Prof. G. Berry and J. Krishnamurthy on the semantics and implementation of reactive languages.

8.6.1.1. Internships

- Nataliia Bielova has co-supervised Hicham Lesfari for 3 months together with Frederic Giroire from Inria Coati team.
- Nataliia Bielova has supervised the intern Michael Toth as a "relai-de-these" for 2 months.
- Ilaria Castellani and Tamara Rezk supervised the intern Carlo Prato for 6 months.
- Tamara Rezk supervised the ENS L3 internship of Maxime Legoupil for 7 weeks in June and July 2019.
- Tamara Rezk has co-supervised the ENS L3 internship of Clément Ogier in July 2019.
- Tamara Rezk supervised the internship of Adam Khayam for 6 months.
- Tamara Rezk supevised -as tutor- the internship of Ayoub Ider Aghbal in a company.

8.6.2. Visits to International Teams

For the third consecutive year, Manuel Serrano and Gérard Berry visited Prof. Robby Findler at University of Northeastern in Chicago. This time, Tamara Rezk joined the delegation that also visited Prof. Christos Dimoulas also working at Northeastern University. The Indes team and Findler's team have applied for the second time to the Inria Associated Team program.

KERDATA Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

8.1.1.1. OverFlow (2015–2019)

Participants: Alexandru Costan, Pedro de Souza Bento Da Silva, Paul Le Noac'h.

Project Acronym: OverFlow

Project Title: Workflow Data Management as a Service for Multisite Applications

Coordinator: Alexandru Costan

Duration: October 2015–October 2019

Other Partners: None (Young Researcher Project, JCJC)

External collaborators: Kate Keahey (University of Chicago and Argonne National Laboratory), Bogdan Nicolae (Argonne National Lab)

Web site: https://sites.google.com/view/anroverflow

This project investigates approaches to data management enabling an efficient execution of geographically distributed workflows running on multi-site clouds.

In 2019, we focused on the challenges of stream processing at the Edge. In particular, Edge computing presents a significant opportunity to realize the potential of distributed ML models with regards to low latency, high availability and privacy. It allows for instance inferences on simple image, video or audio classification; as only the final result is transmitted, delays are minimized, while privacy and bandwidth are preserved in IoT applications. Also, neural networks could be partitioned such that some layers are evaluated at the Edge and the rest in the cloud.

In this context we proposed an architecture in which the initial layers can be used for feature-abstraction functions: as data travels through the neural network, they abstract into high-level features, which are more lightweight, helping reduce latency.

8.1.2. Other National Projects

8.1.2.1. HPC-Big Data Inria Project Lab (IPL)

Participants: Gabriel Antoniu, Alexandru Costan, Daniel Rosendo, Pedro de Souza Bento Da Silva.

Project Acronym: HPC-BigData

Project Title: The HPC-BigData Inria Project Lab

Coordinator: Bruno Raffin

Duration: 2018–2022

Web site: https://project.inria.fr/hpcbigdata/

The goal of this HPC-BigData IPL is to gather teams from the HPC, Big Data and Machine Learning (ML) areas to work at the intersection between these domains. Research is organized along three main axes: high performance analytics for scientific computing applications, high performance analytics for big data applications, infrastructure and resource management. Gabriel Antoniu is a member of the Advisory Board and leader of the Frameworks work package.

In 2019, Daniel Rosendo, who was hired in the context of this IPL project, focused on assessing the state of the art in high performance analytics on hybrid HPC/Big Data infrastructure. In particular, a new path for future work was identified: running Machine Learning algorithm at the Edge.

8.1.2.2. ADT Damaris 2

Participants: Ovidiu-Cristian Marcu, Gabriel Antoniu, Luc Bougé.

Project Acronym: ADT Damaris
Project Title: Technology development action for the Damaris environment
Coordinator: Gabriel Antoniu
Duration: 2019–2021
Web site: https://project.inria.fr/damaris/

This action aims to support the development of the Damaris software. Inria's *Technological Development Office* (D2T, *Direction du Développement Technologique*) provided 2 years of funding support for a senior engineer.

Ovidiu Marcu has been funded through this project to document, test and extend the Damaris software and make it a safely distributable product. In 2019, the main goal was to add Big Data analytics support in Damaris. We have extended Damaris with a streaming interface for writing and analyzing in real-time simulation data through KerA, a distributed streaming storage system.

KerA is further coupled with RAMCloud for in-memory key-value transactions and with Apache Flink for streaming analytics in an architecture that leverages Apache Arrow as in-memory columnar data representation for co-located streaming. This hybrid HPC-Big Data architecture is subject to further exploration within the ZettaFlow.io startup.

8.1.2.3. Grid'5000

We are members of Grid'5000 community and run experiments on the Grid'5000 platform on a daily basis.

8.2. European Initiatives

8.2.1. Collaborations in European Programs, Except FP7 & H2020

8.2.1.1. ZettaFlow: Unified Fast Data Storage and Analytics Platform for IoT

Program: EIT Digital Innovation Factory
Project acronym: ZettaFlow
Project title: ZettaFlow: Unified Fast Data Storage and Analytics Platform for IoT
Duration: October 2019–December 2020
Technical Coordinator: Ovidiu Marcu
Other partners: Technische Universität Berlin and System@tic
Web site: https://zettaflow.io/

The objective of this project is to create a startup in order to commercialize the ZettaFlow platform: a dynamic, unified and auto-balanced real-time storage and analytics industrial IoT platform. ZettaFlow is based on KerA, a streaming storage system prototype developed within the KerData team. ZettaFlow will provide real-time visibility into machines, assets and factory operations and will automate data driven decisions for high-performance industrial processes.

8.2.1.2. FlexStream: Automatic Elasticity for Stream-based Applications

Program: PHC PROCOPE 2020
Project acronym: FlexStream
Project title: Automatic Elasticity for Stream-based Applications
Duration: January 2020–December 2021
Coordinator: Alexandru Costan
Other partners: University of Dusseldorf (UDUS)

Elasticity is one of the key features of cloud computing providing virtual resources as needed according to dynamically changing workloads. This allows to minimize costs and reduce time-to-decision of IoT edge-cloud applications. However, while the underlying resources may easily be scaled many applications and services are not designed to support elastic scalability or require an administrator to manually control elastic scaling.

This project aims at developing concepts providing automatic scaling for stream processing applications. In particular, FlexStream aims at developing and evaluating a prototype which will integrate a stream ingestion-system from IRISA and an in-memory storage from UDUS. For this approach a tight cooperation is mandatory in order to be successful which in turn requires visits on both sides and longer exchanges, especially for the involved PhD students, in order to allow an efficient integrated software design, development as well as joint experiments on large platforms and preparing joint publications.

8.2.2. Collaborations with Major European Organizations

8.2.2.1. BDVA and ETP4HPC

Gabriel Antoniu (as a working group leader) and Alexandru Costan (as a working group member) contributed to the new Strategic Research Agenda (version 4) of European Technology Platform in the area of High-Performance Computing (ETP4HPC).

Gabriel Antoniu and Alexandru Costan are serving as Inria representatives in the working group dedicated to *HPC-Big Data* convergence within the Big Data Value Association (BDVA).

8.2.2.2. International Initiatives

8.2.2.2.1. BDEC: Big Data and Extreme Computing

Since 2015, Gabriel Antoniu has been invited to participate to the yearly workshops of the international Big Data and Extreme-scale Computing (BDEC) working group focused on the convergence of Extreme Computing (the latest incarnation of High-Performance Computing - HPC) and Big Data. BDEC is organized as series of invitation-based international workshops.

In 2019 Gabriel Antoniu was invited again to contribute to the second and third workshops of the BDEC2 series, where he presented two white papers on HPC-Big Data convergence at the level of data processing.

8.3. International Initiatives

8.3.1. Inria International Labs

8.3.1.1. UNIFY: An associated team involved in the JLESC international lab

Title: UNIFY: Intelligent Unified Data Services for Hybrid Workflows Combining Compute-Intensive Simulations and Data-Intensive Analytics at Extreme Scales

Inria International Lab: JLESC: Joint Laboratory for Extreme Scale Computing

International Partner: Argonne National Laboratory (USA) — Department of Mathematics, Symbolic Computation Group — Tom Peterka

Start year: 2019

See also: https://team.inria.fr/unify

The landscape of scientific computing is being radically reshaped by the explosive growth in the number and power of digital data generators, ranging from major scientific instruments to the Internet of Things (IoT) and the unprecedented volume and diversity of the data they generate. This requires a rich, extended ecosystem including simulation, data analytics, and learning applications, each with distinct data management and analysis needs.

Science activities are beginning to combine these techniques in new, large-scale workflows, in which scientific data is produced, consumed, and analyzed across multiple distinct steps that span computing resources, software frameworks, and time. This paradigm introduces new data-related challenges at several levels.

The UNIFY Associate Team aims to address three such challenges. First, to allow scientists to obtain fast, real-time insight from complex workflows combining extreme-scale computations with data analytics, we will explore how recently emerged Big Data processing techniques (e.g., based on stream processing) can be leveraged with modern in situ/in transit processing approaches used in HPC environments.

Second, we will investigate how to use transient storage systems to enable efficient, dynamic data management for hybrid workflows combining simulations and analytics.

Finally, the explosion of learning and AI provides new tools that can enable much more adaptable resource management and data services than available today, which can further optimize such data processing workflows.

8.3.2. Inria Associate Teams Not Involved in an Inria International Labs

8.3.2.1. SmartFastData

Title: Efficient Data Management in Support of Hybrid Edge/Cloud Analytics for Smart Cities

International Partner: Instituto Politécnico Nacional (Mexico) — Centro de Investigación en Computación — Rolando Menchaca-Mendez

- Start year: 2019
- See also: https://team.inria.fr/smartfastdata/

The proliferation of small sensors and devices that are capable of generating valuable information in the context of the Internet of Things (IoT) has exacerbated the amount of data flowing from all connected objects to private and public cloud infrastructures. In particular, this is true for Smart City applications, which cover a large spectrum of needs in public safety, water and energy management. Unfortunately, the lack of a scalable data management subsystem is becoming an important bottleneck for such applications, as it increases the gap between their I/O requirements and the storage performance.

The vision underlying the SmartFastData associated team is that, by smartly and efficiently combining the data-driven analytics at the edge and in the cloud, it becomes possible to make a substantial step beyond state-of-the-art prescriptive analytics through a new, high-potential, faster approach to react to the sensed data.

The goal is to build a data management platform that will enable comprehensive joint analytics of past (historical) and present (real-time) data, in the cloud and at the edge, respectively, allowing to quickly detect and react to special conditions and to predict how the targeted system would behave in critical situations.

In 2019, the first objective of the associated team (i.e., exploring analytical models for performance evaluation of stream storage and ingestion systems) was achieved by means of the two internships of José Canepa and Edgar Romo (described in the New Results section) as well as the visit of Mario Rivero as an Invited Professor, who set up the main research agenda for those internships.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Rosa Badia: Barcelona Supercomputing Center, Spain. Dates: 13-14 March 2019

Michael Schottner: University of Dusseldorf, Germany. Dates: 13-15 March 2019

Valentin Cristea: Politehnica University of Bucharest, Romania. Dates: 13-15 March 2019

Toni Cortés: Universitat Politècnica Catalunya, Spain. Dates: 4-5 November 2019

Kate Keahey: Argonne National Lab, USA. Dates: 4-5 November 2019

Matthieu Dorier: Argonne National Lab, USA. Dates: 4-5 November 2019

8.4.1.1. Invited Professors

Mario Rivero (Professor, Instituto Politécnico Nacional, Mexico) was an invited professor in the KerData team from June to July 2019, through the *Scientist Invitation Program* of IRISA and ISTIC. During his stay, he gave several talks at Inria/IRISA and worked on the modeling Smart City applications, laying the path for the work program of the upcoming internships of José Aguilar-Canepa and Edgar Romo.

8.4.1.2. Internships

Jose Aguilar-Canepa (PhD student, Instituto Politécnico Nacional, Mexico) has done a 3-month internship within the team, working with Alexandru Costan and Pedro Silva on hybrid Edge/Cloud stream processing. This work is validated through large scale experiments on Grid'5000 and is subject to a journal paper in submission, currently on the works, to be submitted by January 2020.

Edgar Romo (PhD student, Instituto Politécnico Nacional, Mexico) did a 3-month internship at KerData from September to November 2019. He worked on Objective 2 of the SmartFastData Associate Team, specifically on designing a complex model for predicting the stream arrival rates for vehicular networks in Smart Cities. To validate this proposal, he carried out several experiments on Grid'5000; this work is currently the topic of a workshop paper submission.

8.4.2. Visits to International Teams

Alexandru Costan and Gabriel Antoniu visited the NDS-Lab team at Instituto Politécnico Nacional from October 24 to November 3, 2019, in the context of the SmartFastData associate team. Working closely with Rolando Menchaca, they defined the work program for the upcoming year with respect to the team's objectives. They also presented KerData's vision on future hybrid analytics combining Edge, Cloud and HPC computing.

MARACAS Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- QAMUT *Quantum Algorithms for Multi Users wireless Transmissions* (2019-2021, leader : MARACAS, partners LIP and Institut Camille Jourdan). This project aims to propose new multi-user detection algorithms for wireless transmission systems, based on a quantum architecture.
- *Statistical Hypothesis Testing with Persistent Homology* 2019-2021, leader: MARACAS, partners CRAL. This project aims to develop statistical signal processing methods exploiting persistent homology.

9.2. National Initiatives

9.2.1. ANR

- ANR EPHYL *Enhanced PHY for Cellular Low Power Communication IoT* (2016-2019, 183 keuros, leader : Sequans). This project aims to investigate coming and future LPWA technologies with the aim to improve coverage, data rate and connectivity while keeping similar level of complexity and power consumption at the node for the access. New waveforms enablers will be investigated and trialled in order to increase the efficiency of future systems and to provide efficient and fair access to the radio resource. The proposed new waveforms should comply with system constraints and with the coexistence of multiple communications.
- ANR ARBURST *Acheivable region of bursty wireless networks* (2016-2020, 195 KEuros, leader : MARACAS). In this project, we propose an original approach complementary to other existing projects, devoted to the study of IoT networks fundamental limits. Instead of proposing one specific technical solution, our objective is to define a unified theoretical framework. We aim at establishing the fundamental limits for a decentralized system in a bursty regime which includes short packets of information and impulsive interference regime. We are targeting the fundamental limits, their mathematical expression (according to the usual information theory framework capturing the capacity region by establishing a converse and achievability theorems). We will use the recent results relative to finite block-length information theory and we will evaluate the margin for improvement between existing approaches and these limits and we will identify the scientific breakthrough that may bring significant improvements for IoT/M2M communications. This project will contribute to draw the roadmap for the development of IoT/M2M networks and will constitute a unified framework to compare existing techniques, and to identify the breakthrough concepts that may afford the industry the leverage to deploy IoT/M2M technical solutions.
- ANR EquipEx FIT/CorteXlab (2009-2020, 1M€, leader : UPMC). The FIT projet is a national equipex headed by the Lip6 laboratory. As a member of Inria, Maracas is in charge of the development of the Experimental Cognitive Radio platform (CorteXlab) that is used as a testbed for SDR terminals and cognitive radio experiments. This has been operational since 2014 and is maintained for a duration of 7 years. To give a quick view, the user will have a way to configure and program through Internet several SDR platforms (MIMO , SISO , and baseband processing nodes).

9.2.2. Autres sections...

1. SILECS is a research infrastructure being built to gather the efforts of several testbeds, relying on the success of Grid'5000 and FIT https://www.silecs.net/.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

1. COM-MED, *COMMunication systems with renewable Energy micro-griD*
   - Programm: H2020
   - Duration: October 2016 - October 2019
   - Coordinator: Inria
   - Inria contact: Samir M. Perlaza
   - Summary : A smart micro-grid is a small-scale power-grid system consisting of a number of distributed energy sources and loads which is responsible to ensure power sufficiency in a small area. The effectiveness of a smart micro-grid depends on the proper implementation of a communications and networking system which monitors, controls and manages the grid's operations. Due to the ever growing worldwide energy consumption, the need of an efficient framework for managing the way power is distributed and utilized has increased. The main objective of the project COM-MED is to study the fundamental interplay between communications and power networks in the context of smart micro-grids and renewable energy sources. On one hand, we study advanced signal processing techniques and communications methods to optimize the operation of smart micro-grid systems. On the other hand, we focus on mobile communications networks with renewable energy base-stations (BSs) and we investigate communications and networking techniques that take into account both data traffic and energy profiles to support high quality-of-service (QoS). The objectives of each technical WP have been assigned in such a way as to ensure that the project's target is realized during the project's time period. The theoretical results derived from the WPs 3, 4 and 5 will be tested using the telecommunication network of MTN in Cyprus but also the state-of-the-art equipment of the CITI/Inria research lab in France. The outcome of this project will provide a theoretical framework for the optimal cooperation between communications networks and power networks in the context of smart micro-grids and renewable energy sources. This is in line with the objectives of the call's theme "Renewable Energy" and is of paramount importance for the Mediterranean area. The consortium of the project has the expertise and the infrastructure to implement the objectives set and to bring the project to a successful end.
2. WindMill, *Machine Learning for Wireless Communications*
   - Programm: H2020; European Training Network (ETN).
   - Duration: January 2019 - December 2022.
   - Coordinator: Aalborg University, DK
   - Inria contact: Jean-Marie Gorce
   - Summary : With their evolution towards 5G and beyond, wireless communication networks are entering an era of massive connectivity, massive data, and extreme service demands. A promising approach to successfully handle such a magnitude of complexity and data volume is to develop new network management and optimization tools based on machine learning. This is a major shift in the way wireless networks are designed and operated, posing demands for a new type of expertise that requires the combination of engineering, mathematics and computer science disciplines. The ITN project WindMill addresses this need by providing Early Stage Researchers (ESRs) with an expertise integrating wireless communications and machine learning. The project will train 15 ESRs within a consortium of leading international research institutes and companies comprising experts in wireless communications and machine learning. This a very timely project, providing relevant interdisciplinary training in an area where machine learning represents a meaningful extension of the current methodology used in wireless communication systems. Accordingly, the project will produce a new generation of experts, extremely competitive on the job market, considering the scale by which machine learning will impact the future and empower the individuals that are versed in it. The project will also nurture the sense of responsibility of the ESRs and the other participants through personal engagement in the training program and by promoting teamwork through collaborative joint projects.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

- Program: PHC Amadeus 2020
- Title: Towards Rigorous Design of Molecular Communication Systems
- Duration: 1/2020 - 12/2021
- Coordinator: Malcolm Egan (MARACAS)
- Other Partners: Institute of Mathematics and Scientific Computing, University of Graz, Austria; CNRS.
- Abstract: The main aim of this project is to bring together experts in molecular communication (Univ. Lyon, Inria, CNRS) and in chemical reaction-diffusion systems (Univ. Graz) to (i) develop novel design of molecular communication systems using up-to-date mathematical results in chemical reaction-diffusion systems, and (ii) strengthen the mathematical theory about chemical reaction networks arising from designation of communication systems.
- Program: COST
- Title: COST Action CA15104, IRACON Inclusive Radio Communications
- Duration: 3/2016 - 3/2020
- Coordinator: Prof. Claude Oestges, University Catholique de Louvain, Belgium.
- Other Partners: many, see website.
- Abstract: This COST Action aims at scientific breakthroughs by introducing novel design and analysis methods for the 5th-generation (5G) and beyond-5G radio communication networks. Challenges include i) modelling the variety of radio channels that can be envisioned for future inclusive radio, ii) capacity, energy, mobility, latency, scalability at the physical layer and iii) network automation, moving nodes, cloud and virtualisation architectures at the network layer, as well as iv) experimental research addressing Over-the-Air testing, Internet of Things, localization and tracking and new radio access technologies. The group of experts supporting this proposal comes from both academia and industry, from a wide spread of countries all over Europe, with the support of some non-COST institutions and R&D associations and standardisation bodies worldwide. The proposers have also long experience on COST Actions in the Radiocommunications field.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- Princeton University, School of Applied Science, Department of Electrical Engineering, NJ. USA. This cooperation with Prof. H. Vincent Poor is on topics related to decentralized wireless networks. Samir M. Perlaza has been appointed as Visiting Research Collaborator at the EE Department for the academic period 2016-2017. Scientific-Leaders at Inria: Samir M. Perlaza and Jean-Marie Gorce.
- Technical University of Berlin, Dept. of Electrical Engineering and Computer Science, Germany. This cooperation with Prof. Rafael Schaffer is on secrecy and covert communications. Scientific-Leaders at Inria: Samir M. Perlaza.
- National University Singapore (NUS), Department of Electrical and Computer Engineering, Singapore. This collaboration with Prof. Vincent Y. F. Tan is on the study of finite block-length transmissions in multi-user channels and the derivation of asymptotic capacity results with non-vanishing error probabilities. Scientific-Leaders at Inria: Samir M. Perlaza
- University of Sheffield, Department of Automatic Control and Systems Engineering, Sheffield, UK. This cooperation with Prof. Inaki Esnaola is on topics related to information-driven energy systems and multi-user information theory. Scientific-in-charge at Inria: Samir M. Perlaza.

- University of Arizona, Department of Electrical and Computer Engineering, Tucson, AZ, USA. This cooperation with Prof. Ravi Tandon is on topics related to channel-output feedback in wireless networks. Scientific-Leader at Inria: Samir M. Perlaza.
- University of Cyprus, Department of Electrical and Computer Engineering, University of Cyprus, Nicosia, Cyprus. This cooperation with Prof. Ioannis Krikidis is on topics related to energy-harvesting and wireless communications systems. Scientific-Leaders at Inria: Guillaume Villemaud and Samir M. Perlaza.
- Queen's University Belfast, UK. This collaboration is on molecular communication and massive MIMO with Prof. Trung Q. Duong. Scientific-in-charge at Inria: Malcolm Egan
- Czech Technical University in Prague, Czech Republic. This collaboration is on optimisation methods related to machine learning with Dr. Vyacheslav Kungurtsev. Scientific-in-charge at Inria: Malcolm Egan
- TUMCREATE, Singapore. This collaboration is on signal processing in communications with Dr. Ido Nevat. Scientific-in-charge at Inria: Malcolm Egan.
- UMNG (Universidad Militar de Nueva Granada), Telecommunications Department, Bogota, Colombia. Ongoing collaboration on security for GSM networks using deep learning. Scientific-in-charge at Inria: Leonardo S. Cardoso.
- Department of Power, Electronic and Communication Engineering, University of Novi Sad, Serbia. This collaboration is on GNU radio and signal processing around FIT/CorteXlab with Prof. Dejan Vukobratovic. Scientific-in-charge at Inria: Jean-Marie Gorce.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Internships

1. Huy Duy Do, February-July 2019, Master Thesis MONABIPHOT, ENS Cachan, "Biological Circuits for Detection in Molecular Communication".
2. Antoine Dejonghe, September 2018-July 2020, Telecommunication Department's Research Track, INSA-Lyon, "Techniques for Massive Access in Dense IoT Networks" (Provisional Title)
3. Nuria Vinyes, September 2019-January 2020, Master Thesis, UPC Barcelona, "Simultaneous Information and Energy Transmission: Towards Feasible Systems"
4. Charlotte Hoefler-Hoerle – Undergraduate Student at INSA de Lyon (programme "parcours recherche" de l'INSA de Lyon), Leonardo S. Cardoso and Samir M. Perlaza.
5. INSA de Lyon, D´epartement des T´el´ecommunications. I have advised the following students during their final projects for obtaining the title of Engineer of INSA of Lyon: Samia Bouchareb (2015) and Naslaty Ali Kari (2016), L´elio Chetot (2016), Matias Dwek (2016), and Mamy Niang (2016), Charlotte Hoefler-Hoerle (2019), Adam Ben-Ltaifa (2019), Carl Hatoum (2019).
6. ENS de Lyon, D´epartement d'Informatique. I have advised the following students during their M2-level projects: Lucas Venturini (2019) and Tran Xuan Thang (2019).
7. Matei Catalin Moldoveanu – Master Student at University of Sheffield (Research Intern, Summer 2019).

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Léonardo Cardoso visited Carles Anton, CTTC (Barcelona, Spain), June 2019.

MIMOVE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

"BottleNet: Understanding and Diagnosing End-to-end Communication Bottlenecks of the Internet", project funded by the French research agency (ANR), from Feb 2016 to Sep 2020.

9.1.1. Inria Support

9.1.1.1. Inria IPL BetterNet

Participants: Renata Teixeira, Vassilis Christophides, Giulio Grassi.

- **Name:** BetterNet – *An observatory to measure and improve Internet service access from user experience*
- **Period:** [2016 – 2019]
- **Inria teams:** Diana, Dionysos, Inria Chile, Madynes, MiMove, Spirals
- **URL:** https://project.inria.fr/betternet/

BetterNet aims at building and delivering a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. In this Inria Project Lab, we will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks. Our observatory can be defined as a vantage point, where:

1. tools, models and algorithms/heuristics will be provided to collect data,
2. acquired data will be analyzed, and shared appropriately with scientists, stakeholders and civil society,
3. and new value-added services will be proposed to end-users.

9.1.1.2. Inria ADT SocialBus

Participants: Valérie Issarny , Rafael Angarita, Nikolaos Georgantas, Ehsan Ahvar , Lior Diler .

- **Name:** SocialBus – *Contributing to the development of SocialBus - A Universal Social Network Bus*
- **Period:** [July 2018 – June 2019 ; November 2019 – October 2020]
- **Partners:** Inria MiMove.

Computer-mediated communication can be defined as any form of human communication achieved through computer technology. From its beginnings, it has been shaping the way humans interact with each other, and it has influenced many areas of society. There exist a plethora of social interaction services enabling computer-mediated social communication (e.g., Skype, Facebook Messenger, Telegram, WhatsApp, Twitter, Slack, etc.). Based on personal preferences, users may prefer a social interaction services rather than another. As a result, users sharing same interests may not be able to interact since they are using incompatible technologies.

To tackle the above interoperability barrier, we propose SocialBus, a middleware solution targeted to enable the interaction via heterogeneous social interaction services. The ADT specifically supports the related implementation through the funding an engineer, toward technology transfer in the mid-term.

The SocialBus software is available under the AGPL open source license at https://gitlab.inria.fr/usnb/universal-social-network-bus.

9.2. International Initiatives

9.2.1. Inria International Labs

Inria@EastCoast

Associate Team involved in the International Lab:

9.2.1.1. HOMENET

Title: Home network diagnosis and security

International Partner (Institution - Laboratory - Researcher):

Princeton (United States) - Computer Science - Nick Feamster

Start year: 2017

See also: https://team.inria.fr/homenet/

Modern households connect a multitude of networked devices (ranging from laptops and smartphones to a number of Internet of Things devices) via a home network. Most home networks, however, do not have a technically skilled network administrator for managing the network, for example to identify faulty equipment or take steps to secure end hosts such as applying security patches. Home networks represent a particularly challenging environment due to the diversity of devices, applications, and services users may connect. The goal of HOMENET is to assist users in diagnosing and securing their home networks. Our approach is based on developing new algorithms and mechanisms that will run on the home router (or in-collaboration with the router). The router connects the home network to the rest of the Internet; it is hence the ideal place to secure home devices and to distinguish problems that happen in the home from those happening elsewhere. We will address a number of research challenges for example in device discovery and fingerprinting, anomaly detection in the Internet of Things, home network diagnosis (including wireless diagnosis). HOMENET will bring together two leading research teams in the network measurement arena with successful prior collaboration. Moreover, Princeton brings an existing home router platform and expertise in security, wireless, and software-defined networks; and Muse brings an existing Web-based measurement platform, and expertise in traffic-based profiling and anomaly detection.

Inria@SiliconValley

Associate Team involved in the International Lab:

9.2.1.2. MINES

Title: Adaptive Communication Middleware for Resilient Sensing & Actuation IN Emergency Response Scenarios

International Partner (Institution - Laboratory - Researcher):

University of California, Irvine (United States) - Information and Computer Science - Nalini Venkatasubramanian

Start year: 2018

See also: http://mimove-apps.paris.inria.fr/mines/index.html

Emerging smart-city and smart-community efforts will require a massive deployment of connected entities (Things) to create focused smartspaces. Related applications will enhance citizen quality of life and public safety (e.g., providing safe evacuation routes in fires). However, supporting IoT deployments are heterogeneous and can be volatile and failure-prone as they are often built upon low-powered, mobile and inexpensive devices - the presence of faulty components and intermittent network connectivity, especially in emergency scenarios, tend to deliver inaccurate/delayed information. The MINES associate team addresses the resulting challenge of enabling interoperability and resilience in large-scale IoT systems through the design and development of a dedicated middleware. More specifically, focusing on emergency situations, the MINES middleware will: (i) enable the dynamic composition of IoT systems from any and all available heterogeneous devices; (ii) support the timely and reliable exchange of critical data within and across IoT in the enabled large-scale and dynamic system over heterogeneous networks. Finally, the team will evaluate the proposed solution in the context of emergency response scenario use cases.

9.2.2. Inria International Partners

9.2.2.1. Informal International Partners

- Northeastern University (Prof. David Choffnes): We are working on methods based on active probing to diagnose poor video quality.
- Universidade Federal do Rio de Janeiro, Brazil (Prof. Edmundo Souza e Silva): We are working on characterizing Internet bottlenecks.
- Universidade Federal de Goias, Brazil (Prof. Fabio Costa): We are working on service selection and cloud resource allocation for QoS-aware enactment of service choreographies.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

Mark Crovella from Boston University was visiting professor at Inria.

9.3.2. Visits to International Teams

9.3.2.1. Sabbatical programme

Renata Teixeira is visiting scholar at the Computer Science Department at Stanford University.

9.3.2.2. Research Stays Abroad

Georgios Bouloukakis was Inria postdoctoral fellow at University of California, Irvine, in the context of the Inria@SiliconValley program.

Myriads Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. INDIC - Cybersecurity Pole of Excellence (2014-2020)

Participants: Clément Elbaz, Christine Morin, Louis Rilling, Amir Teshome Wonjiga.

Our study carried out in the framework of a collaboration with DGA-MI aims at defining and enforcing SLA for security monitoring of virtualized information systems. To this aim we study three topics:

- defining relevant SLA terms for security monitoring,
- enforcing and evaluating SLA terms,
- making the SLA terms enforcement mechanisms self-adaptable to cope with the dynamic nature of clouds.

The considered enforcement and evaluation mechanisms should have a minimal impact on performance. The funding from DGA funded the PhD of Anna Giannakou (defended in 2017) and Amir Teshome Wonjiga (defended in 2019). Clément Elbaz is partially funded by the Brittany Regional Council in the PEC framework.

8.2. National Initiatives

8.2.1. ADEME RennesGrid (2017-2020)

Participants: Anne Blavette, Benjamin Camus, Anne-Cécile Orgerie, Martin Quinson.

The aim of the RennesGrid project is to design and implement a large-scale preindustrial microgrid demonstrator in the territory of Rennes Metropole to organize the shared self-consumption of a group of photovoltaic panels coupled to stationary storage devices. Traditional approaches to power grid management tend to overlook the costs, both energy and economic, of using computers to ensure optimal electricity network management. However, these costs can be significant. It is therefore necessary to take them into account along with the design of IT tools during studies of optimal energy management of smart grids. In addition, telecommunication networks are generally considered to have an ideal functioning, that is to say they can not negatively affect the performance of the electricity network. However, this is not realistic and it is necessary to analyze the impact of phenomena such as congestion, latency, failures related to computer equipment or impact on the batteries of sensors, etc. on strategies for optimal management of the electricity network. In this project, we closely collaborate with Anne Blavette (CR CNRS in electrical engineering, SATIE, Rennes) and co-supervise the post-doc of Benjamin Camus who started in April 2018 on evaluating the impact of the IT infrastructure in the management of smart grids.

8.2.2. Inria ADT Mc SimGrid (2019-2021)

Participants: Ehsan Azimi, Martin Quinson.

The Mc SimGrid technological development action funded by INRIA targets the refactoring of model checker that is integrated to the SimGrid simulation framework. Its software quality should be improved to be on par with the rest of the SimGrid framework. Our ultimate goal is to make this model-checker usable in production, both to assess real-size applications and as a workbench for the researchers designing new techniques and algorithms for the verification of distributed asynchronous applications and algorithms.

The technical actions envisioned for this ADT are the complete re-factoring of this software module, and the exposure of a sensible python interface to experiment with new exploration algorithms. This work is lead by Ehsan Azimi, in collaboration with Thierry Jéron from the Sumo team.

8.2.3. Inria IPL Discovery (2015-2019)

Participants: Anne-Cécile Orgerie, Matthieu Simonin, Genc Tato, Cédric Tedeschi.

The Inria IPL Discovery officially started in September 2015. It targets the design, development and deployment of a distributed Cloud infrastructure within the network's backbone. It will be based upon a set of building blocks whose design will take locality as a primary constraint, so as to minimize distant communications and consequently achieve better network traffic, partition management and improved availability.

Its developments are planned to get integrated within the OpenStack framework. Myriads is involved in the design of new overlay networks for such environments so as to support efficient messaging and routing. Myriads is also involved in the energy/cost benefit analysis of distributed edge-cloud architectures.

8.2.4. Inria IPL Hac Specis (2016-2020)

Participants: Dorra Boughzala, Anne-Cécile Orgerie, The Anh Pham, Martin Quinson.

The goal of the HAC SPECIS (High-performance Application and Computers: Studying PErformance and Correctness In Simulation) project (http://hacspecis.gforge.inria.fr/) is to answer methodological needs of HPC application and runtime developers and to allow to study real HPC systems both from the correctness and performance point of view. To this end, we gather experts from the HPC, formal verification and performance evaluation community.

The Anh Pham defended his thesis on December 6., on techniques to mitigate the state space explosion while verifying asynchronous distributed applications. He proposed a new algorithm to mitigate the state space explosion problem (published this year [19]), using event folding structures to efficiently compute how to not explore equivalent execution traces more than once. This work, co-advised by Martin Quinson with Thierry Jéron (team SUMO, formal methods), was important to bridge the gap between the involved communities.

During her PhD thesis, Dorra Boughzala studied the energy consumption of GPU and the simulation tools of the literature related to this aspect. Her work is co-advised by Laurent Lefèvre (Avalon team, Lyon), Martin Quinson and Anne-Cécile Orgerie.

8.2.5. SESAME ASTRID project (2016-2019)

Participants: Mehdi Belkhiria, Pascal Morillon, Christine Morin, Matthieu Simonin, Cédric Tedeschi.

The Sesame project (http://www.agence-nationale-recherche.fr/Project-ANR-16-ASTR-0026) led by IMT Atlantique aims at develop efficient infrastructures and tools for the maritime traffic surveillance. The role of Myriads is to define a robust and scalable infrastructure for the real-time and batch processing of vessel tracking information. In 2019, we focused on autoscaling and placement for Stream Processing applications.

In 2019, we investigated the dynamic, decentralized scaling of stream processing applications. Also, we collaborated with the Inria OBELIX team to scale and deploy a machine learning application they developed to build a model of a *normal* vessel trajectory.

8.2.6. CNRS GDS EcoInfo

Participant: Anne-Cécile Orgerie.

The EcoInfo group deals with reducing environmental and societal impacts of Information and Communications Technologies from hardware to software aspects. This group aims at providing critical studies, lifecycle analyses and best practices in order to improve the energy efficiency of printers, servers, data centers, and any ICT equipment in use in public research organizations.

8.3. European Initiatives

8.3.1. H2020 Projects

8.3.1.1. H2020 MSCA FogGuru

Participants: Hamidreza Arkian, Davaadorj Battulga, Mozhdeh Farhadi, Julie Montégu, Guillaume Pierre, Mulugeta Ayalew Tamiru, Cédric Tedeschi, Paulo Rodrigues de Souza Junior.

Title: FogGuru – Training the Next Generation of European Fog Computing Experts

Program: H2020 MSCA ITN EID

Duration: September 2017 - August 2021

Coordinator: Guillaume Pierre

Participants:

University of Rennes 1, France (coordinator)

Technische Universität Berlin, Germany

Elastisys AB, Sweden

U-Hopper srl, Italy

EIT Digital Rennes, France

Las Naves, Spain

Abstract: FogGuru is a doctoral training project which aims to to train eight talented PhD students with an innovative and inter-sectoral research program to constitute the next generation of European Cloud and Fog computing experts. Besides their scientific and technical education, FogGuru's PhD students will receive extensive training in technological innovation and entrepreneurship as well as soft skills. These combined skills will enable them to fully master the innovation process stemming from fundamental research towards invention and development of innovative products and services, and to real-life deployment, experimentation and engagement with beta-testers.

8.3.2. Collaborations in European Programs, Except FP7 & H2020

8.3.2.1. EIT Digital DriveTrust

Participant: Guillaume Pierre.

Program: EIT Digital

Project acronym: DriveTrust

Project title: AI-Powered Driving Evaluation

Duration: January 2019 - December 2019

Coordinator: University of Rennes 1, France

Other partners:

Eurapco, Switzerland

Achmea, the Netherlands

Imec, Belgium

Abstract: This project aims to develop and commercialize an AI-powered dash cam with short range V2X and LTE communication capabilities. The product uses the newest AI capable hardware for real-time object detection. The device can detect street signs, traffic lights, other cars, and pedestrians. Combined with sensor data from the accelerometer, GPS and weather data from the cloud we use the data to calculate different dimensions of driving profiles. In addition the V2X and object detection capabilities allow us to warn the driver in real-time about dangers on the road.

8.3.3. Inria Associate Teams Not Involved in an Inria International Labs

8.3.3.1. FogCity

Participants: Ayan Mondal, Nikos Parlavatzas, Guillaume Pierre.

Title: QoS-aware Resource Management for Smart Cities

International Partner (Institution - Laboratory - Researcher):

IIT Kharagpur (India) - Department of Computer Science and Engineering - Sudip Misra

IIT Kanpur (India) - Department of Industrial and Management Engineering - Subhas Chandra Misra

Start year: 2018

See also: https://team.inria.fr/myriads/projects/fogcity/

Abstract: The FogCity associate team proposal concerns a collaboration between the Myriads project-team, and two research teams at Indian Institute of Technology Kharagpur and Indian Institute of Technology Kanpur. The proposal focuses on a smart city scenario in which data from static and mobile sensors is routed to appropriate fog data centres based on application QoS requirements. The main goal of the research is to select suitable nodes within the fog data centers to optimize the QoS of the applications in terms of latency. The different teams have complementary expertise in theoretical research (Indian partners) and system research (Inria Myriads project-team) and share a strong research interest in IoT and Fog Computing.

8.3.3.2. FogRein

Participants: Anne-Cécile Orgerie, Martin Quinson.

Title: Steering Efficiency for Distributed Applications

International Partner: Gene Cooperman, College of Computer and Information Science, Northeastern University (USA).

Start year: 2019

In Fog Computing, the Internet of Things (IoT), and Intermittent Computing, low-power devices migrate geographically, and are required to rapidly assimilate new data in a power-efficient manner. This is a key component of any Smart Interfaces solution as devices migrate from the IT infrastructure to the Edge of the Cloud in order to provide Function-as-a-Service, High-availability mobility, and IT infrastructure malleability. A three-tier strategy is proposed toward steering Fog applications in order to optimize the energy efficiency and sustainability. The strategy will leverage the backgrounds of the participants in Fog Computing, checkpointing, scheduling, Green Levers within the IT infrastructure, and a simulation infrastructure for predicting and efficiently steering such distributed applications. The Inria team and the Northeastern team are uniquely positioned to make rapid progress due to their long history of collaborative research based on visits by both permanent members and PhD students in the two directions.

8.3.4. Inria International Partners

8.3.4.1. Informal International Partners

UC Louvain (Belgium): We collaborate with Prof. Etienne Riviere on legacy application edgification. Genc Tato spent six month at UCL.

Tlemcen University (Algeria): We collaborate with Dr. Djawida Dib on energy-efficient and fault-tolerant resource management in containerized clouds. Christine Morin and Nikos Parlavantzas are co-advising Yasmina Bouizem, who is enrolled in both Tlemcen University and University of Rennes 1.

University of Bologna (Italy): We collaborate with Prof. Paolo Bellavista on the design of performance-efficient fog computing platforms. Lorenzo Civolani from University of Bologna spent 6 months in the Myriads team to complete his master thesis internship. A paper on his work has been accepted for publication [14].

Umeå University (Sweden): We collaborate with Prof. Erik Elmroth on the control of large-scale cloud and fog computing platforms. Ali Fahs spent 6 months at Umeå University where he worked on autoscaling techniques for future fog computing platforms.

Rutgers University (USA): We collaborate with Prof. Manish Parashar on improving the energy efficiency of distributed data-intensive applications. This collaboration is outlined by a joint publication in [20].

University of Hawaii (USA): We collaborate with Prof. Henri Casanova on simulating the energy consumption of scientific workflows. This collaboration is outlined by a joint publication in [16].

University of Southern California (USA): We collaborate with Dr. Rafael Ferreira da Silva and Prof. Ewa Deelman on simulating the energy consumption of scientific workflows. This collaboration is outlined by a joint publication in [16].

8.3.5. Participation in Other International Programs

8.3.5.1. Inria International Chairs

Deborah AGARWAL

Title: Workflow, user centered design, and data management as well as mobile applications for data science

International Partner (Institution - Laboratory - Researcher):

Université californienne de Santa Barbara (United States) - Computational Research Division - Deborah Agarwal

Duration: 2015 - 2019

Start year: 2015

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

Lorenzo CIVOLANI

Date: Sep 2018 - Feb 2019

Institution: University of Bologna (Italy)

Supervisor: Guillaume Pierre

Adrien GOUGEON

Date: Feb 2019 - Jun 2019

Institution: ENS Rennes

Supervisors: Anne-Cécile Orgerie and Benjamin Camus

Archana WALE

Date: Jan 2019 - Jun 2019

Institution: University of Rennes 1

Supervisor: Guillaume Pierre

Romain Olivo

Date: Juin 2019 - Aug 2019

Institution: Inria

Supervisor: Matthieu Simonin

NEO Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. MYDATA (Sept. 2018 - Nov. 2020)

Participant: Giovanni Neglia.

This is a research project in cooperation with two other labs (LJAD and GREDEG) from Univ Côte d'Azur to study how to achieve privacy through obfuscation. The project is funded by IDEX UCA$^{\mathrm{JEDI}}$ Academy 1 on "Networks, Information and Digital society". It involves the participation of Vidhya Kannan.

9.2. National Initiatives

9.2.1. PIA ANSWER

Participants: Konstantin Avrachenkov, Abhishek Bose, Kishor Yashavant Patil.

Project Acronym: ANSWER

Project Title: Advanced aNd Secured Web Experience and seaRch

Coordinator: QWANT

Duration: 15 November 2017 – 31 December 2020

Others Partners: Inria Project-Teams WIMMICS, INDES, COFFEE

Abstract: ANSWER is a joint project between QWANT and Inria, funded by the French Government's initiative PIA "Programme d'Investissement d'Avenir".

The aim of the ANSWER project is to develop the new version of the search engine http://www.qwant.com by introducing radical innovations in terms of search criteria as well as indexed content and security. This initiative is a part of the Big Data Big Digital Challenges field, since a Web search engine deals with large volumes of heterogeneous and dynamic data.

Of the five characteristics of big data, the ANSWER project will focus more particularly on the aspects of Velocity in terms of near real-time processing of results, and Variety for the integration of new indicators (emotions, sociality, etc.) and meta-data. The Volume, Value and Veracity aspects will necessarily be addressed jointly with these first ones and will also be the subject of locks, especially on the topics of crawling and indexing.

This registration of the search engine in the Big Data domain will only be reinforced by developments in the Web such as the Web of data, and generally by the current trend to integrate the Web of increasingly diverse, rich and complex resources.

9.2.2. ANR MAESTRO5G

Participant: Eitan Altman.

Project Acronym: MAESTRO5G

Project Title: MAnagEment of Slices in The Radio access Of 5G networks

Coordinator: Orange Labs

Duration: February 2019 – January 2022

Others Partners: Nokia Bell Labs, Univ Avignon, Inria Project-Team AGORA, Sorbonne Univ, Telecom SudParis, CentraleSupélec.

Abstract: The project develops enablers for implementing and managing slices in the 5G radio access network, not only for the purpose of serving heterogeneous services, but also for dynamic sharing of infrastructure between operators. MAESTRO-5G develops a framework for resource allocation between slices and a business layer for multi-tenant slicing. It provides an orchestration framework based on Software Define Networking that manages resources and virtual functions for slices. A hardware demonstrator brings the slicing concept to reality and showcases the project's innovations.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

Participant: Konstantin Avrachenkov.

Program: EU COST

Project acronym: COSTNET

Project title: European Cooperation for Statistics of Network Data Science

Duration: May 2016 - April 2020

Coordinator: Ernst Wit (NL), Gesine Reinert (UK)

Other partners: see http://www.cost.eu/COST_Actions/ca/CA15109

Abstract: A major challenge in many modern economic, epidemiological, ecological and biological questions is to understand the randomness in the network structure of the entities they study: for example, the SARS epidemic showed how preventing epidemics relies on a keen understanding of random interactions in social networks, whereas progress in curing complex diseases is aided by a robust data-driven network approach to biology.

Although analysis of data on networks goes back to at least the 1930s, the importance of statistical network modelling for many areas of substantial science has only been recognized in the past decade. The USA is at the forefront of institutionalizing this field of science through various interdisciplinary projects and networks. Also in Europe there are excellent statistical network scientists, but until now cross-disciplinary collaboration has been slow.

This Action aims to facilitate interaction and collaboration between diverse groups of statistical network modellers, establishing a large and vibrant interconnected and inclusive community of network scientists. The aim of this interdisciplinary Action is two-fold. On the scientific level, the aim is to critically assess commonalities and opportunities for cross-fertilization of statistical network models in various applications, with a particular attention to scalability in the face of Big Data. On a meta-level, the aim is to create a broad community which includes researchers across the whole of Europe and at every stage in their scientific career and to facilitate contact with stakeholders.

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. MALENA

Title: Machine Learning for Network Analytics

International Partner (Institution - Laboratory - Researcher):

Indian Institute of Technology Bombay (India) - Electrical Communication Engineering - Vivek Borkar

Start year: 2017

See also: http://www-sop.inria.fr/members/Konstantin.Avratchenkov/MALENA.html

In the past couple of decades network science has seen an explosive growth, enough to be identified as a discipline of its own, overlapping with engineering, physics, biology, economics and social sciences. Much effort has gone into modelling, performance measures, classification of emergent features and phenomena, etc, particularly in natural and social sciences. The algorithmic side, all important to engineers, has been recognised as a thrust area (e.g., two recent Nevanlinna Prize (J. Kleinberg 2006 and D. Spielman 2010) went to prominent researchers in the area of network analytics). Still, in our opinion the area is yet to mature and has a lot of uncharted territory. This is because networks provide a highly varied landscape, each flavour demanding different considerations (e.g., sparse vs dense graphs, Erdos-Renyi vs planted partition graphs, standard graphs vs hypergraphs, etc). Even adopting existing methodologies to these novel situations is often a nontrivial exercise, not to mention many problems that cry out for entirely new algorithmic paradigms. It is in this context that we propose this project of developing algorithmic tools, drawing not only upon established as well as novel methodologies in machine learning and big data analytics, but going well beyond, e.g., into statistical physics tools.

9.4.1.2. THANES

Title: THeory and Application of NEtwork Science

International Partner (Institution - Laboratory - Researcher):

Universidade Federal do Rio de Janeiro (Brazil) - Computer Science Department - Daniel Ratton Figueiredo

Start year: 2017

See also: https://team.inria.fr/thanes/

This team is the follow-up of a joint Inria-UFRJ team (funded by FAPERJ in Rio de Janeiro, Brazil) with the same name and almost the same permanent researchers involved. During the first three years THANES has studied how services in Online Social Networks (OSNs) can be efficiently designed and managed. The joint research activity continued along the line of network science with a focus on network growth models, community detection, information spreading, and recommendation systems for online social networks. A new research axis on deep learning spawned during 2018.

9.4.2. Participation in Other International Programs

9.4.2.1. Indo-French Center of Applied Mathematics (IFCAM)

NEO is involved in the IFCAM with the MALENA project. See 9.4.1.1 .

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Professors/Researchers

Mindaugas Bloznelis, Date: 2-7 Oct, Institution: Vilnius Univ (Lithuania)

Damiano Carra, Date: 17-26 Jun, Institution: Univ of Verona (Italy)

Mahmoud El Chamie, Date: 16-20 Dec, Institution: United Technologies Research Center, East Hartford (USA)

Lasse Leskela, Date: 8-19 April, Institution: Aalto Univ (Finland)

Nelly Litvak, Date: 20 May-2 Jun, Institution: Univ of Twente (Netherlands)

Vincenzo Mancuso, Date: 16-18 Jul , Institution: IMDEA Networks Institute (Spain)

Angelia Nedich, Date: 8-10 Dec, Institution: Arizona State Univ (USA)

Sreenath Ramanath, Date: 2-7 Jul, Institution: Lekha Wireless (India)

Daniel Sadoc Menasche, Date: 24-28 Jun, Institution: UFRJ (Brazil)

Neeraja Sahasrabudhe, Date: 9 May - 4 Jun and 16-20 Dec, Institution: IIT Bombay (India)

Matteo Sereno, Date: 15-17 July, Institution: Univ of Turin (Italy)

Georgy Shevlyakov, Date: 3-17 Nov, Institution: Peter the Great St. Petersburg Polytechnic Univ (Russia)

Gugan Thoppe, Date: 25 Nov - 6 Dec, Institution: IISc Bangalore (India)

Don Towsley, Date: 1-4 Apr, Institution: UMass Amherst (USA)

Kavitha Voleti Veeraruna, Date: 27 May - 8 Jun, Institution: IIT Bombay (India)

9.5.1.2. Postdoc/PhD Students

Tejas Bodas, Date: 12-22 Apr and 11-22 Jun, Postdoc at IIS Bangalore (India)

Mikhail Grigorev, Date: 2-31 Jan, PhD student at MFTI Moscow (Russia)

Eduardo Hargreaves, Date: 24-28 Jun, PhD student at UFRJ (Brazil)

Maksim Mironov, Date: 2-31 Jan and 24 Aug - 7 Sep, PhD student at MFTI Moscow (Russia)

Maksim Ryzhov, Date: 4 Apr - 3 May, PhD student at MFTI Moscow (Russia)

Anirudh Sabnis, Date: 1 Jul - 6 Oct, PhD student at UMass Amherst (USA)

9.5.2. Internships

Note: UCA is the Univ Côte d'Azur.

Younes Ben Mazziane, Date: 19 Nov-13 Dec, Institution: PFE Master Ubinet, UCA, Supervisors: S. Alouf and G. Neglia

Vidhya Kannan, Date: from Dec, Institution: UCA, Supervisor : G. Neglia

Carlos Eduardo Marciano, Date: 13 Sep-9 Dec, Institution: Master student at UFRJ, Brazil, Supervisor: G. Neglia

Kaiyun Pan, Date: 19 Nov-13 Dec, Institution: PFE Master Ubinet, UCA, Supervisor: G. Neglia

Quentin Petitjean, Date: 11 Jun-26 Jul, Institution: ENS Cachan, Supervisors: S. Alouf and A. Jean-Marie

Vilc Queupe Rufino, Date: 17-19 Jun, Institution: Master student at UFRJ, Brazil, Supervisor: D. Sadoc Menasche (UFRJ)

Varvara Samoili, Date: 11 Jan-10 Jul, Institution: Bodossaki Foundation, Supervisor: G. Neglia

Nicola Sebastianelli, Date: 1 Mar-31 Aug, Institution: Master Ubinet, UCA, Supervisor: G. Neglia

Adeel Siddiqui, Date: until Jan 2019, Institution: UCA, Supervisor : G. Neglia

Siemo Zhang, Date: 1 Sep-30 Nov, Institution: Master student at Univ of Twente, Netherlands, Supervisor: K. Avrachenkov

9.6. Visits to International Teams

9.6.1. Research Stays Abroad

Eitan Altman

- Date: 29 January - 4 February, 28 March - 6 April, 20 June - 10 July, 18 October - 4 December, Institution: Technion and Univ Tel-Aviv (Israel)

Konstantin Avrachenkov

- Date: 17-22 February, Institution: Friedrich-Alexander Univ (Germany)
- Date: 4-15 March, Institution: Petrozavodsk State Univ (Russia)
- Date: 26-28 October, Institution: IISc Bangalore (India)
- Date: 30 October - 2 November, Institution: IIT Bombay (India)
- Date: 24-26 November, Institution: Univ Twente (The Netherlands)

Maximilien Dreveton

- Date: 24 May - 9 June, Institution: Aalto Univ (Finland)

Alain Jean-Marie

Date: 17 October - 4 November, Institution: GERAD (Montréal, Canada)

Giovanni Neglia

- Date: 20-22 February, Institution: Univ Florence and Univ Pisa (Italy)
- Date: 23-26 September, Institution: Northeastern Univ and Boston Univ (Massachusetts, United States)

POLARIS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. IDEX UGA

- Nicolas Gast received a grant from the IDEX UGA that funds a two-years post-doctoral researcher (Takai Kennouche) for two years (2018 and 2019) to work on the smart-grid project that focus on distributed optimization in electrical distribution networks.
- Patrick Loiseau and Panayotis Mertikopoulos received a grant from the IDEX UGA that partly funds a PhD student (Benjamin Roussillon) to work on game theoretic models for adversarial classification.

9.2. National Initiatives

9.2.1. Inria Project Labs

Arnaud Legrand is the leader of the HAC SPECIS project. The goal of the HAC SPECIS (High-performance Application and Computers: Studying PErformance and Correctness In Simulation) project is to answer methodological needs of HPC application and runtime developers and to allow to study real HPC systems both from the correctness and performance point of view. To this end, we gather experts from the HPC, formal verification and performance evaluation community. Inria Teams: AVALON, POLARIS, MYRIADS, SUMO, HIEPACS, STORM, MEXICO, VERIDIS.

9.2.2. Grenoble INP grant

Patrick Loiseau and Bary Pradelski received a grant from the Presidence of Grenoble INP that covers half of the funding of PhD student Dimitrios Moustakas to work on dynamic matching. This PhD is done in collaboration with Univ. Zurich (Heinrich Nax), which covers the rest.

9.2.3. DGA Grants

Patrick Loiseau and Panayotis Mertikopoulos received a grant from DGA that complements the funding of PhD student (Benjamin Roussillon) to work on game theoretic models for adversarial classification.

9.2.4. PGMO Projects

PGMO projects are supported by the Jacques Hadamard Mathematical Foundation (FMJH). Our project (HEAVY.NET) is focused on congested networks and their asymptotic properties.

9.2.5. PEPS

Panayotis Mertikopoulos is co-PI of a PEPS I3A project: MixedGAN ("Mixed-strategy generative adversarial networks") (PI: R. Laraki, U. Dauphine).

9.2.6. Fondation Blaise Pascal

Project IAM (Informatique à la Main) funded by fondation Blaise Pascal (Jean-Marc Vincent).

9.2.7. MIAI @ Grenoble Alpes

MIAI @ Grenoble Alpes (Multidisciplinary Institute in Artificial Intelligence) is the 3IA institute of Grenoble that was selected by the government in 2019. With the MIAI institute, Patrick Loiseau is the co-holder of a chair on “Explainable and Responsible AI” of which Nicolas Gast and Bary Pradelski are also members; and Panayotis Mertikopoulos is a member of the “Optimization and Learning” chair.

9.2.8. ANR

- Nicolas Gast obtained funding from the ANR JCJC for the project REFINO. 250k euros. Duration: 4 years
- Bary Pradelski (PI), P. Mertikopoulos and P. Loiseau obtained funding from the ANR for the project ALIAS (Adaptive Learning for Interactive Agents and Systems). This is a bilateral PRCI (collaboration internationale) project joint with Singapore University of Technology and Design (SUTD). The Singapore team consists of G. Piliouras and G. Panageas.
- *ORACLESS (2016–2021)*
  ORACLESS is an ANR starting grant (JCJC) coordinated by Panayotis Mertikopoulos. The goal of the project is to develop highly adaptive resource allocation methods for wireless communication networks that are provably capable of adapting to unpredictable changes in the network. In particular, the project will focus on the application of online optimization and online learning methodologies to multi-antenna systems and cognitive radio networks.
- *CONNECTED (2016–2019)*
  CONNECTED is an ANR Tremplin-ERC (T-ERC) grant coordinated by Patrick Loiseau. The goal of the project is to work on several game-theoretic models involving learning agents and data revealed by strategic agents in response to the learning algorithms, so as to derive better learning algorithms for such special data.

9.3. International Initiatives

9.3.1. Inria International Labs

9.3.1.1. ReDaS

Title: Reproducible Data Science

International Partner (Institution - Laboratory - Researcher):

Universidade Federal do Rio Grande do Sul (Brazil) - Industrial Engineering and Operations Research Departments - Lucas Mello Schnorr

Start year: 2019

See also: https://associatedteam.gitlabpages.inria.fr/redas

Data science builds on a variety of technique and tools that makes analysis often difficult to follow and reproduce. The goal of this project is to develop interactive, reproducible and scalable analysis workflows that provide uncertainty and quality estimators about the analysis.

9.3.1.2. International Initiatives

GENE

Title: Stochastic dynamics of large games and networks

International Partners (Institution - Laboratory - Researcher):

Universidad de Buenos Aires (Argentina) - Matthieu Jonckheere

Universidad de la Republica Uruguay (Uruguay) - Federico La Rocca

CNRS (France) - Balakrishna Prabhu

Universidad ORT Uruguay (Uruguay) - Andrés Ferragut

Duration: 2018 - 2019

Start year: 2018

Through the creation and consolidation of strong research and formation exchanges between Argentina, France and Uruguay, the GENE project will contribute to the fields of performance evaluation and control of communication networks, using tools of game theory, probability theory and control theory. Some of the challenges this project will address are: - Mean-field games and their application to load balancing and resource allocations, - Scaling limits for centralized and decentralized load balancing strategies and implementation of practical policies for web servers farms, - Information diffusion and communication protocols in large and distributed wireless networks.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

We have hosted multiple international scientists for short (typically one-week) visits: Jonathan Newton, Paul Duetting, Jason Marden, Bruno Ziliotto

9.4.2. Visits to International Teams

- V. Danjean spent one week at Porto Allegre (Brasil) at UFRGS, hosted by Lucas M. Schnorr to work on the research subject: Tracing of multi-tasked OpenMP Application.
- A. Legrand spent 10 days at Porto Allegre (Brasil) at UFRGS, hosted by Lucas M. Schnorr to teach scientific methodology and Performance Evaluation and to work on the visual performance analysis of dynamic task-based applications.
- G. Huard visited UFRGS (Porto Alegre, Brasil) in the context of the ReDaS Inria associated team from Nov. 27th to Dec 16th along with Alexis Janon. During this visit we worked with Lucas Schnorr on several application trace analysis cases using our own custom analysis framework and leveraging UFRGS expertise on the design and conduct of practical data analysis.
- B. Pradelski was invited for seminars at several places: IHP Game Theory Seminar, Bar-Ilan University Economic Theory seminar, University of Oxford Game Theory seminar. He is also an associate member of the Oxford Man Institute.

9.4.2.1. Research Stays Abroad

P. Mertikopoulos was invited to spend a three-month research visit at the Ecole Polytechnique Fédérale de Lausanne (EPFL). He was hosted by the LIONS lab (headed by V. Cevher).

RESIST Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

Olivier Festor is leading the Grand Est PACTE initiative on cyber-security. This initiative led to a total funding of 400 K€ to acquire, develop and operate the first Cyber Range in the Grand Est. This unique equipment is deployed at TELECOM Nancy and serves as the main platform for cyber-security training in the Grand Est region for both civil and military staff.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. ANR BottleNet

Participants: Isabelle Chrisment [contact], Antoine Chemardin, Thibault Cholez.

- Acronym: BottleNet
- Title: Understanding and Diagnosing End-to-End Communication Bottlenecks of the Internet
- Coordinator: Inria
- Duration: October 2015 - extended to September 2020
- Others Partners: Inria Muse, Inria Diana, Lille1 University, Telecom Sud-Paris, Orange, IP-Label.
- Abstract: The Quality of Experience (QoE) when accessing the Internet, on which more and more human activities depend on, is a key factor for today's society. The complexity of Internet services and of users' local connectivity has grown dramatically in the last years with the proliferation of proxies and caches at the core and access technologies at the edge (home wireless and 3G/4G access), making it difficult to diagnose the root causes of performance bottlenecks. The objective of BottleNet is to deliver methods, algorithms, and software systems to measure end-to-end Internet QoE and to diagnose the cause of the experienced issues. The result can then be used by users, network and service operators or regulators to improve the QoE.

9.2.1.2. ANR FLIRT

Participants: Rémi Badonnel [contact], Olivier Festor, Thibault Cholez, Jérôme François, Abdelkader Lahmadi, Laurent Andrey.

- Acronym: FLIRT
- Title: Formations Libres et Innovantes Réseaux et Télécoms
- Coordinator: Institut Mines-Télécom (Pierre Rolin)
- Duration: January 2016-Décembre 2020
- Others Partners: TELECOM Nancy, Institut Mines-Télécom, Airbus, Orange, the MOOC Agency, Isograd
- Site: http://flirtmooc.wixsite.com/flirt-mooc-telecom

- Abstract: FLIRT (Formations Libres et Innovantes Réseaux & Télécom) is an applied research project leaded by the Institut Mines-Télécom, for an (extended) duration of 5 years. It includes 14 academic partners (engineering schools including Telecom Nancy), industrial partners (Airbus, Orange) and innovative startups (the MOOC agency, and Isograd). The project is to build a collection of 10 MOOCs (Massive Open Online Courses) in the area of networks and telecommunications, three training programmes based on this collection, as well as several innovations related to pedagogical efficiency (such as virtualization of practical labs, management of student cohorts, and adaptative assessment). The RESIST team is leading a working group dedicated to the building and operation of a MOOC on network and service management. This MOOC covers the fundamental concepts, architectures and protocols of the domain, as well as their evolution in the context of future Internet (e.g. network programming, flow monitoring). It corresponds to a training program of 5 weeks. The main targeted skills are to understand the challenges of network and service management, to know the key methods and techniques related to this area, and to get familiar with the usage and parameterization of network management solutions.

9.2.1.3. ANR MOSAICO

Participants: Thibault Cholez [contact], Olivier Festor.

- Acronym: MOSAICO
- Title: Multi-layer Orchestration for Secured and low lAtency applICatiOns
- Coordinator: Orange Labs
- Start: 01/12/2019
- Duration: 4 years
- Others Partners: Orange Labs, Montimage, ICD-UTT
- Abstract:

  For several years, programmability has become increasingly important in network architectures. The last trend is to finely split services into micro-services. The expected benefits relies on an easier development and maintenance, better quality, scalability and responsiveness to new scenarios than monolithic approaches, while offering more possibilities for operators and management facilities through orchestration. As a consequence, it appears that network functions, such as routing, filtering, etc. can be split in several micro-services, implemented through different means, according to the software environments, and at different topological locations, thus opening the way to fully end-to-end programmable networks. This need for multi-level and multi-technology orchestration is even more important with the emergence of new services, such as immersive services, which exhibit very strong quality of service constraints (i.e. latency cannot exceed a few milliseconds), while preserving end-to-end security. The MOSAICO project proposes to design, implement and validate a global and multi-layer orchestration solution, able to control several underlying network programmability technologies (SDN, NFV, P4) to compose micro-services forming the overall network service. To reach this objective, the project will follow an experimental research methodology in several steps including the definition of the micro-services and of the global architecture, some synthetic benchmarking, the design of orchestration rules and the evaluation against the project use-case of a low latency network application.

  The kick-off meeting of MOSAICO took place the 03/12/2019 in Orange Gardens. Our current work consists in surveying the latest technologies around NFV and Open Networking.

9.2.2. Inria joint Labs

9.2.2.1. Inria-Orange Joint Lab

Participants: Jérôme François [contact], Olivier Festor, Matthews Jose, Paul Chaignon.

- Acronym: IOLab
- Title: Inria - Orange Joint Laboratory

- Duration: September 2015 - August 2020
- Abstract: The challenges addressed by the Inria-Orange joint laboratory relate to the virtualization of communication networks, the convergence between cloud computing and communication networks, and the underlying software-defined infrastructures. Our work concerns in particular monitoring methods for software-defined infrastructures, and management strategies for supporting software-defined security in multi-tenant cloud environnements.

9.2.3. Technological Development Action (ADT)

9.2.3.1. ADT SCUBA

Participants: Abdelkader Lahmadi [Contact], Jérôme François, Thomas Lacour, Frédéric Beck.

- Acronym: SCUBA
- Duration: January 2018-January 2020
- Abstract: The goal of this ADT is to develop a tool suite to evaluate the security of industrial and general public IoT devices in their exploitation environment. The Tool suite relies on a set of security probes to collect information through passive and active scanning of a running IoT device in its exploitation environment to build its Security Knowledge Base (SKB). The knowledge base contains all relevant information of the device regarding its network communications, the enumeration of its used hardware and software, the list of its known vulnerabilities in the CVE format associated to their Common Weakness Enumeration (CWE) and Common Attack Pattern Enumeration and Classification (CAPEC) descriptions. The collected information is used to evaluate the devices associated with their usage scenarios and to identify intrusion chains in an automated way.

9.2.4. FUI

9.2.4.1. FUI PACLIDO

Participants: Abdelkader Lahmadi [contact], Mingxiao Ma, Isabelle Chrisment, Jérôme François.

- Acronym: PACLIDO
- Title: Lightweight Cryptography Protocols and Algorithms for IoT (Protocoles et Algorithmes Cryptographiques Légers pour l'Internet des Objets)
- Coordinator: ADS (Airbus Defence and Space)
- Duration: September 2017- August 2020
- Others Partners: Sophia Conseil, Université de Limoges, Cea tech, Trusted Objects, Rtone, Saint Quentin En Yvelines.
- Abstract: The goal of PACLIDO is to propose and develop lightweight cryptography protocols and algorithms to secure IoT communications between devices and servers. The implemented algorithms and protocols will be evaluated in multiple use cases including smart home and smart city applications. PACLIDO develops in addition an advanced security monitoring layer using machine learning methods to detect anomalies and attacks while traffic is encrypted using the proposed algorithms.

9.2.5. Inria Project Lab

9.2.5.1. IPL BetterNet

Participants: Isabelle Chrisment [contact], Antoine Chemardin, Frederic Beck, Thibault Cholez.

- Acronym: BetterNet
- Coordinator: RESIST (Isabelle Chrisment)
- Duration: October 2016-August 2020
- Others Partners: Inria MiMove, Inria Diana, Inria Spirals, Inria Dionysos, ENS-ERST and IP-Label
- Site: https://project.inria.fr/betternet
- Abstract: BetterNet's goal is to build and deliver a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. We will propose new user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks. Tools, models and algorithms will be provided to collect data that will be shared and analyzed to offer valuable service to scientists, stakeholders and the civil society.

9.2.5.2. IPL Discovery

Participant: Lucas Nussbaum [contact].

- Coordinator: Adrien Lebre (STACK)
- End: June 2019
- Site: http://beyondtheclouds.github.io
- Others Partners: Orange, RENATER
- Abstract: To accommodate the ever-increasing demand for Utility Computing (UC) resources, while taking into account both energy and economical issues, the current trend consists in building larger and larger Data Centers in a few strategic locations. Although such an approach enables UC providers to cope with the actual demand while continuing to operate UC resources through a centralized software system, it is far from delivering sustainable and efficient UC infrastructures for future needs.

  The DISCOVERY initiative aims at exploring a new way of operating Utility Computing (UC) resources by leveraging any facilities available through the Internet in order to deliver widely distributed platforms that can better match the geographical spread of users as well as the ever increasing demand. Critical to the emergence of such locality-based UC (also referred as Fog/Edge Computing) platforms is the availability of appropriate operating mechanisms. The main objective of DISCOVERY is to design, implement, demonstrate and promote a new kind of Cloud Operating System (OS) that will enable the management of such a large-scale and widely distributed infrastructure in an unified and friendly manner.

9.3. European Initiatives

9.3.1. H2020 Projects

9.3.1.1. Fed4Fire+ (2017-2022)

Title: Federation for FIRE Plus

Program: H2020

Duration: January 2017 - December 2021

Coordinator: Interuniversitair Micro-Electronica centrum Imec VZW

Partners:
Universidad de Malaga; National Technical University of Athens - NTUA; The Provost, Fellows, Foundation Scholars & the other members of board of the College of the Holy & Undivided Trinity of Queen Elizabeth Near Dublin; Ethniko Kentro Erevnas Kai Technologikis Anaptyxis; GEANT LImited; Institut Jozef Stefan; Mandat International Alias Fondation Pour la Cooperation Internationale; Universite Pierre et Marie Curie - Paris 6; Universidad De Cantabria; Fundacio Privada I2CAT, Internet I Innovacio Digital A Catalunya; EURESCOM-European Institute For Research And Strategic Studies in Telecommunications GMBH; Nordunet A/S; Technische Universitaet Berlin; Instytut Chemii Bioorganicznej Polskiej Akademii Nauk; Fraunhofer Gesellschaft zur Foerderung Der Angewandten Forschung E.V.; Universiteit Van Amsterdam; University of Southampton; Martel GMBH; Atos Spain SA; Institut National de Recherche en Informatique et automatique.

Inria contact: David Margery (for RESIST: Lucas Nussbaum)

Abstract: Fed4FIRE+ is a successor project to Fed4FIRE. In Fed4FIRE+, we more directly integrate Grid'5000 into the wider eco-system of experimental platforms in Europe and beyond using results we developped in Fed4FIRE. We will also provide a generalised proxy mechanisms to allow users with Fed4FIRE identities to interact with services giving access to different testbeds but not designed to support Fed4FIRE identities. Finally, we will work on orchestration of experiments in a federation context.

9.3.1.2. SecureIoT

Title: Predictive Security for IoT Platforms and Networks of Smart Objects

Duration: December 2017 - December 2020

Coordinator: INTRASOFT International SA

Partners:
Fujitsu Technology Solutions GMBH; Atos Spain S.A; Siemens SRL; Singularlogic S.A.; IDIADA Automotive Technology SA; P@SSPORT Holland B.V.; UBITECH LIMITED; Innovation Sprint Sprl; DWF Germany Rechtsanwaltsgesellschaft mbH; LuxAI S.A.; Institut National de Recherche en Informatique et automatique; it's OWL Clustermanagement GmbH; Research and Education Laboratory in Information Technologies – Athens Information Technology (AIT).

Inria contact: Jérôme François

Url : http://secureiot.eu

Abstract: SecureIoT is a a joint effort of global leaders in IoT services and IoT cybersecurity to secure the next generation of dynamic, decentralized IoT systems, that span multiple IoT platforms and networks of smart objects, through implementing a range of predictive IoT security services. SecureIoT will integrate its security services in three different application scenarios in the areas of: Digital Automation in Manufacturing (Industry 4.0), Socially assistive robots for coaching and healthcare and Connected cars and Autonomous Driving.

Emerging cross-platform interactions and interactions across networks of smart objects require more dynamic, scalable, decentralized and intelligent IoT security mechanisms. Such mechanisms are highly demanded by the industry in order to secure a whole new range of IoT applications that transcend the boundaries of multiple IoT platforms, while involving autonomous interactions between intelligent CPS systems and networks of smart objects. In this direction, the main objectives of the project are to predict and anticipate the behavior of IoT systems, facilitate compliance to security and privacy regulations and provide APIs and tools for trustworthy IoT solutions.

9.3.1.3. SPARTA

Title: Strategic programs for advanced research and technology in Europe

Program: H2020

Duration: February 2019 - January 2022

Coordinator: Commissariat à l'Energie Atomique et aux Energies Alternatives

Partners: see web site

Inria contact: Jérôme François

Url : http://www.sparta.eu

Abstract: Cybersecurity is an urgent and major societal challenge. In correlation with the digitization of our societies, cyberthreats are having an increasing impact on our lives: it is essential to ensure digital security and strategic autonomy of the EU by strengthening its cybersecurity capacities. This challenge will require the coordination of Europe's best competences, along with strong international cooperations, towards common research and innovation goals.

SPARTA is a novel cybersecurity competence network, with the objective to collaboratively develop and implement top-tier research and innovation actions. Strongly guided by concrete challenges forming an ambitious Cybersecurity Research & Innovation Roadmap, SPARTA will tackle hard innovation challenges, leading the way in building transformative capabilities and forming a world-leading cybersecurity competence network across the EU. Four initial research and innovation programs will push the boundaries to deliver advanced solutions to cover emerging issues, with applications from basic human needs to economic activities, technologies, and sovereignty.

9.3.1.4. CONCORDIA

Participants: Thibault Cholez [contact], Rémi Badonnel, Olivier Festor.

Acronym: CONCORDIA

Title: Cyber security cOmpeteNCe fOr Research anD InnovAtion

Program: H2020

Start: 01/01/2019

Duration: 4 years

Coordinator: Research Institute CODE (Munich, Germany)

Partners: 52 partners, 26 academic and 26 industrial, from 19 countries (please see https://www.concordia-h2020.eu/consortium)

Url : https://www.concordia-h2020.eu/

Abstract: CONCORDIA is one of the 4 pilot projects whose goal is to structure and develop a network of cybersecurity competences across Europe. CONCORDIA has a research program to develop next-generation cybersecurity solutions by taking a holistic end-to-end data-driven approach from data acquisition, data transport and data usage, and addressing device-centric, network-centric, software-centric, system-centric, data-centric and user-centric security. The solutions will be integrated in sector-specific (vertical) and cross-sector (horizontal) industrial pilots with building incubators. Vertical pilots include Telecom, Finance, e-Health, Defence and e-Mobility, while horizontal pilots are about two European-scale federated platforms that are the DDoS clearing house and the Threat Intelligence platform . CONCORDIA also develops a CONCORDIA ecosystem by providing lab infrastructures, platforms, tools as "Living Labs" as well as advanced cybersecurity courses on cyber-ranges.

The project kick-off took place in Munich the 28/01/2019. The team is mainly involved in three tasks (research, education and European dimension). On the research side, we begun our work on assessing the reliability of blockchains' networking infrastructure (see section 7.1.3). Regarding the education in cybersecurity, we set up a cyber-range at TELECOM Nancy which was officially launched the 24/09/2019 and is already used by our M1 and M2 students to be trained in cybersecurity. We worked also for the task "Liaison with stakeholders" and were in particular the main editor of the 1st year deliverable of this task.

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. NetMSS

Title: NETwork Monitoring and Service orchestration for Softwarized networks

International Partner (Institution - Laboratory - Researcher):

University of Waterloo (Canada), David R. Cheriton School of Computer Science - Raouf Boutaba

Start year: 2018

Duration: 3 years

See also: https://team.inria.fr/netmss/

Evolution towards softwarized networks are greatly changing the landscape in networking. In the last years, effort was focused on how to integrate network elements in cloud-based models. This lead to the advent of network function virtualization primarily relying on regular virtualization technologies and on some advances in network programmability. Several architectural models have been proposed and, even if no full consensus has been reached yet, they highlight the major components. Among them, monitoring and orchestration are vital elements in order to ensure a proper assessment of the network conditions (network monitoring) serving as the support for the decision when deploying services (orchestration). With softwarization of networks, these elements can benefit from a higher flexibility but the latter requires new methods to be efficiently handled. For example, monitoring softwarized networks necessitates the collection of heterogeneous information, regarding the network but also cloud resources, from many locations. Targeting such a holistic monitoring will then support better decision algorithms, to be applied in a scalable and efficient manner, taking advantage of the advanced capabilities in terms of network configuration and programmability. In addition, real-time constraints in networking are very strong due to the transient nature of network traffic and are faced with high throughputs, especially in data-center networks where softwarization primarily takes place. Therefore, the associate team will promote (1) line-rate and accurate monitoring and (2) efficient resource uses for service orchestration leveraging micro-services.

9.4.2. Inria International Partners

9.4.2.1. Declared Inria International Partners

The team is actively involved in the international program of LUE (Lorraine Université d'Excellence):

Prof. Raouf Boutaba (University of Waterloo): Inria International Chair and Professor@Lorraine

Abir Laraba: international PhD grant in cooperation with University of Waterloo

Mehdi Zakroum: international PhD grant in cooperation with International University of Rabat

9.4.2.2. Informal International Partners

Since 2019, we have started a collaboration with Sonia Mettali from the CRISTAL Lab at the ENSI engineering school (Tunisia) on the development of reinforcement learning methods for the monitoring of IoT. The work is done in the context of the PhD of Mohamed Said Frikha, jointly co-supervised by Sonia Mettali and Abdelkader Lahmadi.

9.4.3. Participation in Other International Programs

9.4.3.1. ThreatPredict

- Title: ThreatPredict, From Global Social and Technical Big Data to Cyber Threat Forecast
- Coordinator: Inria
- Duration: December 2017 - November 2020
- Others Partners: International University of Rabat (IUR), Carnegie Mellon University
- Funding: North Atlantic Treaty Organization
- Abstract: Predicting attacks can help to prevent them or at least reduce their impact. Nowadays, existing attack prediction methods make accurate predictions only hours in advance or cannot predict geo-politically motivated attacks. ThreatPredict aims to predict different attack types days in advance. It develops machine-learning algorithms that capture the spatio-temporal dynamics of cyber-attacks and global social, geo-political and technical events. Various sources of information are collected, enriched and correlated such as honeypot data, darknet, GDELT, Twitter, and vulnerability databases. In addition to warning about attacks, this project will improve our understanding of the effect of global events on cyber-security.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Professor Adel Bouhoula from SUP'COM (Tunisia) from June 2019 until July 2019 in collaboration with PESTO team to develop methods for optimal and verifiable security policies for software-defined networks.

Dashi Kondo, Assistant Professor in Osaka Prefecture University for two weeks in November 2019 to develop new scientific cooperation on network security.

9.5.1.1. Internships

Anthony Samer Abou Jaoude, from March 2019 until May 2019.

Tarek Nsiri, from June 2019 until September 2019.

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

Abdelkader Lahmadi visited the team of Professor Raouf Boutaba in the University of Waterloo for two weeks during the month of June 2019. During this visit, he provided an IEEE seminar on the topic of Self-Driving Networks.

RMOD Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. CAR IMT Douai

Participants: Pablo Tesone, Guillermo Polito, Marcus Denker, Stéphane Ducasse with: L. Fabresse and N. Bouraqadi (IMT Douai)
From 2009, ongoing.

We have signed a convention with the CAR team led by Noury Bouraqadi of IMT Douai. In this context we co-supervised three PhD students (Mariano Martinez-Peck, Nick Papoylias and Guillermo Polito). The team is also an important contributor and supporting organization of the Pharo project.

Pablo Tesone did a PhD co-supervided by RMOD and Pr. L. Fabresse and N. Bouraqadi (finished in 2018). Currently, three PhD Students are co-supervised:

- PhD in progress: Théo Rogliano, *On multiple language kernel*, started Oct 2019, Stéphane Ducasse, Luc Fabresse
- PhD in progress: Pierre Misse-Chanabier, *Modular, green, versatile Virtual Machines*, started Oct 2019, Stéphane Ducasse, Noury Bouraqadi
- PhD in progress: Carolina Hernández, *Tools for MicroKernels* Guillermo Polito and Luc Fabresse

We are collaborating in the Context of CPER Data since 2018.

9.1.2. CPER DATA

Participants: Marcus Denker, Stéphane Ducasse, Allex Oliveira with: L. Fabresse and N. Bouraqadi (IMT Douai)
From 2018, ongoing.

Funding to work one year on the PharoThings Platform. We are creating content for a website and a Demo in callaboration with IMT Douai.

9.2. National Initiatives

9.2.1. CEA List

Participants: Jason Lecerf, Stéphane Ducasse with Thierry Goubier (CEA List)
From 2016, PhD finished 2019.

Jason Lecerf started a shared PhD Oct 2016 and finished November 2019: *Designing Language-Agnostic Code Transformation Engines*.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

University of Novi Sad, Serbia
Participants: Stéphane Ducasse, Anne Etien, Nicolas Anquetil, Vincent Aranega

A collaboration with the University of Novi Sad, Serbia, started in 2018 with the university joining the Pharo Consortium as an academic member.

We have handed in a bilateral project (Campus France) between Novi Sad and RMOD: *An innovative visual environment in service of developer experience*. We expect results by the end of this year.

A Master thesis has been cosupervised. Nina Medic: *Graph library with layout algorithms in Pharo*.

Visitors:

- Sebastijan Kaplar [University of Novi Sad, Serbia, Aug 2019]
- Gordana Rakic [University of Novi Sad, Serbia, from Nov 2019]
- Nina Medic [University of Novi Sad, Serbia, from Jun 2019 until Jul 2019]

University of Prague, Czech Republic
Participants: Stéphane Ducasse.

From 2015, ongoing.

We are working with Dr. Robert Pergl from the University of Prague. Stéphane Ducasse gave a lecture at the University of Prague in 2018, the next lecture is planned for 2020.

University of Cagliari, Italy
Participants: Stéphane Ducasse

We are working on sofware engineering problems in the context of blockchain based sofware.

Visitor: Giuseppe Antonio Pierro [University of Cagliari, until July 2019].

University of Bern, Switzerland
Participants: Stéphane Ducasse, Marcus Denker

We are working on dynamic software update to, for example, automatically transform users of deprecated code.

Visitor: Manuel Leuenberger [University of Bern, from Sep 2019 until Nov 2019]

Siemens AG, Germany
Participants: Stéphane Ducasse, Anne Etien, Nicolas Anquetil

The Siemens Digital Industry Division approached our team to help them restructure a large legacy systems. The joined work resulted in a publication in 2019: *Decomposing God Classes at Siemens* [1].

9.4. International Initiatives

9.4.1. Inria International Labs

Discussions with Inria Chile have started about organizing Pharo lectures in Chile. A first visit to Inria Chile in fall 2019 did not happen due to the political situation in Chile.

9.4.2. Inria Associate Teams Not Involved in an Inria International Labs

VUB Brussels, Belgium
Participants: Guillermo Polito, Stéphane Ducasse, Marcus Denker.

Collaboration with SOFT started 2016, from 2020 Inria Lille North-European associated team funding with SOFT/VUB for 2 years.

Student: Matteo Marra, collaboration with Eliza Gonzalez Boix.

Marcus Denker gave a lecture at VUB in October 2019.

9.4.3. Inria International Partners

9.4.3.1. Informal International Partners

Uqbar Argentina

Participants: Pablo Tesone, Esteban Lorenzano, Guillermo Polito, Stéphane Ducasse.

From 2015, ongoing.

We are working with the Uqbar team from different Argentinian universities. We hired three of the people: Nicolas Passerini(engineer), Esteban Lorenzano (engineer) and Pablo Tesone (PhD).

Pharo in Research:

Participants: Pablo Tesone, Esteban Lorenzano, Guillermo Polito, Marcus Denker, Stéphane Ducasse.
From 2009, ongoing.

We are building an ecosystem around Pharo with international research groups, universities and companies. Several research groups (such as Software Composition Group – Bern, and Pleaid – Santiago) are using Pharo. Many universities are teaching OOP using Pharo and its books. Several companies worldwide are deploying business solutions using Pharo.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Abdelhakim Bouremel [University of Skikda, Algeria, Oct 2019]
- Mohamad Chakroun [Mar 2019]
- Victor Martín Dias [University of Chile, Chile, until Sep 2019]
- Christopher Fuhrman [École de technologie supérieure de Montréal, Canada, until Sep 2019]
- Yann-Gaël Guéhéneuc [Concordia University, Canada, from Apr 2019 until May 2019]
- Sebastijan Kaplar [University of Novi Sad, Serbia, Aug 2019]
- Manuel Leuenberger [University of Bern, Switzerland, from Sep 2019 until Nov 2019]
- Milton Mamani Torres [Object Profile SpA, Chile, Aug 2019]
- Nina Medic [University of Novi Sad, Serbia, from Jun 2019 until Jul 2019]
- Hayatou Oumarou [University of Maroua, Cameroun, from Sep 2019 until Oct 2019]
- Giuseppe Antonio Pierro [University of Cagliari, Italy, until July 2019]
- Gordana Rakic [University of Novi Sad, Serbia, from Nov 2019]
- Moussa Saker [University Badji Mokhtar-Annaba, Algeria, from Dec 2019]

9.5.1.1. Internships

- Dayne Lorena Guerra Calle [Inria, from Feb 2019 until Aug 2019]
- Chia Yu Li [Inria, until Jul 2019]
- Iona Thomas [Centrale Lille, from Jul 2019 until Aug 2019]
- Oleksandr Zaitsev [Inria, until Feb 2019]

ROMA Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

ANR Project SOLHARIS (2019-2013), 4 years. The ANR Project SOLHAR was launched in November 2019, for a duration of 48 months. It gathers five academic partners (the HiePACS, ROMA, RealOpt, STORM and TADAAM) Inria project-teams, and CNRS-IRIT) and two industrial partners (CEA/CESTA and Airbus CRT). This project aims at producing scalable methods for direct methods for the solution of sparse linear systems on large scale and heterogeneous computing platforms, based on task-based runtime systems.

The proposed research is organized along three distinct research thrusts. The first objective deals with the development of scalable linear algebra solvers on task-based runtimes. The second one focuses on the deployement of runtime systems on large-scale heterogeneous platforms. The last one is concerned with scheduling these particular applications on a heterogeneous and large-scale environment.

9.2. International Initiatives

9.2.1. Inria International Labs

9.2.1.1. JLESC — Joint Laboratory on Extreme Scale Computing

The University of Illinois at Urbana-Champaign, Inria, the French national computer science institute, Argonne National Laboratory, Barcelona Supercomputing Center, Jülich Supercomputing Centre and the Riken Advanced Institute for Computational Science formed the Joint Laboratory on Extreme Scale Computing, a follow-up of the Inria-Illinois Joint Laboratory for Petascale Computing. The Joint Laboratory is based at Illinois and includes researchers from Inria, and the National Center for Supercomputing Applications, ANL, BSC and JSC. It focuses on software challenges found in extreme scale high-performance computers.

Research areas include:

- Scientific applications (big compute and big data) that are the drivers of the research in the other topics of the joint-laboratory.
- Modeling and optimizing numerical libraries, which are at the heart of many scientific applications.
- Novel programming models and runtime systems, which allow scientific applications to be updated or reimagined to take full advantage of extreme-scale supercomputers.
- Resilience and Fault-tolerance research, which reduces the negative impact when processors, disk drives, or memory fail in supercomputers that have tens or hundreds of thousands of those components.
- I/O and visualization, which are important part of parallel execution for numerical silulations and data analytics
- HPC Clouds, that may execute a portion of the HPC workload in the near future.

Several members of the ROMA team are involved in the JLESC joint lab through their research on scheduling and resilience. Yves Robert is the Inria executive director of JLESC.

9.2.2. Inria International Partners

9.2.2.1. Declared Inria International Partners

- Anne Benoit, Frederic Vivien and Yves Robert have a regular collaboration with Henri Casanova from Hawaii University (USA). This is a follow-on of the Inria Associate team that ended in 2014.

9.2.3. Cooperation with ECNU

ENS Lyon has launched a partnership with ECNU, the East China Normal University in Shanghai, China. This partnership includes both teaching and research cooperation.

As for teaching, the PROSFER program includes a joint Master of Computer Science between ENS Rennes, ENS Lyon and ECNU. In addition, PhD students from ECNU are selected to conduct a PhD in one of these ENS. Yves Robert is responsible for this cooperation. He has already given four classes at ECNU, on Algorithm Design and Complexity, and on Parallel Algorithms, together with Patrice Quinton (from ENS Rennes).

As for research, the JORISS program funds collaborative research projects between ENS Lyon and ECNU. Anne Benoit and Mingsong Chen have lead a JORISS project on scheduling and resilience in cloud computing. Frédéric Vivien and Jing Liu (ECNU) are leading a JORISS project on resilience for real-time applications. In the context of this collaboration two students from ECNU, Li Han and Changjiang Gou, have joined Roma for their PhD.

9.3. International Research Visitors

9.3.1. Visits to International Teams

9.3.1.1. Research Stays Abroad

- Yves Robert has been appointed as a visiting scientist by the ICL laboratory (headed by Jack Dongarra) at the University of Tennessee Knoxville since 2011. He collaborates with several ICL researchers on high-performance linear algebra and resilience methods at scale.

SOCRATE Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. Insa-Spie IoT Chair

The Insa-Spie IoT Chair http://www.citi-lab.fr/chairs/iot-chair/ relies on the expertise of the CITI Lab. The skills developed within the different teams of the lab integrate the study, modelling, conception and evaluation of technologies for communicating objects and dedicated network architectures. It deals with network, telecom and software matters as well as societal issues such as privacy. The chair will also lean on the skills developed at INSA Lyon or in IMU LabEx.

7.1.2. Inria Project Lab: ZEP

The ZEP project addresses the issue of designing tiny computing objects with no battery by combining non-volatile memory (NVRAM), energy harvesting, micro-architecture innovations, compiler optimizations, and static analysis. The main application target is Internet of Things (IoT) where small communicating objects will be composed of this computing part associated to a low-power wake-up radio system. The ZEP project gathers four Inria teams that have a scientific background in architecture, compilation, operating system and low power together with the CEA Lialp and Lisan laboratories of CEA LETI & LIST. The major outcomes of the project will be a prototype harvesting board including NVRAM and the design of a new microprocessor associated with its optimizing compiler and operating system.

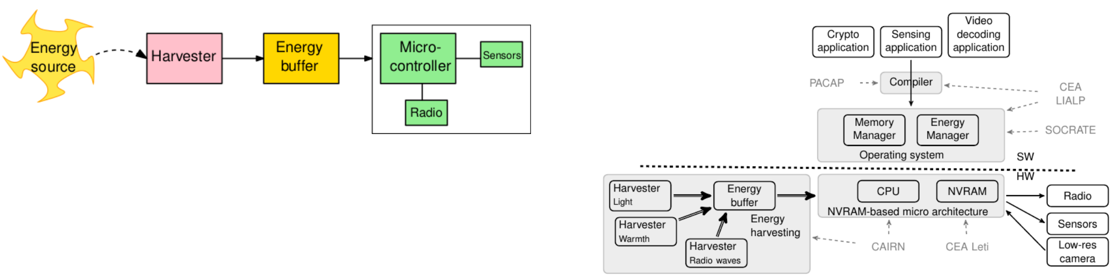

Figure 5. Example of system targeted by the ZEP project on the left, and on the right: the ZEP research program.

The scientific work (in progress) is organized around three fields :

- specific NVRAM-based architecture
- dedicated compiler pass that computes a worst-case energy consumption
- operating system managing NVRAM and energy, ensuring memory consistency across power outages

The project is illustrated by the figure 5 , where PACAP, SOCRATE, CORSE, and CAIRN are the teams involved in the project.

Another important goal of the project is to structure the research and innovation that should occur within Inria to prepare the important technological shift brought by NVRAM technologies.

7.1.3. ANR - Imprenum

The objective of this project (INSA-Lyon, École Normale Supérieure de Lyon, CEA LETI) is to promote **accuracy as a first class concern** in all the levels of a computing system:

- at the hardware level, with better support for lower-than-standard and higher-than-standard precisions;
- at the level of run-time support software, in particular answering the memory management challenges entailed by adaptive precision;
- at the lower level of mathematical libraries (kernel level), for instance BLAS for linear algebra, enhancing well established libraries with precision and accuracy control;
- at the higher level of mathematical libraries (solver level, including algebraic linear solvers such as LAPACK, ad hoc steppers for Ordinary Differential Equation, eigenvalues kernels, triangularization problems for computational geometry, etc.) Here, accuracy and precision control of the lower levels should enable higher-level properties such as convergence and stability;
- at the compiler level, enhancing optimising compilers with novel optimisations related to precision and accuracy;
- at the language level, embedding accuracy specification and control in existing languages, and possibly defining domain-specific languages with accuracy-aware semantics for some classes of applications.

7.1.4. ADT SytaRiot

The Riot system (https://www.riot-os.org/) is well known within Inria, it is a joint implementation of Inria and Freie Universität Berlin which is today one of the most widely used open-source OS on small embedded systems. The arrival of non-volatile memories promises a new generation of sensors on which the memory hierarchy will be more heterogeneous than today. The communicating system will be able to undergo a power cut em complete and resume its current activity when power returns.

Sytare (https://gitlab.inria.fr/citi-lab/sytare/), developed for three years by the Socrates team (with the support of an ADT), targets intermittent feeding which will arrive when the technologies of *harvesting* (recovery of ambient energy) are democratized.

The objective of this ADT is to make Riot compatible with NVRAM-based architecture, therefore to integrate Sytare with Riot and thus open Riot to ultra low power platforms containing NVRAM, *eg* Texas microcontrollers Instrument MSP430FR5969.

7.1.5. Digital Hardware AI Architectures

Florent de Dinechin participates to the chair *Digital Hardware AI Architectures* held by Prof. Frédéric Pétrot at the Multidisciplinary Institute in Artificial Intelligence (MIAI) of Grenoble. The other participants are François Duhem (Spintec/CEA) and Fabrice Rastello (LIG/Inria), with industrial partners Google France, Kalray, STMicroelectronics, and Upmem.

This chair funds the PhD of Maxime Christ, which studies how very low-precision arithmetic formats may improve the efficiency of the learning phase of neural networks.

7.2. European Initiatives

7.2.1. Collaborations in European Programs, Except FP7 & H2020

Socrate is very active in COST IRACON CA15104: Guillaume Villemaud is National Delegate (Alt.) and FIT/CorteXlab is identify as one of the COST platform.

7.3. International Initiatives

7.3.1. Inria International Partners

7.3.1.1. Informal International Partners

Socrate has collaborations with the following international partners.

- **University of Cyprus**, Department of Electrical and Computer Engineering, University of Cyprus, Nicosia, Cyprus. This cooperation with Prof. Ioannis Krikidis is on topics related to energy-harvesting and wireless communications systems. Scientific-Leaders at Inria: Guillaume Villemaud.
- **Universidad Nacional del Sur**, LaPSyC laboratory, Bahía Blanca , Argentina. This cooperation with Prof. Juan Cousseau is on topics related to Full-Duplex communications and Interference Alignment. Scientific-in-charge at Inria: Guillaume Villemaud.
- **Technical University "Gh. Asachi" of Iasi, Romania**, Department of Electronics, Telecommunications and Information Technology. This recent collaboration has started on topics related on the theoretical aspects of the ultra-low power radio communications. Scientific-in-charge at Inria: Florin Hutu
- **Technical University of Fulda, Germany**. This collaboration with the group of Martin Kumm covers many aspects of computer arithmetic, with several joint papers, collaboration on the FloPoCo project, and work in progress on a textbook to appear in 2020. Scientific-in-charge at Inria: Florent de Dinechin
- **Imperial College, London, UK**, departments of Computing and Electrical Engineering. This collaboration with the groups of David Thomas and George Constantinides covers several aspects of reconfigurable computing and reconfigurable arithmetic. Scientific-in-charge at Inria: Florent de Dinechin

SPIRALS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Région Hauts-de-France

9.1.1.1. CIRRUS

Participants: Stéphanie Challita, Guillaume Fieni, Alexandre Garnier, Christophe Gourdin, Philippe Merle [contact person], Romain Rouvoy, Lionel Seinturier, Faiez Zalila.

CIRRUS is a 3-year (2017–20) joint team with the Scalair cloud operator and architect company funded by the Hauts-de-France region. The CIRRUS joint team is developing novel solutions in the domains of the on demand configuration of heterogeneous cloud resources, the management of cloud elasticity for all deployed services (SaaS, PaaS, IaaS) in order to guarantee quality of service and user quality of experience, and the taming of financial costs of cloud infrastructures.

9.1.1.2. Alloy@Scale

Participants: Abderrahman Lahiaouni, Philippe Merle [contact person], Romain Rouvoy, Lionel Seinturier.

Alloy@Scale is a 12-month (2018–19) project funded in the context of CPER Data program. Alloy@Scale aims at overcoming the limits of the formal verification of large software systems specified with the Alloy formal specification language. For that, the program combines the Grid'5000 infrastructure and the Docker container technology.

9.1.1.3. Rigorous Component-Based Design of Correct-by-Construction Software and Systems: Application to Cloud Computing

Participants: Simon Bliudze [contact person], Larisa Safina.

This 24-month (2019–20) project is funded in the context of the STaRS program. It aims at the development of methods and tools for rigorous design of cloud computing platforms and applications, which can be proven to be correct by construction. First results have been published in [17], [31], [3].

9.1.1.4. Indoor Analytics

Participants: Pierre Bourhis, Remy Raes, Romain Rouvoy [contact person], Lionel Seinturier.

Indoor Analytics is a 32-month (2019–21) project funded in the context of CPER Data program. Indoor Analytics aims at collaborating with the Mapwize company on the development of novel analytics for indoor location systems. In particular, Mapwize and Spirals target the joint delivery of an open-source software solution devoted to the acquisition, storage and processing of location events at scale.

9.1.1.5. COMMODE

Participants: Pierre Bourhis, Laurence Duchien, Clément Quinton [contact person].

COMMODE (Knowledge COMpilation for feature MODEls) is a 24-month (2019–21) project funded in the context of CPER Data program. COMMODE aims at using techiques from knowledge compilation, a subarea of artificial intelligence, for feature models, a representation of software products used in software engineering.

9.1.2. Inria Lille - Nord Europe

9.1.2.1. North European Lab LLEX

Participants: Benjamin Danglot, Martin Monperrus, Lionel Seinturier [contact person].

North European Lab LLEX (2017–19) is an international initiative supported by the Inria Lille - Nord Europe Center that takes place in the context of a collaboration between Inria and KTH. LLEX deals with research on automated diagnosis and repair of software bugs. Automated software repair is the process of fixing software bugs automatically. An automated software repair system fixes software bugs with no human intervention. The goal of automated software repair is to save maintenance costs and to enable systems to be more resilient to bugs and unexpected situations. This research may dramatically improve the quality of software systems. This initiative led to several results that have been published [24], [21], [45], [36], [10] and to the PhD thesis of Benajamin Danglot [11] that have been defended in November 2019.

9.1.2.2. ADT FingerKit

Participants: Antoine Canda, Walter Rudametkin Ivey [contact person], Antoine Vastel.

ADT FingerKit (2018–20) is a technology development initiative supported by the Inria Lille - Nord Europe Center that focuses on the design and development of a new and enhanced version of the AmIUnique platform. AmIUnique is a data collection and analysis platform to better understand, analyze and vulgarize the uses and threats of browser fingerprinting. This initiative led by Inria is a key asset to better understand novel techniques that threatens the user privacy on Internet. This ADT builds on our first results with the PhD thesis of Antoine Vastel [14].

9.1.2.3. ADT e-Lens

Participants: Arthur d'Azémar, Guillaume Fieni, Romain Rouvoy [contact person].

ADT e-Lens (2018–20) is a technology development initiative supported by the Inria Lille - Nord Europe Center that aims at extending the PowerAPI energy monitoring library that we develop in the team since 2011. The extension deals with the integration of new power models (for GPU, disk, network interface), the implementation of a self-optimization algorithm, the port of the platform to embedded systems running with Raspberry Pi, ROS and Android, and the implementation of an active learning algorithm for power models. This ADT builds on our results with the defended PhD theses of Adel Noureddine [68] and Maxime Colmant [52], and with the ongoing PhD thesis of Guillaume Fieni.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. ANR BottleNet

Participants: Romain Rouvoy [contact person], Walter Rudametkin Ivey, Lionel Seinturier.

BottleNet is a 48-month project (2015–19) funded by ANR. The objective of BottleNet is to deliver methods, algorithms, and software systems to measure Internet *Quality of Experience* (QoE) and diagnose the root cause of poor Internet QoE. Our goal calls for tools that run directly at users' devices. We plan to collect network and application performance metrics directly at users' devices and correlate it with user perception to model Internet QoE, and to correlate measurements across users and devices to diagnose poor Internet QoE. This data-driven approach is essential to address the challenging problem of modeling user perception and of diagnosing sources of bottlenecks in complex Internet services. BottleNet will lead to new solutions to assist users, network and service operators as well as regulators in understanding Internet QoE and the sources of performance bottleneck. Several results and publications have been obtained in the context of this project [6], [5], [76]. The paper [5] won the Best Paper award at the 19th International Conference on Distributed Applications and Interoperable Systems (DAIS 2019). The PhD thesis of Lakhdar Meftah [13], supervised by Romain Rouvoy and Isabelle Chrisment (Inria Nancy), was defended in December 2019 in the context of this project. This project is in relation with the Inria IPL BetterNet.

9.2.1.2. ANR SATAS

Participants: Alexandre Garnier, Philippe Merle [contact person], Romain Rouvoy, Lionel Seinturier.

SATAS is a 48-month project (2015–20) funded by ANR. SATAS aims to advance the state of the art in massively parallel SAT solving with a particular eye to the applications driving progress in the field. The final goal of the project is to be able to provide a "pay as you go" interface to SAT solving services, with a particular focus on their power consumption. This project will extend the reach of SAT solving technologies, daily used in many critical and industrial applications, to new application areas, which were previously considered too hard, and lower the cost of deploying massively parallel SAT solvers on the cloud. Our results from this project have been published in the following papers [53], [60].

9.2.1.3. ANR Headwork

Participants: Pierre Bourhis [contact person], Marion Tommasi.

Headwork is a 48-month project (2016–21) funded by ANR. The main objective of Headwork is to develop data-centric workflows for programming crowd sourcing systems in a flexible declarative manner. The problem of crowd sourcing systems is to fill a database with knowledge gathered by thousands or more human participants. A particular focus is to be put on the aspects of data uncertainty and for the representation of user expertise. This project is coordinated by D. Gross-Amblard from the Druid Team (Rennes 1). Other partners include the Dahu team (Inria Saclay), Sumo (Inria Bretagne), and Links (Inria Lille) with J. Nierhen and M. Sakho. Our results from this project have been published in the following paper [1].

9.2.1.4. ANR Delta

Participant: Pierre Bourhis [contact person].

Delta is a 48-month project (2016–21) funded by ANR. The project focuses on the study of logic, transducers and automata. In particular, it aims at extending classical framework to handle input/output, quantities and data. This project is coordinated by M. Zeitoun from LaBRI. Other partners include LIF (Marseille), IRIF (Paris-Diderot), and D. Gallois from the Inria Lille Links team. Several results and publications have been obtained in the context of this project [18], [16], [28], [27].

9.2.1.5. ANR CQFD

Participant: Pierre Bourhis [contact person].

CQFD is a 48-month project (2018–22) funded by ANR. The project focuses on the complex ontological queries over federated heterogeneous data. The project targets to set the foundations, to provide efficient algorithms, and to provide query rewriting oriented evaluation mechanisms, for ontology-mediated query answering over heterogeneous data models. This project is coordinated by Federico Ulliana from Inria Sophia Antipolis. Other partners include LaBRI, Inria Saclay, IRISA, LTCI, and LIG.

9.2.1.6. ANR FP-Locker

Participants: Vikas Mishra, Walter Rudametkin Ivey [contact person].

FP-Locker is a 42-month project (2019–23) funded by ANR in the context of the JCJC program. This project proposes to investigate advanced browser fingerprinting as a configurable authentication mechanism. We argue that it has the potential to be the only authentication mechanism when used in very low-security, public websites; it can be used to block bots and other fraudulent users from otherwise open websites. It also has the potential to be used as a second factor authentication mechanism, or as an additional factor in Multi-Factor Authentication (MFA) schemes. Besides strengthening a session's initial authentication, it can also be used for continuous session authentication to protect against session hijacking. In many contexts, fingerprinting is fully transparent to users, meaning that contrary to authentication processes that rely on external verification cards, code generating keys, special apps, SMS verification codes, users do not have to do anything to improve their security. In more restricted contexts, administrators can enforce different policies, for example, enrolling fingerprints from devices that connect from trusted IP addresses (e.g., an internal network), and then verifying these fingerprints when the same users connect from untrusted IP addresses. Consequently, we plan to design an architecture and implement it to be able to plug the browser fingerprinting authentication process to an existing authentication system.

9.2.1.7. ANR Koala

Participants: Pierre Bourhis, Clément Quinton [contact person].

Koala is a 42-month project (2019–23) funded by ANR in the context of the JCJC program. The project aims to deliver a series of innovative tools, methods and software to deal with the complexity of fog computing environments configurations and adaptations. In particular, we take a step back on the current limitations of existing approaches (e.g., lack of expressiveness and scalability) and address them placing knowledge as a first-class citizen. We plan to tackle configuration issues from a novel perspective in the field of variability management, using recent techniques from the area of knowledge compilation. Specifically, we will investigate the best-suited d-DNNF representation for each reasoning operation, and we plan to provide new variability modeling mechanisms (e.g., dimensions, priorities and scopes) required in a fog context. Regarding adaptation concerns, we want to leverage machine learning techniques to improve adaptation management and evolution under uncertainty, relying on a continuously enriched and reusable knowledge base. In particular, we plan to propose an approach for suggesting evolution scenarios in a predictive manner, relying on an evolution-aware knowledge base acquired at run-time through machine learning feedback.

9.2.2. Competitivity Clusters

9.2.2.1. FUI StoreConnect

Participants: Romain Rouvoy, Lionel Seinturier [contact person].

StoreConnect is a 36-month project (2016–19) funded by FUI and labelled by the PICOM (Pôle des Industries du COMmerce) competitivity cluster. The partners are Tevolys, Ubudu (leader), Smile, STIME, Leroy Merlin, Insiteo, Inria Spirals, Inria Fun, Inria Stars. The goal of the project is to define a modular multi-sensors middleware platform for indoor geolocation. Several results and publications have been obtained in the context of this project [5], [38], [66].

9.2.3. Inria National Initiatives

9.2.3.1. Inria IPL BetterNet

Participants: Lakhdar Meftah, Romain Rouvoy [contact person].

BetterNet (2016–19) aims at building and delivering a scientific and technical collaborative observatory to measure and improve the Internet service access as perceived by users. In this Inria Project Lab, we will propose new original user-centered measurement methods, which will associate social sciences to better understand Internet usage and the quality of services and networks. Our observatory can be defined as a vantage point, where: (1) tools, models and algorithms/heuristics will be provided to collect data, (2) acquired data will be analyzed, and shared appropriately with scientists, stakeholders and civil society, and (3) new value-added services will be proposed to end-users. IPL BetterNet is led by Isabelle Chrisment (Inria Madynes), with the participation of the Diana, Dionysos, Inria Chile, Muse, and Spirals Inria project-teams, as well as the ARCEP French agency and the ip-label company. Our results in the context of this project have been published in [66].

9.2.4. CNRS Momentum

9.2.4.1. Manage Your Data Without Information Leakage

Participants: Pierre Bourhis [contact person], Louis Jachiet.

"Gérer vos données sans fuite d'information" is a 3-year (2018–20) project granted in the context of the CNRS-Momentum call for projects. Data manipulated by modern applications are stored in large databases. To protect these pieces of data, security policies limit a user's access to what she is allowed to see. However, by using the semantics of the data, a user can deduce information that she was not supposed to have access to. The goal of this project is to establish methods and tools for understanding and detecting such data leaks. Several results and publications have been obtained in the context of this project [32], [29], [30].

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: H2020 ICT-10-2016.

Project acronym: STAMP.

Project title: Software Testing Amplification.

Duration: 36 months (2016–19).

Coordinator: Inria.

Other partners: ActiveEon (France), Atos (Spain), Engineering (Italy), OW2 (France), SINTEF (Norway), TellU (Norway), TU Delft (The Netherlands), XWiki (France).

Abstract: By leveraging advanced research in automatic test generation, STAMP aims at pushing automation in DevOps one step further through innovative methods of test amplification. It will reuse existing assets (test cases, API descriptions, dependency models), in order to generate more test cases and test configurations each time the application is updated. Acting at all steps of development cycle, STAMP techniques aim at reducing the number and cost of regression bugs at unit level, configuration level and production stage.

Participants: Benjamin Danglot, Martin Monperrus [contact person].

Program: H2020 JU Shift2Rail.

Project acronym: X2Rail-1.

Project title: Start-up activities for Advanced Signalling and Automation System.

Duration: 36 months (2016–19).

Coordinator: Siemens.

Other partners: 19 partners, among others Bombardier, Siemens, Thales, IRT Railenium.

Abstract: Our contribution to the project is focused on adaptive communication middleware for cyber-physical railway systems.

Participants: Lionel Seinturier [contact person].

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: EUREKA Celtic-Plus.

Project acronym: SENDATE.

Project title: SEcure Networking for a DATa Center Cloud in Europe.

Duration: 36 months (2016–19).

Coordinator: Nokia.

Other partners: 50+ partners in Finland, France, Germany, Norway, and Sweden. Selected partners involved: Nokia, Orange.

Abstract: The project addresses the convergence of telecommunication networks and IT in the context of distributed data centers. We are involved in the TANDEM subproject that targets the infrastructure of such a distributed system. More specifically, we are studying new approaches in terms of software engineering and component-based solutions for enabling this convergence of network and IT.

Participants: Lionel Seinturier [contact person].

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. SOMCA

Title: Self-Optimization of Service Oriented Architectures for Mobile and Cloud Applications

International Partner (Institution - Laboratory - Researcher):

Université du Québec à Montréal (Canada) - LATECE - Naouel MOHA

Start year: 2017

See also: http://sofa.uqam.ca/somca.php

The long-term goal of this research program is to propose a novel and innovative methodology embodied in a software platform, to support the runtime detection and correction of anti-patterns in large-scale service-oriented distributed systems in order to continuously optimize their quality of service. One originality of this program lies in the dynamic nature of the service-oriented environments and the application on emerging frameworks for embedded and distributed systems (e.g., Android/iOS for mobile devices, PaaS/SaaS for Cloud environments), and in particular mobile systems interacting with remote services hosted on the Cloud.

9.4.2. Participation in Other International Programs

9.4.2.1. Partnership for joint Curriculum Development and Research in Energy Informatics (PACE)

Participants: Mohammed Chakib Belgaid, Arthur d'Azémar, Guillaume Fieni, Alexandre Garnier, Zakaria Ournani, Clément Quinton, Romain Rouvoy [contact person], Lionel Seinturier.

PACE is a 3-year (2019–21) project funded by the Research Council of Norway. The goal of the project is to establish a sustained education and research-oriented collaboration between four partner universities in energy informatics and green computing that will strengthen quality academic relations and mutually improve each other's quality of research and researcher training both at PhD and master level. Partner universities are: University of Oslo (Norway), University of Stavanger (Norway), TU Munich (Germany), Université de Lille.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Internships

Jonatan Enes, PhD Student in Computer Science from University of A Coruña, visited us for 3 months from April to July.

Alejandro Grez, from Pontifical Catholic University of Chile, visited us for 1 month in April.

STACK Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. SysMics

Participants: Jean-Marc Menaud, Mario Südholt [coordinator].

The SysMics project aims at federating the NExT scientific community toward a common objective: anticipate the emergence of systems medicine by co-developing 3 approaches in population-scale genomics: genotyping by sequencing, cell-by-cell profiling and microbiome analysis. STACK investigates new means for secure and privacy-aware computations in the context of personalized medecine, notably genetic analyses.

This project is financed by the Nantes excellency initiative in Medecine and Informatics (NExT) from 2018-22.

9.1.2. SHLARC

Participants: Mario Südholt [coordinator], Sirine Sayadi.

The SHLARC project is an international network involving more than 20 partners from more than 15 countries located on four continents. The network aims at improving HLA imputation techniques in the domain of immunobiology, notably by investigation better computational methods for the correspoding biomedical analyses.

The ambition of the SHLARC is to bring together international expertise to solve essential questions on immune-related pathologies through innovative algorithms and powerful computation tool development. To achieve this goal, we determined 3 main objectives

- Data. By bringing together scientists from around the world, we will collectively increase the amount of SNP+HLA data available, both in terms of quantity and diversity.
- Applied mathematical and computer sciences. We will further optimize SNP-HLA imputation methods using the attribute-bagging HIBAG tool, and particularly for genetically diverse and admixed populations.
- Accessibility and service to the scientific community. Following the Haplotype Reference Consortium (HRC) initiative, the network envisions building a free, user-friendly webserver where researchers can access improved imputation protocols by simply uploading their data and obtaining the best possible HLA imputation for their dataset.

In this context, the STACK team is working on improved analysis techniques that harness distributed infrastructures.

This project is financed by the Nantes excellency initiative in Medecine and Informatics (NExT) from 2019-22.

9.1.3. Oncoshare

Participant: Mario Südholt [coordinator].

The ONCOSHARe project (ONCOlogy big data SHAring for Research) will demonstrate, through a multidisciplinary cooperation within the Western CANCEROPOLE network, the feasibility and the added value of a Cancer Patient Centered Information Common for in-silico research. The STACK team will work on challenges to the security and the privacy of user data in this context.

This project is financed by three French regions from 2018-2021.

9.2. National Initiatives

9.2.1. Ademe

9.2.1.1. GL4MA

Participants: Brice Nédelec, Thomas Ledoux [coordinator].

The Green Label for Microservices Architecture (GL4MA) project aims to design and develop a technological platform (tools, framework, dedicated languages) for the self management of eco-responsible micro-service architectures for the Cloud. The experiments will be carried out through case studies provided by Sigma Informatique and the presence of renewable energy will initially be simulated. At the end of the project, the technological platform will be deployed as part of the CPER SeDuCe platform. This project is founded by the Ademe (call Perfecto) running for 18 months (starting in September 2019).

9.2.2. CominLabs laboratory of excellence

9.2.2.1. PrivGen

Participants: Fatima Zahra Boujdad, Mario Südholt [coordinator].

PrivGen ("Privacy-preserving sharing and processing of genetic data") is a three-year project that has been started in Oct. 2016 and is conducted by three partners: a team of computer scientists from the LATIM Inserm institute in Brest mainly working on data watermarking techniques, a team of geneticians from an Inserm institute in Rennes working on the gathering and interpretation of genetic data, and the STACK team. The project provides funding of 330 KEUR altogether with an STACK share of 120 KEUR.

The project considers challenges related to the outsourcing of genetic data that is in the Cloud by different stakeholders (researchers, organizations, providers, etc.). It tackles several limitations of current security solutions in the cloud, notably the lack of support for different security and privacy properties at once and computations executed at different sites that are executed on behalf of multiple stakeholders.

The partners are working on three main challenges:

- Mechanisms for a continuous digital content protection.
- Composition of security and privacy-protection mechanisms
- Distributed processing and sharing of genetic data.

The STACK team is mainly involved in providing solutions for the second and third challenges.

9.2.2.2. SeDuCe++

Participants: Jonathan Pastor, Jean-Marc Menaud [coordinator].

SeDuCe++ is an extended version of the SeDuCe project. Funded by the LS2N (CNRS), an allocated budget of 10K€ for one year, it aims at studying the energy footprint of extreme edge infrastructure.

9.2.3. ANR

9.2.3.1. GRECO (ANR)

Participants: Adrien Lebre [Contact point], Alexandre Van Kempen.

The GRECO project (Resource manager for cloud of Things) is an ANR project (ANR-16-CE25-0016) running for 42 months (starting in January 2017 with an allocated budget of 522K€, 90K€ for STACK).

The consortium is composed of 4 partners: Qarnot Computing (coordinator) and 3 academic research group (DATAMOVE and AMA from the LIG in Grenoble and STACK from Inria Rennes Bretagne Atlantique).

The goal of the GRECO project (https://anr-greco.net) is to design a manager for cloud of things. The manager should act at the IaaS, PaaS and SaaS layer of the cloud. To move forward to this objective, we have been designing a simulator to innovate in designing scheduling and data management systems. This simular leverage the Simgrid/PyBATSIM solution [27].

9.2.3.2. KerStream (ANR)

Participant: Shadi Ibrahim [Coordinator].

The KerStream project (Big Data Processing: Beyond Hadoop!) is an ANR JCJC (Young Researcher) project (ANR-16-CE25-0014-1) running for 48 months (starting in January 2017 with an allocated budget of 238K€).

The goal of the KerStream project is to address the limitations of Hadoop when running Big Data stream applications on large-scale clouds and do a step beyond Hadoop by proposing a new approach, called KerStream, for scalable and resilient Big Data stream processing on clouds. The KerStream project can be seen as the first step towards developing the first French middleware that handles Stream Data processing at Scale.

9.2.4. FSN

9.2.4.1. Hydda (FSN)

Participants: Hélène Coullon, Jean-Marc Menaud [coordinator].

The HYDDA project aims to develop a software solution allowing the deployment of Big Data applications (with hybrid design (HPC/CLoud)) on heterogeneous platforms (cluster, Grid, private Cloud) and orchestrators (Task scheduler like Slurm, Virtual orchestrator (like Nova for OpenStack or Swarm for Docker). The main questions we are investigating are :

- How to propose an easy-to-use service to host (from deployment to elimination) application components that are both typed Cloud and HPC?
- How propose a service that unifies the HPCaaS (HPC as a service) and the Infrastructure as a Service (IaaS) in order to offer resources on demand and to take into account the specificities of scientific applications?
- How optimize resources usage of these platforms (CPU, RAM, Disk, Energy, etc.) in order to propose solutions at the least cost?

9.2.5. CPER

9.2.5.1. SeDuCe

Participants: Adrien Lebre, Jean-Marc Menaud [coordinator], Jonathan Pastor.

The SeDuCe project (Sustainable Data Centers: Bring Sun, Wind and Cloud Back Together), aims to design an experimental infrastructure dedicated to the study of data centers with low energy footprint. This innovative data center will be the first experimental data center in the world for studying the energy impact of cloud computing and the contribution of renewable energy (solar panels, wind turbines) from the scientific, technological and economic viewpoints. This project is integrated in the national context of grid computing (Grid'5000), and the Constellation project, which will be an inter-node (Pays de la Loire, Brittany).

9.2.6. Inria Project Labs

9.2.6.1. DISCOVERY

Participants: Javier Rojas Balderrama, Hélène Coullon, Marie Delavergne, Shadi Ibrahim, Adrien Lebre [coordinator], Ronan-Alexandre Cherrueau, Matthieu Simonin, Alexandre Van Kempen.

To accommodate the ever-increasing demand for Utility Computing (UC) resources, while taking into account both energy and economical issues, the current trend consists in building larger and larger Data Centers in a few strategic locations. Although such an approach enables UC providers to cope with the actual demand while continuing to operate UC resources through centralized software system, it is far from delivering sustainable and efficient UC infrastructures for future needs.

The DISCOVERY initiative [0] aims at exploring a new way of operating Utility Computing (UC) resources by leveraging any facilities available through the Internet in order to deliver widely distributed platforms that can better match the geographical dispersal of users as well as the ever increasing demand. Critical to the emergence of such locality-based UC (also referred as Fog/Edge Computing) platforms is the availability of appropriate operating mechanisms. The main objective of DISCOVERY is to design, implement, demonstrate and promote a new kind of Cloud Operting System (OS) that will enable the management of such a large-scale and widely distributed infrastructure in an unified and friendly manner.

The consortium is composed of experts in the following research areas: large-scale infrastructure management systems, networking and P2P algorithms. Moreover, two key network operators, namely Orange and RENATER, are involved in the project.

By deploying and using a Fog/Edge OS on backbones, our ultimate vision is to enable large parts of the Internet to be hosted and operated by its internal structure itself: a scalable set of resources delivered by any computing facilities forming the Internet, starting from the larger hubs operated by ISPs, governments and academic institutions, to any idle resources that may be provided by end users.

STACK led the DISCOVERY IPL and contributes mainly around two axes: VM life cycle management and deployment/reconfiguration challenges.

The IPL ended in July 2019.

9.2.7. InriaHub

9.2.7.1. Mercury

Participants: Ronan-Alexandre Cherrueau, Adrien Lebre [coordinator], Matthieu Simonin.

STACK, in particular within the framework of the DISCOVERY initiative has been working on the massively distributed use case since 2013. With the development of several proof-of-concepts around OpenStack, the team has had the opportunity to start an InriaHub action. Named Mercury, the goal of this action is twofold: (i) support the research development made within the context of DISCOVERY and (ii) favor the transfer toward the OpenStack community.
Further information available at: http://beyondtheClouds.github.io.

The Mercury action ended in July 2019.

9.2.7.2. Apollo/Soyuz

Participants: Javier Rojas Balderrama, Ronan-Alexandre Cherrueau, Adrien Lebre [coordinator], Matthieu Simonin.

The Apollo/Soyuz is the second InriaHub action attached the DISCOVERY IPL. While Mercury aims mainly at supporting development efforts within the DISCOVERY IPL, the Apollo/Soyuz is focusing on the animation and the dissemination of the DISCOVERY activities within the different open-source ecosystem (*i.e.*, OpenStack, OPNFV, etc.). One additional engineer will join the current team in January 2019.
Further information available at: http://beyondtheClouds.github.io.

The Apollo/Soyuz ended in Dec 2019.

9.2.8. Fonds d'amorçage IMT Industrie du Futur 2017

9.2.8.1. aLIFE

Participants: Hélène Coullon [coordinator], Jacques Noyé.

As a follow-up of the aLIFE workshop (Nantes, Jan. 2018), organized in partnership with colleagues from IMT Atlantique and gathering both academic and industrial partners, we have written a booklet [29] summarizing the workshop discussions and proposing a shared vision of what software research could bring to Industry 4.0 initiatives.

[0] http://beyondtheclouds.github.io

9.2.9. Connect Talent

9.2.9.1. Apollo (Connect Talent)

Participant: Shadi Ibrahim [Coordinator].

The Apollo project (Fast, efficient and privacy-aware Workflow executions in massively distributed Data-centers) is an individual research project "Connect Talent" running for 36 months (starting in November 2017 with an allocated budget of 201K€).

The goal of the Apollo project is to investigate novel scheduling policies and mechanisms for fast, efficient and privacy-aware data-intensive workflow executions in massively distributed data-centers.

9.2.10. Etoiles Montantes

9.2.10.1. VeRDi

Participant: Hélène Coullon [Coordinator].

VeRDi is an acronym for Verified Reconfiguration Driven by execution. The VeRDi project is funded by the French region Pays De La Loire where Nantes is located. The project starts in November 2018 and ends on December 2020 with an allocated budget of 172800€.

It aims at addressing distributed software reconfiguration in an efficient and verified way. The aim of the VeRDi project is to build an argued disruptive view of the problem. To do so we want to validate the work already performed on the deployment in the team and extend it to reconfiguration.

9.3. International Initiatives

9.3.1. Inria International Labs

Inria@SiliconValley

Associate Team involved in the International Lab:

9.3.1.1. Hermes

Title: Accelerating the Performance of Multi-Site Scientific applications through Coordinated Data management.

International Partner (Institution - Laboratory - Researcher):

Lawrence Berkeley National Laboratory (United States) - Scientific Data Management Group - Suren Byna.

Start year: 2019

See also: http://hermes-ea2019.gforge.inria.fr.

Advances in computing, experimental, and observational facilities are enabling scientists to generate and analyze unprecedented volumes of data. A critical challenge facing scientists in this era of data deluge is storing, moving, sharing, retrieving, and gaining insight from massive collections of data efficiently. Existing data management and I/O solutions on high-performance computing (HPC) systems require significant enhancements to handle the three V's of Big Data (volume, velocity, and variety) in order to improve productivity of scientists. Even more challenging, many scientific Big Data and machine learning applications require data to be shared, exchanged, and transferred among multiple HPC sites. Towards overcoming these challenges, in this project, we aim at accelerating scientific Big Data application performance through coordinated data management that addresses performance limitations of managing data across multiple sites. In particular, we focus on challenges related to the management of data and metadata across sites, distributed burst buffers, and online data analysis across sites.

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

Huazhong university of Science and Technology (HUST): We collaborate on resource management for stream data applications in the edge, I/O scheduling for SDDs and network-aware task scheduling for MapReduce.

National University of Singapore (NUS): We collaborate on resource management for workflows in the clouds and optimizing graph processing in geo-distributed data-centers.

ShenZhen University: We collaborate on resource management for workflows in the clouds and optimizing graph processing in geo-distributed data-centers.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Suren Byna, a Staff Scientist in the Scientific Data Management Group at Lawrence Berkeley National Lab (LBNL), visited the STACK team from September 30 to October 4 2019. This visit was in the context of the Hermes Associate team.
- Twinkle Jain, a PhD student at Northeastern university, visited the STACK team from May 1 to July 31 2019. Twinkle was working with S. Ibrahim on stragglers mitigation in big data systems. The visit was funded by the ANR KerStream and the Apollo Connect Talent projects.

9.4.1.1. Internships

- Asha Begam Mohamed Mubarak, a master student at University of Rennes 1, joined the team as a research intern from April 2019 until August 2019. Her thesis was on fast Container Image Retrieval in the Edge.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

HUST, China: From August 23 to September 2, S. Ibrahim visited the Services Computing Technology and System Lab at Huazhong university of Science and Technology.

STORM Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

HPC/Big-Data Convergence

- Team participants : Olivier Aumage, Nathalie Furmento, Samuel Thibault.
- Other participants : David Auber, Olivier Beaumont, Lionel Eyraud-Dubois, Gérald Point
- Abstract: The goal of this project is to gather teams from the HPC and Big Data communities to work at the intersection between these domains. We will focus on how StarPU can be adapted to achieve good performances on Big Data platforms.

9.2. National Initiatives

ELCI The ELCI PIA project (Software Environment for HPC) aims to develop a new generation of software stack for supercomputers, numerical solvers, runtime and programming development environments for HPC simulation. The ELCI project also aims to validate this software stack by showing its capacity to offer improved scalability, resilience, security, modularity and abstraction on real applications. The coordinator is Bull, and the different partners are CEA, Inria, SAFRAN, CERFACS, CNRS CORIA, CENAERO, ONERA, UVSQ, Kitware and AlgoTech.

9.2.1. ANR

ANR SOLHAR (http://solhar.gforge.inria.fr/doku.php?id=start).

ANR MONU 2013 Program, 2013 - 2018 (36 months extended)

Identification: ANR-13-MONU-0007

Coordinator: Inria Bordeaux/LaBRI

Other partners: CNRS-IRIT, Inria-LIP Lyon, CEA/CESTA, EADS-IW

Abstract: This project aims at studying and designing algorithms and parallel programming models for implementing direct methods for the solution of sparse linear systems on emerging computers equipped with accelerators. The ultimate aim of this project is to achieve the implementation of a software package providing a solver based on direct methods for sparse linear systems of equations. Several attempts have been made to accomplish the porting of these methods on such architectures; the proposed approaches are mostly based on a simple offloading of some computational tasks (the coarsest grained ones) to the accelerators and rely on fine hand-tuning of the code and accurate performance modeling to achieve efficiency. This project proposes an innovative approach which relies on the efficiency and portability of runtime systems, such as the StarPU tool developed in the runtime team (Bordeaux). Although the SOLHAR project will focus on heterogeneous computers equipped with GPUs due to their wide availability and affordable cost, the research accomplished on algorithms, methods and programming models will be readily applicable to other accelerator devices such as ClearSpeed boards or Cell processors.

ANR EXACARD

AAPG ANR 2018 (42 months)

Coordinator: Yves Coudière (Carmen) Inria Bordeaux

Abstract: Cardiac arrhythmia affect millions of patients and cause 300,000 deaths each year in Europe. Most of these arrhythmia are due to interaction between structural and electrophysiological changes in the heart muscle. A true understanding of these phenomena requires numerical simulations at a much finer resolution, and larger scale, than currently possible. Next-generation, heterogeneous, high-performance computing (HPC) systems provide the power for this. But the large scale of the computations pushes the limits of current runtime optimization systems, and together with task-based parallelism, prompts for the development of dedicated numerical methods and HPC runtime optimizations. With a consortium including specialists of these domains and cardiac modeling, we will investigate new task-based optimization techniques and numerical methods to utilize these systems for cardiac simulations at an unprecedented scale, and pave the way for future use cases.

9.2.2. ADT - Inria Technological Development Actions

ADT SwLoc (http://swloc.gforge.inria.fr/web/)

Participants: Raymond Namyst, Pierre-André Wacrenier, Andra Hugo, Brice Goglin, Corentin Salingue.

Inria ADT Campaign 2017, 10/2017 - 9/2019 (24 months)

Coordinator: Raymond Namyst

Abstract: The Inria action ADT SwLoc is aiming at developing a library allowing dynamic flexible partitioning of computing resources in order to execute parallel regions concurrently inside the same processes.

ADT Gordon

Participants: Denis Barthou, Nathalie Furmento, Samuel Thibault, Pierre-André Wacrenier.

Inria ADT Campaign 2018, 11/2018 - 11/2020 (24 months)

Coordinator: Emmanuel Jeannot (Tadaam)

Other partners: HiePACS, PLEIADE, Tadaam (Inria Bordeaux)

Abstract: Teams HiePACS, Storm and Tadaam develop each a brick of an HPC software stack, namely solver, runtime, and communication library. The goal of the Gordon project is to consolidate the HPC stack, to improve interfaces between each brick, and to target a better scalability. The bioinformatics application involved in the project has been selected so as to stress the underlying systems.

ADT AFF3CT Matlab

Participants: Denis Barthou, Olivier Aumage, Adrien Cassagne, Kun He.

Inria ADT Campaign 2018, 12/2018 - 12/2019 (12 months)

Coordinator: Denis Barthou

Other partners: C.Jégo and C.Leroux (IMS lab, U.Bordeaux)

Abstract: AFF3CT is a toolchain for designing, validation and experimentation of new Error Correcting codes. This toolchain is written in C++, and this constitutes a difficulty for many industrial users, who are mostly electronics engineers. The goal of this ADT is to widen the number of possible users by designing a Matlab and Python interface for AFF3CT, in collaboration with existing users, and proposing a parallel framework in OpenMP.

9.2.3. IPL - Inria Project Lab

HAC-SPECIS (High-performance Application and Computers, Studying PErformance and Correctness In Simulation)

Participants: Samuel Thibault, Emmanuelle Saillard, Olivier Aumage, Idriss Daoudi.

Inria IPL 2016 - 2020 (48 months)

Coordinator: Arnaud Legrand (team Polaris, Inria Rhône Alpes)

Since June 2016, the team is participating to the HAC-SPECIS http://hacspecis.gforge.inria.fr/ Inria Project Lab (IPL). This national initiative aims at answering methodological needs of HPC application and runtime developers and allowing to study real HPC systems both from the correctness and performance point of view. To this end, it gathers experts from the HPC, formal verification and performance evaluation community.

HPC-BigData (High Performance Computing and Big Data)
Participant: Samuel Thibault.

Inria IPL 2018 - 2022 (48 months)

Coordinator: Bruno Raffin (team DataMove, Inria Rhône Alpes)

Since June 2018, the team is participating to the HPC-BigData https://project.inria.fr/hpcbigdata/ Inria Project Lab (IPL). The goal of this HPC-BigData IPL is to gather teams from the HPC, Big Data and Machine Learning (ML) areas to work at the intersection between these domains. Research is organized along three main axes: high performance analytics for scientific computing applications, high performance analytics for big data applications, infrastructure and resource management.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Exa2PRO

- Title: Enhancing Programmability and boosting Performance Portability for Exascale Computing systems
- Program: H2020-FETHPC
- Duration: May 2018 - April 2021
- Coordinator: ICCS
- Inria contact: Samuel Thibault
- Partners:
  * Institute of Communications and Computer Systems (ICCS) (Greece)
  * Linköpiung University (LIU) (Sweden)
  * Centre for Research and Technology Hellas (CERTH) (Greece)
  * Institut National de Recherche en Informatique et en Automatique (Inria) (France)
  * Maxeler Technologies Limited (MAX) (UK)
  * Forschungszentrum Jülich (JUELICH) (Germany)
  * Centre National de la Recherche Scientifique (CNRS) (France)

The vision of EXA2PRO is to develop a programming environment that will enable the productive deployment of highly parallel applications in exascale computing systems. EXA2PRO programming environment will integrate tools that will address significant exascale challenges. It will support a wide range of scientific applications, provide tools for improving source code quality, enable efficient exploitation of exascale systems' heterogeneity and integrate tools for data and memory management optimization. Additionally, it will provide various fault-tolerance mechanisms, both user-exposed and at runtime system level and performance monitoring features. EXA2PRO will be evaluated using 4 use cases from 4 different domains, which will be deployed in JUELICH supercomputing center. The use cases will leverage the EXA2PRO tool-chain and we expect:

  * Increased applications performance based on EXA2PRO optimization tools (data and memory management)
  * Efficient exploitation of heterogeneity by the applications that will allow the evaluation of more complex problems.
  * Identification of trade-offs between design qualities (source code maintainability/reusability) and run-time constraints (performance/energy consumption).
  * Evaluation of various fault-tolerance mechanisms for applications with different characteristics.

EXA2PRO outcome is expected to have major impact in a) the scientific and industrial community that focuses on application deployment in supercomputing centers: EXA2PRO environment will allow efficient application deployment with reduced effort. b) on application developers of exascale application: EXA2PRO will provide tools for improving source code maintainability/ reusability, which will allow application evaluation with reduced developers' effort. c) on the scientific community and the industry relevant to the EXA2PRO use cases. At least two of the EXA2PRO use cases will have significant impact to the CO2 capture and to the Supercapacitors industry.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

PRACE-5IP

- Title: PRACE 5th Implementation Phase
- Program: PRACE
- Duration: 2017 - 2019
- Coordinator: PRACE
- Inria contact for team STORM: Olivier Aumage
- Abstract: The objectives of PRACE-5IP are to build on and seamlessly continue the successes of PRACE and start new innovative and collaborative activities proposed by the consortium. These include:
  * assisting the transition to PRACE2 including analysis of TransNational Access;
  * strengthening the internationally recognised PRACE brand;
  * continuing and extend advanced training which so far provided more than 18 800 person-training days;
  * preparing strategies and best practices towards Exascale computing;
  * coordinating and enhancing the operation of the multi-tier HPC systems and services;
  * supporting users to exploit massively parallel systems and novel architectures.

  A high level Service Catalogue is provided. The proven project structure will be used to achieve each of the objectives in 6 dedicated work packages. The activities are designed to increase Europe's research and innovation potential especially through:
  * seamless and efficient Tier-0 services and a pan-European HPC ecosystem including national capabilities;
  * promoting take-up by industry and new communities and special offers to SMEs;
  * implementing a new flexible business model for PRACE 2;
  * proposing strategies for deployment of leadership systems;
  * collaborating with the ETP4HPC, CoEs and other European and international organisations on future architectures, training, application support and policies.

9.4. International Initiatives

9.4.1. Inria International Labs

Inria@SiliconValley

Associate Team involved in the International Lab:

9.4.1.1. COHPC

Title: Correctness and Performance of HPC Applications

International Partner (Institution - Laboratory - Researcher):

Lawrence Berkeley National Laboratory (United States) - Costin Iancu

Start year: 2019

See also: https://team.inria.fr/cohpc/

High Performance Computing (HPC) plays an important role in many fields like health, materials science, security or environment. The current supercomputer hardware trends lead to more complex HPC applications (heterogeneity in hardware and combinations of parallel programming models) that pose programmability challenges. As indicated by a recent US DOE report, progress to Exascale stresses the requirement for convenient and scalable debugging and optimization methods to help developers fully exploit the future machines; despite all recent advances these still remain manual complex tasks.

This collaboration aims to develop tools to aid developers with problems of correctness and performance in HPC applications for Exascale systems. There are several requirements for such tools: precision, scalability, heterogeneity and soundness. In order to improve developer productivity, we aim to build tools for guided code transformations (semi-automatic) using a combination of static and dynamic analysis. Static analysis techniques will enable soundness and scalability in execution time. Dynamic analysis techniques will enable precision, scalability in LoCs and heterogeneity for hybrid parallelism. A key aspect of the collaboration is to give precise feedback to developers in order to help them understand what happens in their applications and facilitate the debugging and optimization processes.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Scott Baden, LBNL (USA), from April 29 to May 3, 2019

TADAAM Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. CRA HPC Scalable Ecosystem, 2018-2021

2018 - 2021 (36 months)

Coordinator: Emmanuel AGULLO

Other partners: INRA, Institut Pprime, UPPA, Airbus, CEA, CATIE

Abstract: The goal is to design a unified runtime-system for numerical simulation at large-scale and with a large amount of data. We aim at contributing significantly to the convergence between HPC and BigData. TADAAM is involved in scheduling data access and managing communication efficiently on large-scale system.

9.2. National Initiatives

9.2.1. ANR

ANR SATAS SAT as a Service (http://www.agence-nationale-recherche.fr/Project-ANR-15-CE40-0017).

AP générique 2015, 01/2016 - 12/2019 (48 months)

Coordinator: Laurent Simon (LaBRI)

Other partners: CRIL (Univ. Artois), Inria Lille (Spirals)

Abstract: The SATAS project aims to advance the state of the art in massively parallel SAT solving. The final goal of the project is to provide a "pay as you go" interface to SAT solving services and will extend the reach of SAT solving technologies, daily used in many critical and industrial applications, to new application areas, which were previously considered too hard, and lower the cost of deploying massively parallel SAT solvers on the cloud.

ANR DASH Data-Aware Scheduling at Higher scale (https://project.inria.fr/dash/).

AP générique JCJC 2017, 03/2018 - 02/2022 (48 months)

Coordinator: Guillaume PALLEZ (Tadaam)

Abstract: This project focuses on the effecient execution of I/O for High-Performance applications. The idea is to take into account some knowledge on the behavior of the different I/O steps to compute efficient schedules, and to update them dynamically with the online information.

ANR Solharis SOLvers for Heterogeneous Architectures over Runtime systems, Investigating Scalability .

AAPG ANR 2019, 2019 - 2023 (48 months)

Coordinator: Alfredo BUTTARI (IRIT-INPT)

Abstract: The Solharis project aims at producing scalable methods for the solution of large sparse linear systems on large heterogeneous supercomputers, using the STARPU runtime system, and to address the scalability issues both in runtime systems and in solvers.

9.2.2. ADT - Inria Technological Development Actions

ADT Gordon

10/2018 - 09/2020 (24 months)

Coordinator: Emmanuel JEANNOT

Other partners: Storm, HiePACS, PLEIADE (Inria Bordeaux)

Abstract: Teams HiePACS, Storm and Tadaam develop each a brick of an HPC software stack, namely solver, runtime, and communication library. The goal of the Gordon project is to consolidate the HPC stack, to improve interfaces between each brick, and to target a better scalability. The bioinformatics application involved in the project has been selected so as to stress the underlying systems.

9.2.3. IPL - Inria Project Lab

High-Performance computing and BigData

Participants: Guillaume Pallez, Emmanuel Jeannot, Nicolas Vidal, Francieli Zanon-Boito

HPC and Big Data evolved with their own infrastructures (supercomputers versus clouds), applications (scientific simulations versus data analytics) and software tools (MPI and OpenMP versus Map/Reduce or Deep Learning frameworks). But Big Data analytics is becoming more compute-intensive (thanks to deep learning), while data handling is becoming a major concern for scientific computing. The goal of this HPC-BigData IPL is to gather teams from the HPC, Big Data and Machine Learning (ML) areas to work at the intersection between these domains. Research is organized along three main axes: high performance analytics for scientific computing applications, high performance analytics for big data applications, infrastructure and resource management

9.2.4. Collaboration with CERFACS

Developments on the HIPPO software

Participants: Brice Goglin, Guillaume Mercier

A Memorandum of Understanding is currently being negociated between Inria and CERFACS to organize the collaboration between both entities pertaining to the developements on the HIPPO software. The goal is to provide a portable solution to address the issue of dynamic placement of hybrid coupled MPI + OpenMP applications, especially for climate modelling. Météo France is one of the targer of this work but other teams/institutes around the globe have expressed an interest in HIPPO. Therefore we want to create a solution that would match the needs of the community on the whole.

9.3. European Initiatives

9.3.1. Collaborations with Major European Organizations

Partner 1: INESC-ID, Lisbon, (Portugal)

Subject 1: Application modeling for hierarchical memory system

Partner 2: University Carlos III de Madrid, (Spain)

Subject 2: I/O Scheduling

9.4. International Initiatives

9.4.1. Inria International Labs

Joint-Lab on Extreme Scale Computing (JLESC):

Coordinators: Franck Cappello (general) and Yves Robert (Inria coordinator).

Other partners: Argonne National Lab, University of Urbanna Champaign (NCSA), Tokyo Riken, Jülich Supercomputing Center, Barcelona Supercomputing Center (BSC).

Abstract: The purpose of the Joint Laboratory for Extreme Scale Computing (JLESC) is to be an international, virtual organization whose goal is to enhance the ability of member organizations and investigators to make the bridge between Petascale and Extreme computing. The founding partners of the JLESC are Inria and UIUC. Further members are ANL, BSC, JSC and RIKEN-AICS.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

Partner 1: Argonne National Lab

Subject 1: Binomial Checkpointing Strategies for Machine Learning (recipient of a FACCTS grant, 2018-2020) as well as network performance prediction.

Partner 2: Vanderbilt University

Subject 2: Scheduling for Neurosciences 7.8

Partner 3: ICL at University of Tennessee

Subject 3: on instrumenting MPI applications and modeling platforms (works on HWLOC take place in the context of the Open MPI consortium) and MPI and process placement

Partner 4: Lawrence Livermore National Laboratory

Subject 4: Exposing Heterogeneous Memory Characteristics to HPC Applications 7.1

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Ana Gainaru, Reseach Assistant Professor at U. Vanderbilt, visited the team for one week in December 2019.

TRIBE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Digicosme - Thesis - ECOMICENE

Participants: Cedric Adjih, Hirah Malik, Michel Kieffer [L2S, CNRS–CentraleSupelec–Univ Paris-Sud, Univ Paris-Saclay], Claudio Weidmann [ETIS / ENSEA - Université de Cergy-Pontoise, CNRS (UMR 8051)].

Partners: Centrale-Supelec L2S, ETIS-ENSEA

Subject : Efficient COding of Meta-information in Information-CEntric NEtworks.

8.1.2. Digicosme - Post doc - ICN-based-Vehicles

Participants: Cedric Adjih, Ines Khoufi [Telecom SudParis], Anis Laouiti [Telecom SudParis].

Partners: SAMOVAR, Telecom Sud-Paris (IPP)

Subject: In this work, the project is to design and propose a new architecture model that combines several new emerging research fields which are FANETs (Flying Ad-hoc NETworks). We will modelled a FANET problem of information gathering and distribution, reviewed related literature in [5]. We are now focusing on some mobility patterns for the FANETs in order to optimize the movement of the flying vehicles while they are enhancing the radio coverage for the VANETs and trying to improve data exchange experience between different damaged locations, using genetic algorithms. (link)

8.1.3. Digicosme - Engineer - LoRaWAN simulator

Participants: Cedric Adjih, Kinda Khawam [UVSQ], Samer Lahoud [ESIB], Steven Martin [LRI, Université Paris-Saclay].

Subject: LoRa-MAB: A Flexible Simulator for Decentralized Learning Resource Allocation in IoT Networks

The simulator is available at https://github.com/tuyenta/IoT-MAB

8.2. National Initiatives

8.2.1. Equipex FIT:

Participants: Cedric Adjih, Alexandre Abadie [Inria, SED], Emmanuel Baccelli.

Partners: Sorbonne Université, Inria (Lille, Sophia-Antipolis, Grenoble), INSA, Institut Telecom Paris, Institut Télécom Evry, LSIIT Strasbourg.

FIT (Future Internet of Things) aims to develop an experimental facility, a federated and competitive infrastructure with international visibility and a broad panel of customers. It provides this facility with a set of complementary components that enable experimentation on innovative services for academic and industrial users. The project gives french internet stakeholders a means to experiment on mobile wireless communications at the network and application layers thereby accelerating the design of advanced networking technologies for the future internet. FIT was one of 52 winning projects from the first wave of the French Ministry of Higher Education and Research's "Équipements d'Excellence" (Equipex) research grant program, in 2011.

One component of the FIT platform is the sets of IoT-LAB testbeds (see the IoT-LAB web site). These were motivated by the observation that the world is moving towards an "Internet of Things", in which most communication over networks will be between objects rather than people.

8.2.2. ANR

8.2.2.1. MITIK

Participants: Aline Carneiro Viana, Catuscia Palamidessi.

Funding instrument/scientific committee: PRC/CE25

Project acronym: MITIK

Project title: Mobility and contact traces from non-intrusive passive measurements

Duration: 2020–2023

Coordinator: Aline Carneiro Viana

Other partners: COMETE/Inria, Universite de la Rochelle, Sorbonne Universite.

Abstract: The MITIK project is a 42-month ANR project that will start in February 2020. Mitik's primary objective is the design of an entirely new methodology to help the community obtain real wireless contact traces that are non-intrusive, representative, and independent of third parties. The secondary outcome of the project is be the public release of (1) the measurement tool designed for the easy contact gathering task; (2) contact traces which are clean, processed, and privacy-preserving, i.e., protecting both the anonymity and the location privacy of the users; and (3) their spatiotemporal statistical analysis. We expect that Miti's outcomes will support non-biased research on the modeling as well as on the leveraging of wireless contact patterns.

8.2.2.2. GORILLA

Participants: Cedric Adjih, Aline Carneiro Viana, Nadjib Achir.

Funding instrument/scientific committee: Under submission to the PRC/CE25 (Phase I)

Project acronym: GORILLA

Project title: GeO-distributed pRivacy-preserving InteLLigent orchestrAtion of data-hungry Services

Duration: 2021–2024

Coordinator: Cedric Adjih

Other partners: IRIT – Toulouse INP, LS2N – IMT Atlantiquen L2TI – University Paris 13.

Abstract: The GORILLA project has been submitted to the ANR - PCR program (PHASE I). Users of mobile applications keep calling for better user privacy while getting better user experience, and this fact has become a competitive challenge for application developers. As of today, privacy is often promoted through personal storage and is sometimes opposed to cloud solutions which are nevertheless well-established. GORILLAS proposes to revisit this dilemma with the recent emergence of edge computing. The idea is to leverage edge computing as a middle ground that will act as a trusted third party that ensures privacy and confidentiality requirements. GORILLAS will design a framework that captures the user's privacy requirements, the services requirements as well as current and future users, networks, edge, and cloud operational contexts to perform privacy-persistent and QoE-aware data placement in addition to a tailored QoE-aware service computing orchestration over edge and cloud resources

8.3. European Initiatives

8.3.1. H2020 SPARTA project

Participants: Emmanuel Baccelli, Francois-Xavier Molina.

Program: H2020 SU-ICT-03-2018: Establishing and operating a pilot for a Cybersecurity Competence Network to develop and implement a common Cybersecurity Research & Innovation Roadmap

Project acronym: SPARTA

Project title: Strategic Programs for Advanced Research and Technology in Europe

Duration: 2019-2022

Participant from TRiBE: Emmanuel Baccelli, Francois-Xavier Molina

Other partners include CEA, TU Muenchen, IMT among many others

Abstract: The Sparta project is a 3-year H2020 project started in February 2019, which will put in motion a competence network on cybersecurity, with a view to shape a future EU-wide cybersecurity agency. In more details: TRiBE participates on topics around low-power IoT security, whereby RIOT is used as the base platform on top of which advances will be experimented with and made available in practice.

8.4. International Initiatives

8.4.1. Inria Project Lab RIOT-fp

Project lead: Emmanuel Baccelli

Full name: Reconcile IoT & Future-Proof Security

Partners: teams EVA, PROSECCO (Inria Paris), teams GRACE, TRiBE (Inria Saclay), team TEA, CELTIQUE (Inria Rennes), Freie Universitaet Berlin

Project Start: April 2019

Project Length: 4 years

Website: https://future-proof-iot.github.io/

Summary:

Today's Internet of Things (IoT) does not provide an acceptable tradeoff of functionality vs. risk for end-users. To improve this tradeoff, we must simultaneously

(i) enrich IoT functionality and (ii) improve IoT cyber-security with respect to diverse attack vectors. Concerning the former, RIOT is emerging as one of the major open-source software platforms for low-end IoT devices. Concerning the latter, research challenges must be addressed in various domains including secure network protocol stacks, cryptography, software execution guarantees, embedded system design. RIOT-fp is a research project on IoT cyber-security. Taking a global and

practical approach, RIOT-fp gathers partners planning a scientific agenda aiming to enhance RIOT with an array of security mechanisms. The main scientific challenges tackled by RIOT-fp are: (1) developing high-speed, high-security, low-memory IoT crypto primitives, (2) providing guarantees for software execution on low-end IoT devices, and (3) enabling secure IoT software updates and supply-chain, over the network.

8.4.2. Inria Associate Teams Not Involved in an Inria International Labs

8.4.2.1. EMBRACE

Title: Leveraging Human Behavior and Uncertainty in 5G Networks to Build Robust Resource Allocation and Services Orchestration Models

International Partners (Institution - Laboratory - Researcher):

UTFPR (Brazil) - Departamento Acadêmico de Informática (DAINF) Curso de Pós-Graduação em Engenharia Elétrica e Informática Industrial (CPGEI) - Anelise Munaretto

UFG (Brazil) - Institute of Computational Mathematics and Scientific / Engineering Computing - Kleber Vieira Cardoso

UFMG (Brazil) - Dpt of Statistics - Antonio A. F. Loureiro

Start year: 2017 – Ending year: 2019

See also: https://team.inria.fr/embrace/

Abstract: EMBRACE propose une architecture novatrice pour gérer des ressources et des services opérationnels hétérogènes. EMBRACE se concentre sur les défis scientifiques liés des ensembles de données collectées dans le monde réel et décrivant le comportement du réseau des utilisateurs. En particulier, EMBRACE exploite la modélisation du comportement humain en termes de mobilité, de demande de contenu, d'intérêts communs et des interactions entre-utisateurs. En construisant des modèles d'allocation les ressources tenant compte de l'utilisateur, EMBRACE a pour objectif de diminuer l'incertitude et mieux cerner les profils humains dans les réseaux 5G. La communication D2D sera également utilisée comme service opérationnel pour gérer la croissance du trafic mobile en libérant des ressources des réseaux cellulaires, sans augmenter les coûts. La nouveauté de l'architecture réside dans les algorithmes conçus qui exploiteront les caractérisations tirés de l'analyse du comportement des utilisateurs, l'hétérogénéité du réseau, et de l'incertitude. L'évaluation par simulation et l'émulation sera également l'un des thèmes clés. Enfin, les équipes concernées (Inria Infine, UFMG, UFG, UTFPR) ont un long historique de coopération sur ces thèmes.

Nest steps: A new proposal extending the EMBRACE project was submitted in Nov. 2019. Besides, partners keep going their collaborations with two students currently visiting the team (Lucas Santos from UFMG and Felipe Fonseca from UFG) and with two researchers from UFG starting their sabbatical year from February 2020.

8.4.3. Inria International Partners

8.4.3.1. Declared Inria International Partners

1. Renewed IOTPUSH collaboration with Freie Universitaet Berlin around the long-term stay of Emmanuel Baccelli in Berlin, on research topics about the Internet of Things, RIOT and Information-Centric Networking.

8.4.3.2. Informal International Partners

1. Although the project has finished, the team keep going their collaboration with UFMG and UFG institutions, previous partners of EMBRACE project, on human behavior leveraging in 5G networks.
2. Collaboration with Mark Crovella from Boston University, where Licia Amichi will spend 5 months in an internship from March 2020. She will work on our current collaboration on the modelling and analysis of novelty-seeking preferences in human mobility.
3. Collaboration with Javier Bustos from NIC Lab/University of Chile, involving the PhD co-advising of Diego Madriaga, who is doing a joint PhD between Univ. of Chile and IPP and is working on short-term time series analysis and prediction for anticipatory Nnetworking.
4. Collaboration with Ana Aguiar from University of Porto, involving the PhD co-advising of Emanuel Lima, who is working on data offloading via mobile crowdsensing.
5. Collaboaration with Marco Fiore from IMDEA on adaptive sampling of human mobility. This collaboration involves the participation of Diego Madriaga.
6. Informal collaborations with ENSI Tunis and ENIso.

8.4.4. Participation in Other International Programs

8.4.4.1. STIC AmSud MOTIf 2017

Participant: Aline Carneiro Viana.

Program: STIC AmSud

Project title: Mobile phone sensing of human dynamics in techno-social environment

Duration: 2017-2019

Coordinators: Marton Karsai (ENS/Inria) and Jussara M. Almeida (UFMG) and Alejo Salles (Univ. of Buenos Aires)

Abstract: Information and Communication Technology (ICT) is becoming increasingly social, as demonstrated by the multitude of emerging technologies and technology platforms that facilitate social interactions, taking place as communication via telephone, text message, email, online social networks etc. At the same time, our social activities are increasingly embedded in the ICT environments that enable and enhance our ability to transact, share experiences, and maintain social relationships. One of the best ways to explore these developments is through the mining and analysis of data, which are collected through mobile phones and allow us to investigate how individuals act when embedded in a technology-enabled environment. The MOTIf project builds on the analysis and modeling of geo-localized temporally detailed but fully anonymised mobile phone call networks. These datasets allow us to address the two scientific objectives about spatiotemporal patterns of service usage of anonymised individuals to learn when, where, and what people are doing; and about the fine-grained sociodemographic structure of society and its effect on the the individual social behaviour. In other words our goal in general is to understand how individuals behave in a dynamic techno-social environment.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Prof. Kleber Vieira Cardoso and Sand Luz Correa forom UFG, Brazil, will do their sabbatical year at the TRiBE team, under Brazilian funding and in the context of the EMBRACe project. They will work with Aline C. Viana and Felipe Fonseca on trajectory reconstruction of tourists and their 5G resource optimization.

8.5.2. Internships

Felipe Fonseca is doing an internship of 3 months in our team (Nov 201-Jan 2020). He work with Aline C. Viana, Kleber V. Cardoso and Sand L. Correa on trajectory reconstruction of tourists.

Lucas Santos is doing an internship of 3 months in our team (Nov 201-Jan 2020) in the context of EMBRACE associated team. He work with Aline C. Viana and Pedro Olmo on the investigation of causalities in habits of human visits.

Douglas Teixira did an internship of 10 months our team (May 2019-Jan 2020) in the context of EMBRACE associated team. He is in cotutelle between IPP and UFMG and is co-advised by Aline C. Viana and Jussara Almeida on the limits of a context-aware predictability of human mobility.

Amina Ben Hassine did an intership of 6 months (2019) in collaboration with Ichrak Amdouni (ENSISo) and Anis Laouiti (Telecom SudParis) on the subject of "Unmanned Aerial Vehicles Path Planning Using Machine Learning" using reinforcement learning.

8.5.3. Visits to International Teams

8.5.3.1. Research Stays Abroad

Aside of working for Inria, **Emmanuel Baccelli** is also Professor at Freie Universitaet (FU) Berlin, within the context of a chair resulting of a partnership between Inria, FU Berlin and Einstein Center for Digital Future (ECDF: umbrella organization for Berlin's technical universities). The topic of this chair is *Open and Secure IoT Ecosystem*. In this context, Emmanuel Baccelli stays at FU Berlin. See online: https://www.digital-future.berlin/en/about-us/professors/prof-dr-emmanuel-baccelli/

WHISPER Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- City of Paris, 2016-2019, 100 000 euros. As part of the "Émergence - young team" program the city of Paris is supporting part of our work on domain-specific languages and trustworthy domain-specific compilers.

9.2. National Initiatives

9.2.1. ANR

ITrans - awarded in 2016, duration 2017 - 2020

Members: LIP6 (Whisper), David Lo (Singapore Management University)

Coordinator: Julia Lawall

Whisper members: Julia Lawall, Gilles Muller, Lucas Serrano, Van-Anh Nguyen

Funding: ANR PRCI, 287,820 euros.

Objectives:

Large, real-world software must continually change, to keep up with evolving requirements, fix bugs, and improve performance, maintainability, and security. This rate of change can pose difficulties for clients, whose code cannot always evolve at the same rate. This project will target the problems of *forward porting*, where one software component has to catch up to a code base with which it needs to interact, and *back porting*, in which it is desired to use a more modern component in a context where it is necessary to continue to use a legacy code base, focusing on the context of Linux device drivers. In this project, we will take a *history-guided source-code transformation-based* approach, which automatically traverses the history of the changes made to a software system, to find where changes in the code to be ported are required, gathers examples of the required changes, and generates change rules to incrementally back port or forward port the code. Our approach will be a success if it is able to automatically back and forward port a large number of drivers for the Linux operating system to various earlier and later versions of the Linux kernel with high accuracy while requiring minimal developer effort. This objective is not achievable by existing techniques.

VeriAmos - awarded in 2018, duration 2018 - 2021

Members: Inria (Antique, Whisper), UGA (Erods)

Coordinator: Xavier Rival

Whisper members: Julia Lawall, Gilles Muller

Funding: ANR, 121,739 euros.

Objectives:

General-purpose Operating Systems, such as Linux, are increasingly used to support high-level functionalities in the safety-critical embedded systems industry with usage in automotive, medical and cyber-physical systems. However, it is well known that general purpose OSes suffer from bugs. In the embedded systems context, bugs may have critical consequences, even affecting human life. Recently, some major advances have been done in verifying OS kernels, mostly employing interactive theorem-proving techniques. These works rely on the formalization of the programming language semantics, and of the implementation of a software component, but require significant human intervention to supply the main proof arguments. The VeriAmos project will attack this problem by building on recent advances in the design of domain-specific languages and static analyzers for systems code. We will investigate whether the restricted expressiveness and the higher level of abstraction provided by the use of a DSL will make it possible to design static analyzers that can statically and fully automatically verify important classes of semantic properties on OS code, while retaining adequate performance of the OS service. As a specific use-case, the project will target I/O scheduling components.

9.3. International Initiatives

9.3.1. Inria Associate Teams Not Involved in an Inria International Labs

9.3.1.1. CSG

Title: Proving Concurrent Multi-Core Operating Systems

International Partner (Institution - Laboratory - Researcher):

University of Sydney (Australia) - Willy Zwaenepoel

Start year: 2019

See also: https://team.inria.fr/csgroup/

The initial topic of this cooperation is the development of proved multicore schedulers. Over the last two years, we have explored a novel approach based on the identification of key scheduling abstractions and the realization of these abstractions as a Domain-Specific Language (DSL), Ipanema. We have introduced a concurrency model that relies on execution of scheduling events in mutual execution locally on a core, but that still permits reading the state of other cores without requiring locks.

In the three next years, we will leverage on our existing results towards the following directions: (i) Better understanding of what should be the best scheduler for a given multicore application, (ii) Proving the correctness of the C code generated from the DSL policy and of the Ipanema abstract machine, (iii) Extend the Ipanema DSL to the domain of I/O request scheduling, (iv) Design of a provable complete concurrent kernel.

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

Julia Lawall and Gilles Muller collaborate with David Lo and Lingxiao Jiang of Singapore Management University in the context of the ANR-NRF funded project ITrans. This project supports the PhD of Lucas Serrano. In 2019, this collaboration led to an experience paper at ECOOP on a transformation tool (a variant of Coccinelle) for Java [21] and a tool paper at ICSE on using machine learning for identifying bug-fixing patches for the Linux kernel [19]. The latter has been extended to a journal article published in the IEEE Transactions on Software Engineering [11]. Lawall and Serrano spent two weeks visiting Lo and Jiang at Singapore Management University in December 2019.

Julia Lawall collaborates with Jia-Ju Bai at Tsinghua University on bug finding for the Linux kernel. In 2019, this collaboration led to a paper at SANER on detecting data races in device drivers [17], a paper at ISSRE on extending Linux kernel fuzzing to be able to detect bugs in error-handling code [20], a paper at ASPLOS on detection of unnecessary spinning in the Linux kernel [14], a paper at USENIX ATC on detection of use-after free concurrency bugs in the Linux kernel [13]. Bai visited the Whisper team for 2 months starting in January 2019. Lawall visited Bai at Tsinghua University for one week in August.

Michele Martone of the Leibniz Supercomputing Centre in Munich, Germany has been using Coccinelle in an HPC context and giving workshops on Coccinelle in the HPC research engineer community. Martone has contributed some patches to Coccinelle and we keep in touch with him about possible improvements to Coccinelle that may have an impact on its use in the HPC community.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Jia-Ju Bai visited the Whisper team for 2 months starting in January 2019. During this time, he and Julia Lawall worked on a prototype of an interprocedural program analysis tool for C code.

Victor Miraldo (Ultrech University) visited the Whisper team for 2 weeks in June 2019, where he worked with Pierre-Évariste Dagand on data structures for efficient differencing of data structures.

9.4.1.1. Internships

Pierre-Évariste Dagand has supervised the Master 2 research internship of Pierre Nigron (University Paris Diderot), from April to August 2019, on the topic of "Effectful programs and their proofs in a dependently-typed setting". Pierre Nigron was awarded a DGA-Inria grant to pursue a PhD under Julia Lawall's supervision, co-supervised by Pierre-Évariste Dagand.

Pierre-Évariste Dagand has supervised the Bachelor research internship of Quentin Corradi (École Normale Supérieure de Lyon), for 6 weeks starting in June 2019, on the topic of "A Formal Semantics of SIMD Instruction Sets".

Pierre-Évariste Dagand has supervised a pre-doctoral internship of Rémi Oudin (École Normale Supérieure de Cachan), from April to August 2019, on the topic of "Hardware interfaces for transiently-powered systems". Rémi Oudin was awarded a "Contrat Doctoral Spécifique pour Normaliens".

9.4.2. Visits to International Teams

Gilles Muller spent two weeks in November 2019 visiting the University of Sydney as part of our associated team.

Julia Lawall spent one week at Tsinghua University visiting the group of Jia-Ju Bai in August 2019. Julia Lawall and Lucas Serrano spent two weeks at Singapore Management University visiting the group of David Lo and Lingxiao Jiang in December 2019. During the latter visit, Lawall and Serrano also visited National University of Singapore and Lawall also visited Yale-NUS.

WIDE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Web of Browser's (Brittany Region and Labex CominLabs 2019-2020)

Participant: François Taïani.

Browsers are de facto the most widely deployed execution environments in the world. Initially simple HTML readers, they now run complex applications interacting with humans and web services. The recent introduction of WebRTC has further extended the capability of browsers by introducing support for browser-to-browser communication. This turns browsers into a decentralized execution environment where interactions between human and web services are enabled without third party.

The Web of browsers is a vision where the web is serverless, ephemeral and massively decentralized. Web where pages are hosted by networks of browsers connected through WebRTC. The objective of the project is to build and experiment the Web of Browsers.

8.2. National Initiatives

8.2.1. ANR Project PAMELA (2016-2020)

Participants: Davide Frey, George Giakkoupis, François Taïani.

PAMELA is a collaborative ANR project involving Inria/IRISA, Inria Lille (MAGNET team), UMPC, Mediego and Snips. The project aims at developing machine learning theories and algorithms in order to learn local and personalized models from data distributed over networked infrastructures. This project seeks to provide fundamental answers to modern information systems built by interconnecting many personal devices holding private user data in the search of personalized suggestions and recommendations. A significant asset of the project is the quality of its industrial partners, Snips and Mediego, who bring in their expertise in privacy protection and distributed computing as well as use cases and datasets.

8.2.2. ANR Project OBrowser (2016-2020)

Participants: David Bromberg, Davide Frey, François Taïani.

OBrowser is a collaborative ANR project involving Inria, the University of Nantes, the University of South Brittany, and Orange. The project emerges from the vision of designing and deploying distributed applications on millions of machines using web-enabled technologies without relying on a cloud or a central authority. OBrowser proposes to build collaborative applications through a decentralized execution environment composed of users' browsers that autonomously manages issues such as communication, naming, heterogeneity, and scalability.

8.2.3. ANR Project DESCARTES (2016-2020)

Participants: George Giakkoupis, Michel Raynal, François Taïani.

DESCARTES is a collaborative ANR project involving Inria/IRISA, Labri (U. Bordeaux), IRIF (U. Paris Diderot), Inria Paris (GANG Team), Vérimag (Grenoble), LIF (Marseilles), and LS2N (former LINA, Nantes). The DESCARTES project aims at bridging the lack of a generic theoretical framework in order to unify the large body of fundamental knowledge on distributed computation that has been acquired over the last 40 years. In particular, the project's objective is to develop a systematic model of distributed computation that organizes the functionalities of a distributed computing system into reusable modular constructs assembled via well-defined mechanisms that maintain sound theoretical guarantees on the resulting system.

8.2.4. Labex CominLab PROFILE (2016-2019)

Participants: David Bromberg, Davide Frey, François Taïani.

The PROFILE (2016-2019) project brings together experts from law, computer science (the Inria teams DIVERSE and ASAP/WIDE, the IRISA team DRUID) and sociology to address the challenges raised by online profiling, following a multidisciplinary approach. More precisely, the project will pursue two complementary and mutually informed lines of research: first, the project will investigate, design, and introduce a new right of opposition into privacy Law to better regulate profiling and to modify the behavior of commercial companies. Second, the project aims to provide users with the technical means they need to detect stealthy profiling techniques, and to control the extent of the digital traces they routinely produce.

8.3. International Initiatives

8.3.1. LiDiCo

- Title: Aux limites du calcul réparti
- International Partner (Institution - Laboratory - Researcher):
  - UNAM (Mexico) - Instituto de Matematicas - Sergio Rajsbaum
- Start year: 2017
- See also: https://sites.google.com/site/lidicoequipeassociee/
- Today distributed applications are pervasive, some very successful (e.g., Internet, P2P, social networks, cloud computing), and benefit everyone, but the design and the implementation of many of them still rely on ad-hoc techniques instead of on a solid theory. The next generation of distributed applications and services will be more and more complex and demands research efforts in establishing sound theoretical foundations to be able to master their design, their properties and their implementation. This is a step in this inescapable direction.

8.4. International Research Visitors

Roberto Rodrigues Filho (Lancaster University, UK), July–September 2019.

Mohamed Lechiakh, (ENSIAS, Ecole Nationale Supérieure d'Informatique et d'Analyse des Systèmes, Rabat, Morocco), March–May 2019.

Hasnaa Dyani, (ENSIAS, Ecole Nationale Supérieure d'Informatique et d'Analyse des Systèmes, Rabat, Morocco), April–June 2019.

Chaimaa Tarzi, (ENSIAS, Ecole Nationale Supérieure d'Informatique et d'Analyse des Systèmes, Rabat, Morocco), April–June 2019.

Arsany Guirguis, (EPFL, Lausanne, Switzerland), July–September 2019.

Marcus Kaboret, (Laboratoire de Mathématiques et Informatique, Joseph Ki-Zerbo University, Ouagadougou, Burkina Faso), September–October 2019.

Hayk Saribekyan (University of Cambridge, UK), 2-–12 April 2019.

Giorgi Nadiradze (IST Austria), 20–24 May 2019.

Emanuele Natale (CNRS, Sophia-Antipolis), 13–17 March 2019.

8.4.1. Visits to International Teams

Adrien Luxey visited Paulo Ferreira, University of Oslo, Norway, from the 1st May to the 30th of June 2019.

ALICE Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- We coordinate a work package for the CPER CyberEntreprise 2017–2020 ($\approx$ 30k euros). The application goal is to develop modelling methods, which are of interest to oil companies in order to optimize oil production.
  Program: CPER (Contrat de Plan État Région)
  Project title: Cyber-Entreprises
  Duration: 01/07/2015 – 31/12/2020
  Participants: Bruno Lévy, Dmitry Sokolov and Nicolas Ray
  Coordinator: Emmanuel Thomé and Marc Jungers (CRAN)

ALMANACH Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- **ANR SoSweet** (2015-2019, PI J.-P. Magué, resp. ALMAnaCH: DS; Other partners: ICAR [ENS Lyon, CRNS], Dante [Inria]). Topic: studying sociolinguistic variability on Twitter, comparing linguistic and graph-based views on tweets
- **ANR ParSiTi** (2016-2021, PI Djamé Seddah, Other partners: LIMSI, LIPN). Topic: context-aware parsing and machine translation of user-generated content
- **ANR PARSE-ME** (2015-2020, PI. Matthieu Constant, resp. Marie Candito [ALPAGE, then LLF], ALMAnaCH members are associated with Paris-Diderot's LLF for this project). Topic: multi-word expressions in parsing
- **ANR Profiterole** (2016-2020, PI Sophie Prévost [LATTICE], resp. Benoit Crabbé [ALPAGE, then LLF], ALMAnaCH members are associated with Paris-Diderot's LLF for this project). Topic: modelling and analysis of Medieval French
- **ANR TIME-US** (2016-2019, PI Manuela Martini [LARHRA], ALMAnaCH members are associated with Paris-Diderot's CEDREF for this project). Topic: Digital study of remuneration and time budget textile trades in XVIIIth and XIXth century France
- **ANR BASNUM** (2018-2021, PI Geoffrey Williams [Université Grenoble Alpes], resp. ALMAnaCH: LR). Topic: Digitalisation and computational linguistic study of Basnage de Beauval's *Dictionnaire universel* published in 1701.

9.1.2. Competitivity Clusters and Thematic Institutes

- **PRAIRIE institute** (2019-2024, Dir.: Isabelle Ryl). Benoît Sagot was granted a Chair in this newly created research institute dedicated to Artificial Intelligence.
- **GDR LiFT** (2019-): LiFT is a CNRS-funded national coordination structure (GDR) involving many French teams involved in computational, formal and descriptive linguistics, in order to facilitate the emergence of fruitful collaborations. ALMAnaCH is involved in the GDR.
- **LabEx EFL** (2010-2019, PI Christian Puech [HTL, Paris 3], Sorbonne Paris Cité). Topic: empirical foundations of linguistics, including computational linguistics and natural language processing. ALPAGE was one of the partner teams of this LabEx, which gathers a dozen of teams within and around Paris whose research interests include one aspects of linguistics or more. BS serves as deputy head (and former head) of one of the scientific strands of the LabEx, namely strand 6 dedicated to language resources. BS and DS are in charge of a number of scientific "operations" within strands 6, 5 ("computational semantic analysis") and 2 ("experimental grammar"). BS, EVdLC and DS are now individual members of the LabEx EFL since 1st January 2017, and BS still serves as the deputy head of strand 6. Main collaborations are on language resource development (strands 5 and 6), syntactic and semantic parsing (strand 5, especially with LIPN [CNRS and U.Paris 13]) and computational morphology (strands 2 and 6, especially with CRLAO [CNRS and Inalco]).

9.1.3. Other National Initiatives

- **LECTAUREP project** (2017-2019): A preliminary study has been launched in collaboration with the National Archives in France, in the context of the framework agreement between Inria and the Ministry of Culture, to explore the possibility of extracting various components from digitised 19th Century notary registers.

- **Nénufar (DGLFLF - Délégation générale à la langue française et aux langues de France)**: The projects is intended to digitize and exploit the early editions (beginning of the 20th Century) of the Petit Larousse dictionary. ALMAnaCH is involve to contribute to the automatic extraction of the dictionary content by means of GROBID-Dictionaries and define a TEI compliant interchange format for all results.
- **PIA Opaline** (2017-2020): The objective of the project is to provide a better access to published French literature and reference material for visually impaired persons. Financed by the Programme d'Investissement d'Avenir, it will integrate technologies related to document analysis and re-publishing, textual content enrichment and dedicated presentational interfaces. Inria participate to deploy the GROBID tool suite for the automatic structuring of content from books available as plain PDF files.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

- **H2020 Parthenos** (2015-2019, PI Franco Niccolucci [University of Florence]; LR is a work package coordinator) Topic: strengthening the cohesion of research in the broad sector of Linguistic Studies, Humanities, Cultural Heritage, History, Archaeology and related fields through a thematic cluster of European Research Infrastructures, integrating initiatives, e-infrastructures and other world-class infrastructures, and building bridges between different, although tightly interrelated, fields.
- **H2020 EHRI** "European Holocaust Research Infrastructure" (2015-2019, PI Conny Kristel [NIOD-KNAW, NL]; LR is task leader) Topic: transform archival research on the Holocaust, by providing methods and tools to integrate and provide access to a wide variety of archival content.
- **H2020 Iperion CH** (2015-2019, PI Luca Pezzati [CNR, IT], LR is task leader) Topic: coordinating infrastructural activities in the cultural heritage domain.
- **H2020 HIRMEOS**: HIRMEOS objective is to improve five important publishing platforms for the open access monographs in the humanities and enhance their technical capacities and services and rendering technologies, while making their content interoperable. Inria is responsable for improving integrating the entity-fishing component deplyed as an infrastructural service for the five platforms.
- **H2020 DESIR**: The DESIR project aims at contributing to the sustainability of the DARIAH infrastructure along all its dimensions: dissemination, growth, technology, robustness, trust and education. Inria is responsable for providing of a portfolio of text analytics services based on GROBID and entity-fishing.

9.2.2. Collaborations in European Programs, Except FP7 & H2020

- **ERIC DARIAH "Digital Research Infrastructure for the Arts and Humanities"** (set up as a consortium of states, 2014-2034; LR served president of the board of director until August 2018) Topic: coordinating Digital Humanities infrastructure activities in Europe (17 partners, 5 associated partners).
- **COST enCollect** (2017-2020, PI Lionel Nicolas [European Academy of Bozen/Bolzano]) Topic: combining language learning and crowdsourcing for developing language teaching materials and more generic language resources for NLP

9.2.3. Collaborations with Major European Organizations

Collaborations with institutions not cited above (for the SPMRL initiative, see below):

- Berlin-Brandenburgische Akademie der Wissenschaften [Berlin-Brandenburg Academy of Sciences and Humanities], Berlin, Germany (Alexander Geyken) [lexicology]
- Österreichische Akademie der Wissenschaften [Austrian Academy of Sciences], Vienna, Austria (Karlheinz Moerth) [lexicology]

- Bar Ilan University (Yoav Goldberg, Hila Gonen) [non-canonical text processing]
- Dublin City University, Ireland (Teresa Lynn) [low-resource languages, user-generated content]
- University of Sheffield, United Kingdom (Lucia Specia, Carolina Scarton, Fernando Alva-Manchego) [text simplification]
- Univerza v Ljubljani [University of Ljubljana], Ljubljana, Slovenia (Darja Fišer) [wordnet development]

9.3. International Initiatives

9.3.1. Participation in Other International Programs

ANR-NSF project MCM-NL "Petit Prince" (2016-2020, PI John Hale [Cornell University, USA], resp. for Inria Paris/ALMAnaCH: Éric de La Clergerie) Topic: exploring correlations between data from neuro-imagery (fMRI, EEG) and data from NLP tools (mostly parsers). The data will come from "Le Petit Prince" read in French and English, and parsed with different parsers. Other partners: Cornell Univ., Univ. Michigan, Paris Saclay/Neurospin, Univ. Paris 8. Grant for ALMAnaCH: 108,500 euros

PHC Maïmonide (2018-2019, PI Djamé Seddah, co-PI Yoav Goldberg [Bar Ilan University]). Topics: Building NLP resources for analysing reactions to major events in Hebrew and French social media. Amount of the grant for the French side: 59,000 euros (89,000 euros for the whole project).

Auctus Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Woobot

The main objective of Woobot is to propose a methodology for designing and controlling a collaborative robotic system to assist and secure an operator's actions. The system must preserve the health and sensory expertise of the operator while guaranteeing his or her mobility. Motivated by a pilot case from carpentry, the determination of the behavior of the collaborative robot will be based on a human-centered approach and based on a precise ergonomic analysis of the task and the biomechanical performances and needs of the operator. Two scientific issues are important: the choice of the system architecture (type of collaborative robot, number of degrees of freedom, level of redundancy with respect to the task, type of interaction of the collaborative robot with the task and/or the human...), and the behavior of the collaborative robot that must be implemented in the control. To answer these questions, it is then necessary to consider in the same formalism the human and task constraints from the point of view of:

- of the performance necessary for the task (cutting forces, trajectories);
- of the operator's biomechanical performance (kinematics -i.e. dexterity; static -i.e. manipulability and human dynamics).
- ergonomic (task, work environment, human posture).

Other partners: Région Nouvelle-Aquitaine, BTP CFA Blanquefort [0], Aerospline [0]

9.1.2. Portage

The global objective of this project is to develop a semi-autonomous carrier dedicated to the transport of heavy structures in industrial factories. The Auctus team has been assigned the role of task analysis and human systems interactions analysis in order to determine the best interface, to improve ergonomics, to reduce risks and to account for acceptability. A postdoctoral student, Charles Fage, has been recruited for the first year of the study.

A 2-years contract (2019-2021) has been signed with AKKA Technologies as part of a consortium, which included two other companies, IIDRE and Ez-Wheel, and another research team from IMS laboratory.

9.2. European Initiatives

Program: COVR (https://safearoundrobots.com/)

Project acronym: HARRY[2]

Project title: **H**ighly s**A**fe **R**obot integ**R**ation for the industr**Y** throug**H** an **A**dvanced cont**R**ol and monito**R**ing strateg**Y**

Duration: 2019/07 – 2020/03

Coordinator: Vincent Padois

Other partners: RoBioSS [0], PPRIME (Poitiers, France), Fuzzy Logic Robotics [0] (Paris France)

Abstract: he objective of the HARRY2 project is to attain more advanced workspace sharing capabilities through fully exploiting the collaborative possibilities defined by ISO TS 15066. We will achieve this by:

[0] http://www.btpcfa-aquitaine.fr
[0] https://www.aerospline.eu
[0] https://www.pprime.fr/?q=fr/robioss
[0] https://www.flr.io

- Developing PLC software and motion controllers using robot-agnostic industrially-rated components to ease and standardize the development of safe robotic applications with workspace sharing.
- Integrating state-of-the-art energy-based control algorithms using these industrial hardware components, so that safety is no longer treated as an exception but considered as a constraint when computing the control solution in real-time.
- Enabling the use of high-level and intuitive teaching interfaces reducing robot programming time and difficulty.
- Developing a systematic and practical methodology for quantitative safety evaluation.

9.3. International Initiatives

9.3.1. Inria International Partners

- Vincent Padois is collaborating with Alessandro Saccon from TU Eindhoven regarding research activities on the modeling and control of robots physically interacting with their environments and more specifically on impact models for such interactions. A ICRA 2020 paper has been submitted based on this collaboration [21].
- Jean-Marc Salotti worked with Ephraim Suhir, Departments of Mechanical and Materials Engineering and Electrical and Computer Engineering, Portland State University. Ephraim Suhir is a world expert in systems reliability. He and Jean-Marc Salotti worked on human-in-the-loop issues and published a paper in an IEEE conference [14].

AVIZ Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

- PCR ANR project EMBER "Situated Visualizations for Personal Analytics". Duration: 48 months. Total funding: 712 k€. Partners: Inria Saclay, Inria Bordeaux, Sorbonne Université. Coordinator: Pierre Dragicevic. See website: http://ember.inria.fr/.
- Naviscope Inria Project Lab on Image-guided NAvigation and VIsualization of large data sets in live cell imaging and microSCOPy; collaboration with several Inria project teams and external collaborators; this grant supports a PhD position and funds travel and equipment.

9.2. European Initiatives

9.2.1. Collaborations in European Programs, Except FP7 & H2020

Program: ANR PRCI

Project acronym: MicroVis

Project title: Micro visualizations for pervasive and mobile data exploration

Duration: 11/2019 - 08/2022

Coordinator: Petra Isenberg

Other partners: University of Stuttgart

Abstract: The goal of this joint Franco-German project is to study very small data visualizations, micro visualizations, in display contexts that can only dedicate minimal rendering space for data representations. We will study human perception of and interaction with micro visualizations given small as well as complex data. The increasing demand for data visualizations on small mobile devices such as fitness tracking armbands, smart watches, or mobile phones drives our research. Given this usage context, we focus on situations in which visualizations are used "on the go," while walking, riding a vehicle, or running. It is still unclear to which extent our knowledge of desktop-sized visualizations transfers to contexts that involve minimal display space, diverse viewing angles, and moving displays.

Program: 2016 FWF–ANR Call for French-Austrian Joint Projects

Project acronym: ILLUSTRARE

Project title: Integrative Visual Abstraction of Molecular Data

Duration: 48 months

Coordinator: Tobias Isenberg and Ivan Viola

Other partners: TU Wien, Austria

Abstract: The essential building block of visualization is the phenomenon of visual abstraction. While visual abstraction is intuitively understood, there is no scientific theory associated with it that would be useful in the visualization synthesis process. Our central aim of this project is thus to gain better understanding of the visual abstraction characteristics. We lay down a hypothetical initial basis of theoretical foundations of visual abstractions in the proposal. We hypothesize that visual abstraction is a multidimensional phenomenon that can be spanned by axes of abstraction. Besides abstractions associated with a static structure we take a closer look at abstractions related to dynamics, procedures, and emergence of the structure. We also study abstraction characteristics related to multi-scale phenomena defined both in space and in time. This hypothetical basis is either supported or rejected by means of exemplary evidence from the specific application domain of structural biology. Structural biology data is very complex, it includes the aspect of emergence and it is defined over multiple scales. Furthermore, abstraction has led to key discoveries in biology, such as the organization of the DNA. We study the multiscale visual abstraction characteristics on the visualization of long nucleic strands and the abstractions that convey emerging phenomena on visualization of molecular machinery use cases. From these two fields we work toward a theory of visual abstraction in a bottom-up manner, investigating the validity of the theory in other application domains as well.

Program: CHIST-ERA

Project acronym: IVAN

Project title: Interactive and Visual Analysis of Networks

Duration: May 2018 - April 2021

Coordinator: Dr. Torsten Möller, Uni Wien, Austria

Other partners: EPFL, Switzerland, Inria France, Uni Wien, Austria

Abstract: The main goal of IVAN is to create a visual analysis system for the exploration of dynamic or time-dependent networks (from small to large scale). Our contributions will be in three principal areas:

1. novel algorithms for network clustering that are based on graph harmonic analysis and level-of-detail methods;
2. the development of novel similarity measures for networks and network clusters for the purpose of comparing multiple network clusterings and the grouping (clustering) of different network clusterings; and
3. a system for user-driven analysis of network clusterings supported by novel visual encodings and interaction techniques suitable for exploring dynamic networks and their clusterings in the presence of uncertainties due to noise and uncontrolled variations of network properties.

Our aim is to make these novel algorithms accessible to a broad range of users and researchers to enable reliable and informed decisions based on the network analysis.

9.2.2. Collaborations with Major European Organizations

The Bauhaus-Universität Weimar (Germany)

Steve Haroz collaborates with Florian Echtler to analyze research transparency in human-computer interaction.

Hasso Plattner Institute (Germany)

Pierre Dragicevic and Tobias Isenberg collaborate with Amir Semmo on stylization filters for facilitating the examination of disturbing visual content.

University of Zurich (Switzerland)

Pierre Dragicevic and Steve Haroz collaborate with Chat Wacharamanotham on transparent statistical reporting and efficient statistical communication.

KU Leuven (Belgium)

Pierre Dragicevic collaborates with Andrew Vande Moere on a survey on data physicalization.

Linköping University (Sweden)

Tobias Isenberg, Xiyao Wang, and Mickael Sereno collaborate with Lonni Besançon on interaction with 3D visualization.

University of Granada (Spain)

Tobias Isenberg collaborates with Domingo Martin and German Arroyo on digital stippling.

University of Roma (Italy), TU Darmstadt (Germany)

Jean-Daniel Fekete Fekete collaborates with Giuseppe Santucci, Carsten Binnig and colleagues on the design of database benchmarks to better support visualization;

University of Bari (Italy)

Jean-Daniel Fekete collaborates with Paolo Buono on hypergraph visualization;

University of Konstanz (Germany)

Petra Isenberg collaborated with Johannes Fuchs and Anastasia Bezerianos on visualization for teaching clustering algorithms.

9.3. International Initiatives

9.3.1. Inria Associate Teams Not Involved in an Inria International Labs

9.3.1.1. SEVEN

Title: Situated and Embedded Visualization for Data Analysis

International Partner (Institution - Laboratory - Researcher):

University of Calgary (Canada) - ILab - Wesley Willett

Start year: 2018

See also: http://aviz.fr/seven

The goal of this joint work between the Aviz team at Inria Saclay and the ILab at the University of Calgary is to develop and study situated data visualizations to address the limitations of traditional platforms of data analytics. In a situated data visualization, the data is directly visualized next to the physical space, object, or person it refers to. Situated data visualizations can surface information in the physical environment and allow viewers to interpret data in-context, monitor changes over time, make decisions, and act on the physical world in response to the insights gained. However, research on this topic remains scarce and limited in scope. We will build on our track record of successfull collaborations to jointly develop situated visualization as a novel research direction. The objective for the first year is to design and implement situated visualizations to support health and aging. Our joint work is expected to generate benefits at multiple levels, including to society and industry (by empowering individuals and professionals with technology), to the scientific community (by developing a new research direction), to the academic partners (by reinforcing existing research links and establishing them as leaders on the topic), and to students (by providing them with unique training opportunities with a diverse team of world-class researchers).

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

Microsoft Research: Petra Isenberg, Tobias Isenberg, and Tanja Blascheck regularly collaborate with Bong-shin Lee on topics related to non-desktop visualizations such as mobile visualization, ubiquitous visualization, or touch interaction for visualization.

University of Maryland: Catherine Plaisant regularly collaborates with various team members on projects related to temporal exploratory visualization.

9.3.3. Participation in Other International Programs

9.3.3.1. Inria International Chairs

IIC PLAISANT Catherine

Title: Visual Analytics for Exploratory Data Analysis

International Partner (Institution - Laboratory - Researcher):

University of Maryland (United States) - HCIL - Catherine Plaisant

Duration: 2018 - 2022

Start year: 2018

Visual Analytics for Exploratory Data Analysis: The project leverages Dr. Plaisants 30 years of experience in the design and evaluation of novel user interface and the longstanding synergies between my research activities and those of the AVIZ lab. It also builds on early collaborative activities having taken place between Maryland and Inria during a 2017 summer visit. The joint work particularly focuses on: event analysis, network analysis, and novel evaluation methods for visual analytics.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Catherine Plaisant (June–July): Invited professor from the University of Maryland, USA. Invited through a DigiCosme grant, Catherine Plaisant has spent two months with Aviz. We have launched two research projects, one on hypergraph visualization and one on tracing users to understand their use of visualization. Catherine Plaisant has interacted with all of the Aviz students and post-doctoral fellows, as well as with the permanent researchers.
- Paolo Buono, from the University of Bari, Italy (August–September): Paolo Buono has spent two months with Aviz working on the visualization of dynamic networks. He has collaborated with Paoa Valdivia, Catherine Plaisant, and Jean-Daniel Fekete for that project. He has also interacted with all the members of Aviz.
- Claudio Silva (August 2018 – June 2019): Sabbatical from New York University (USA). Also, invited professor through a DigiCosme grant for 3 months. Claudio Silva is spending one year with Aviz. We launched a bi-weekly seminar on explainable machine-learning with visualization.
- Wesley Willett and Lora Oehlberg (June): as part of the associated team SEVEN both professors came for a three-day workshop to Aviz during which we discussed designs for the noise project sensors and the associated data displays. We also worked in more depth on a survey article we plan to publish.

CEDAR Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- AIDE ("A New Database Service for Interactive Exploration on Big Data") is an ANR "Young Researcher" project led by Y. Diao, started at the end of 2016.
- ContentCheck (2015-2018) is an ANR project led by I. Manolescu, in collaboration with U. Rennes 1 (F. Goasdoué), INSA Lyon (P. Lamarre), the LIMSI lab from U. Paris Sud, and the Le Monde newspaper, in particular their fact-checking team Les Décodeurs. Its aim is to investigate content management models and tools for journalistic fact-checking.
- CQFD (2019-2022) is an ANR project coordinated by F. Ulliana (U. Montpellier), in collaboration with U. Rennes 1 (F. Goasdoué), Inria Lille (P. Bourhis), Institut Mines Télécom (A. Amarilli), Inria Paris (M. Thomazo) and CNRS (M. Bienvenu). Its research aims at investigating efficient data management methods for ontology-based access to heterogeneous databases (polystores).

8.1.2. Others

- The goal of the iCODA project is to develop the scientific and technological foundations for knowledge- mediated user-in-the-loop collaborative data analytics on heterogenous information sources, and to demonstrate the effectiveness of the approach in realistic, high-visibility use-cases. The project stands at the crossroad of multiple research fields—content analysis, data management, knowledge represen- tation, visualization—that span multiple Inria themes, and counts on a club of major press partners to define usage scenarios, provide data and demonstrate achievements. This is a project funded directly by Inria ("Inria Project Lab"), and is in collaboration with GraphIK, ILDA, LINKMEDIA (coordinator), as well as the press partners AFP, Le Monde (Les Décodeurs) and Ouest-France.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

IDEAA: Issue-Driven European Arena Analytics is a project funded by the European Commission Union's Horizon 2020 research and innovation programme. The project started in July 2018 for a duration of two years. Its purpose is to allow citizens to easily explore the trove of publicly available data with the aim of building a viewpoint on specific issues. Its main strengths are: supply users with succinct and meaningful knowledge with respect to the issue they are interested in; allow users to interact with the provided knowledge to refine their information need and advance understanding; suggest interesting or unexpected aspects in the data and support the comparison of knowledge discovered from different data sources. IDEAA is inspired by human-to-human dialogues, where questions are explorative, possibly imprecise, and answers may be a bit inaccurate but suggestive, conveying an idea that stimulates the interlocutor to further questions.

The project supports a two-years presence of Mirjana Mazuran as an experienced post-doc in our team.

8.3. International Initiatives

8.3.1. Inria Associate Teams Not Involved in an Inria International Labs

8.3.1.1. WebClaimExplain

Title: Mining for explanations to claims published on the Web

International Partner (Institution - Laboratory - Researcher):

AIST (Japan) - Julien Leblay

Start year: 2017

See also: https://team.inria.fr/cedar/projects/webclaimexplain/

The goal of this research is to create tools to find explanations for facts and verify claims made online. While this process cannot be fully automated, the main focus of our work will be explanation finding via trusted sources, based on the observation that one can only trust a statement if he/she can explain it through rules and proofs that can themselves be trusted.

8.3.2. Inria International Partners

8.3.2.1. Informal International Partners

- We collaborate with Alin Deutsch and Rana Al-Otaibi from the University of California in San Diego, on the topic of efficient data management in polystore sytems.
- We collaborate with Helena Galhardas from the University of Lisbon on the topic of efficiently interconnecting heterogeneous data sources for journalistic applications.
- We collaborate with Anna Liu from U. Massachussets at Amherst; she co-advises PhD thesis of several students in the group (E. Huang and L. Di Palma).

8.3.3. Participation in International Programs

8.3.3.1. AYAME

WebClaimExplain

Title: Mining for explanations to claims published on the Web

International Partner (Institution - Laboratory - Researcher):

AIST (Japan) - Leblay Julien

Duration: 2017 - 2019

Start year: 2017

See also: https://team.inria.fr/cedar/connectionlens/

The goal of this research is to create tools to find explanations for facts and verify claims made online. While this process cannot be fully automated, the main focus of our work will be explanation finding via trusted sources, based on the observation that one can only trust a statement if he/she can explain it through rules and proofs that can themselves be trusted.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

We have hosted from January to July 2019 the sabbatical visit of Juliana Freire, a professor at the New York University and the president of the prestigious ACM SIGMOD scientific association.

CHORALE Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. SPHERE ADT Inria project, 2019-20

Participants: Philippe Martinet, Patrick Rives, Renato Martins. The project SPHERE is an Inria ADT coordinated by Philippe Martinet. The aim is to put in place the PERCEPTION360 framework embedded inside the vehicle ICAV in order to map, localize and navigate autonomously in urban areas. It funds an Inria expert engineer position in CHORALE (John Thomas, 12/19-05/20) focusing on instrumentation, control and software development around the autonomous vehicle ICAV.

8.1.2. E-WHEELED ATT Inria project, 2019-21

Participants: Philippe Martinet. The project E-WHEELED is an Inria ATT coordinated by Philippe Martinet. The aim is to provide mobility to things by implementing connectivity techniques. It makes available an Inria expert engineer (Nicolas Chleq) in CHORALE in order to demonstrate the Proof of Concept using a small size demonstrator.

8.1.3. Local initiatives

CHORALE is in touch with local government CASA (Communauté d'Agglomération de Sophia Antipolis) in order to have access to the experimental site dedicated to Autonomous Vehicle demonstration. The first demonstration of autonomous driving has been done mid December. This site will be inaugurated during spring 2020.
Contacts with local companies involved in connected and autonomous driving have been made (including Renault Software Lab and Hitachi). CHORALE has participated to the GetTogether meetings organized by the local initiative SmartVehicles06.

8.2. National Initiatives

8.2.1. ANR Platinum (14-19)

The ANR Platinum (ended in november 2019), led locally by P. Rives, aims to develop methods and algorithms to map an urban environment, enrich it and automatically update it using visual sensors that communicate and are embedded by system users. The consortium is made of 4 academic partners: LITIS, Le2I (VIBOT), Inria-LAGADIC (CHORALE) et IGN-MATIS. One Phd (Mohammed Boussaha) is working on semantization of urban scenes.

8.2.2. ANR Mobi-Deep (17-22)

The ANR MOBI-Deep project, led locally by P. Rives (then P. Martinet since December 2019) aims to develop technologies that enable (or help) autonomous navigation in open and unknown environments using low-cost sensors such as digital cameras. The consortium is made of 2 academic partners: GREYC, Inria-LAGADIC (CHORALE), one association INJA and 3 industrial partners SAFRAN, SAFRAN Electronic & Defence and NAVOCAP. Philippe Martinet took the coordination of the project in December 2019. One master student (Wanting Jin) has worked (6 months) on proactive navigation, and one post-doc (Renato Martins) has been recruted in April 2019 for two years to work on End to End deep learning navigation.

8.2.3. ANR CLARA (19-22)

The ANR CLARA project, led and coordinated by G. Allibert, is focused in autonomous navigation of an aerial drone, equipped with 360-degree cameras, evolving in a forest to provide 3D mapping using deep learning techniques. The consortium is made of 3 academic partners: I3S/Inria CHORALE, LITIS, ViBot. One PhD student (Ihab Mohamed) is working on autonomous navigation using MPPI technics and one master (Haozhou Zhang) has investigated Optical Flow Estimation in Spherical Images.

8.2.4. Collaboration with LS2N-ARMEN

Philippe Martinet as a strong collaboration with the ARMEN team at LS2N. This mainly concerns autonomous parking maneuvers (with Olivier Kermorgant and Salvador Dominguez; we had a phd student), platoon control and observers (with Olivier Kermorgant and Salvador Dominguez; we had 1 post-doc), high speed visual servoing (with Olivier Kermorgant; we have one phd student), collaborative SLAM (with Olivier Kermorgant; we had one phd student), and Control based design (Sébastien Briot; we had one phd student and have one postdoc). These collaborations are mainly funded by ANR projects (initialized and/or prepared when I was in Nantes).

8.2.4.1. ANR Valet (15-19)

The ANR VALET (coordinated by F. Nashashibi from Inria RITS) proposes the development of an automatic redistribution system for sharing vehicles in urban environments. The principle is based on the creation of automated vehicle platoons guided by manually driven vehicles. The collected vehicles are transported to a charging centre or to a car park; here, each vehicle is assigned a parking space to which it must go and then in which it must park fully autonomously. Throughout the movement of platoons and vehicles, they must interact with other road users, including vehicle-type obstacles and pedestrians. The consortium is made of 2 academic partners: Inria (RITS, Chroma, Prima) and Ircyyn (LS2N) Ecole Centrale de Nantes and the AKKA company. One phD student (David Perez Morales) has worked on autonomous parking. One post doc (Ahmed Khalifa) has worked on observer and control design for platoon applications. CHORALE is working inside Hianic via the collaboration with ARMEN.

8.2.4.2. ANR Hianic (18-21)

The HIANIC project (coordinated by A. Spalanzani from Inria CHROMA) proposes to endow autonomous vehicles with smart behaviors (cooperation, negotiation, socially acceptable movements) that better suit complex shared space situations. It integrates models of human behaviors (pedestrian, crowds and passengers), social rules, as well as smart navigation strategies that will manage interdependent behaviors of road users and of cybercars. The consortium is made of 3 academic partners: Inria (RITS, Chroma, Pervasive Interaction teams), Lig Laboratory (Magma team) and LS2N laboratory (ARMEN and PACCE teams). CHORALE is working inside Hianic via the collaboration with CHROMA and ARMEN. One phd student (Maria Kabtoul) is working on proactive navigation of a vehicle among the crowd.

8.2.4.3. ANR SESAME (19-22)

The ANR SESAME (coordinated by S. Briot from LS2N ARMEN) aims to study singularities and stability of sensor-based controllers The consortium is made of 3 academic partners: LS2N (ARMEN and OGRE), Inria (RAINBOW), LIP6 (POLSYS). One master student (John Thomas) has worked on the design of controller based on the concept of hidden robot. One post doc (Abhilash Nayak) is working of the determination of singularities. CHORALE is working inside SESAME via the collaboration with ARMEN.

8.2.5. Collaboration with VIBOT

Guillaume Allibert has a strong collaboration with Pr Cédric Demonceaux from the ERL VIBOT. This mainly concerns activities around perception for robotics. Specifically, we are interested in how to integrate model-based knowledge into deep learning approaches. Two Master students have been involved in 2019: Haozhou Zhang (Optical Flow Estimation In Spherical Images) and Yanis Marchand (New Convolution for Spherical Images Using Depth Information).

8.2.6. Collaboration with RAINBOW Inria Team

Paolo Salaris has a strong collaboration with the RAINBOW Inria team about the research field on active sensing control for robotic platforms where the objective is to determine the robot trajectories that maximise the amount of information coming from sensors. In this activity was involved 1 PostDoc (2017-2019) and recently 1 Master student. This collaboration gave raise to 1 journal and 3 conference papers (one of them under review in the procedeeing of ICRA 2020).

8.3. FP7 & H2020 Projects

Program: H2020

Project acronym: CROWDBOT

Project title: Safe Navigation of Robots in Dense Human Crowds

Duration: Jan 2018 - Jun 2021

Coordinator: Julien Pettré

Other partners: ETHZ (Switzerland), EPFL (Switzerland), UCL (UK), RWTH (Germany), Softbank (France), Locomotec (Germany)

Abstract: CrowdBot will enable mobile robots to navigate autonomously and assist humans in crowded areas. Today's robots are programmed to stop when a human, or any obstacle is too close, to avoid coming into contact while moving. This prevents robots from entering densely frequented areas and performing effectively in these high dynamic environments. CrowdBot aims to fill in the gap in knowledge on close interactions between robots and humans during navigation tasks.

8.4. International Initiatives

8.4.1. Collaboration with Universidade Federal de Minas Gerais, San Paolo

Patrick Rives and Renato Martins have strong collaborations with two research groups at Universidade Federal de Minas Gerais (UFMG), Brazil. The research topics of CHORALE have a large coverage and share common interests with ongoing projects at these groups.

In this context, Patrick Rives spent two months (Nov-Dec 2018) on a Chair Position at UFMG conjointly funded by Le Ministère des Affaires étrangères (France) and UFMG (Brazil). During his stay, he worked with Prof. Alessandro Correa Victorino in the domain of advanced perception for autonomous vehicles.

One objective of his visit was to initiate a long-term scientific collaboration between UFMG and Inria, based on scientific internships of researchers and PhD students (co-tutelle). Originally, this collaboration should be funded by the CAPES-COFECUB International Program. Unfortunately, due to the political changes in Brazil, this project of collaboration is still pending.

Renato Martins, for his part, is a former postdoctoral researcher in the Computer Vision and Robotics Laboratory - VeRLab (UFMG), where he is currently an external collaborator. He actively collaborates on computer vision, perception and robotic vision with Prof. Erikson R. Nascimento, whose research interests and expertise spans from Computer Vision to Computer Graphics.

8.4.2. Inria International Partners

8.4.2.1. Informal International Partners

Universidade Federal de Minas Gerais (UFMG), Brazil
Jaume I University (UJI), Spain
National University of Singapore, Singapore (Marcelo H. Ang)
Universidade de Sao Paulo, Brazil

8.5. Visits of International Scientists

Enric Cervera Associated Professor at the Jaume I University (SPAIN). He is working in visual servoing application. During his stay (May-July 2019) as invited professor, he has worked on 360 degree view visual perception for autonomous navigation.

8.5.1. Visits to International Teams

8.5.1.1. Research Stays Abroad

Patrick Rives spent two months (Nov-Dec 2018) on a Chair Position at UFMG conjointly funded by Le Ministère des Affaires étrangères (France) and UFMG (Brazil).

CHROMA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Inria ADT 'CORDES' (2017-19) & 'COLOC' (2019-20)

Participants: Olivier Simonin, Vincent Le Doze, Jilles Dibangoye, Alessandro Renzaglia.

The COLOC ADT, which follows the CORDES ADT, aims to coordinate a team of UAVs using both SLAM techniques and communication-based localization, considering outdoor urban environments. These ADT are coordinated by Olivier Simonin. They fund an Inria expert engineer position in Chroma (Vincent Le Doze, 10/17-11/20) focusing on UAVs control and localization. The project provides both a 3D simulator of UAV fleets (SimuDronesGR) and a new experimental platform exploiting IntelAero UAVs.

9.1.2. COMODYS project, FIL (Federation d'Informatique de Lyon), 2017-19

Participants: Laetitia Matignon, Olivier Simonin.

Project between two teams of two laboratories from Lyon : CHROMA (CITI) and SMA (LIRIS), entitled "COoperative Multi-robot Observation of DYnamic human poSes", 2017-2019. Leader : L. Matignon & O. Simonin.

This project funds materials, missions and internships and its objectives are the on-line adaptation of a team of robots that observe and must recognize human activities.

9.1.3. WIFI-Drones project, FIL (Federation d'Informatique de Lyon), 2019-21

Participants: Remy Grunblatt, Isabelle Guerin-Lassous [Inria/Lyon1 Dante team], Olivier Simonin.

Project between two teams of two laboratories from Lyon : DANTE (LIP) and CHROMA (CITI), entitled "*Performances des communications Wi-Fi dans les réseaux de drones : une approche expérimentale*", 2019-2021. Leader : I. Guerin-Lassous & O. Simonin.

The project aims to experimentally evaluate the Wireless communication in UAVs fleet scenarios. We consider the recent version of Wi-Fi based on 802.11n and 802.11 ac. Experimental measures will be used to build propagation models in order to be integrated in UAVs fleet simulations (in particular with Gazebo and NS3 simulators).

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. ANR JCJC "Plasma" (2019-2023)

The ANR JCJC Plasma, led by Jilles S. Dibangoye, aims at developing a general theory and algorithms with provable guarantees to treat planning and (deep) RL problems arising from the study of multi-agent sequential decision-making, which may be described as Partially Observable Stochastic Games (POSG), see Figure 1. We shall contribute to the development of theoretical foundations of the fields of intelligent agents and MASs by characterizing the underlying structure of the multi-agent decision-making problems and designing scalable and error-bounded algorithms. The research group is made of four senior researchers, O. Simonin, C. Wolf (INSA Lyon), F. Charpillet (Inria Nancy) and O. Buffet (Inria Nancy), and two junior researchers Jilles S. Dibangoye and A. Saffidine (Univeristy of New South Whales). We plan to hire one PhD and one post-doc for two years as well as internships. We received a support for 42-months starting in March 2020 with a financial support of about 254 269,80 euros.

9.2.1.2. ANR "Delicio" (2019-2023)

The ANR Delicio, led by C. Wolf (INSA Lyon, LIRIS), proposes fundamental and applied research in the areas of Machine Learning and Control with applications to drone (UAV) fleet control. The consortium is made of 3 academic partners: INSA-Lyon/LIRIS (C. Wolf and L. Matignon), INSA-Lyon/CICI (J. Dibangoye, O. Simonin, and I. Redko), University Lyon 1/LAGEPP (M. Nadri, V. Andrieu, D. Astolfi, L. bako, and G. Casadei), and ONERA (S. Bertrand, J. Marzat, H. Piet-Lahanier). We plan to hire two Ph.D and two post-doc for one year as well as interships. We received a support for 48-months starting in October 2019 with a financial support of about 540 000 euros.

9.2.1.3. ANR "Valet" (2016-19)

The ANR VALET, led by A. Spalanzani, proposes a novel approach for solving the car-sharing vehicles redistribution problem using vehicle platoons guided by professional drivers. An optimal routing algorithm is in charge of defining platoons drivers' routes to the parking areas where the followers are parked in a complete automated mode. The consortium is made of 2 academic partners: Inria (RITS, Chroma, Prima) and Irccyn Ecole Centrale de Nantes and the AKKA company. The PhD student (Pavan Vashista) recruited in this project focuses on integrating models of human behaviors to evaluate and communicate a risk to pedestrians that may encounter the trajectory of the VALET vehicle. His PhD thesis, codirected by D. Vaufreydaz (Inria/PervasiveInteraction), has been defended in June 2019.

9.2.1.4. ANR "HIANIC" (2017-21)

The HIANIC project, led by A. Spalanzani, proposes to endow autonomous vehicles with smart behaviors (cooperation, negotiation, socially acceptable movements) that better suit complex SharedSpace situations. It will integrate models of human behaviors (pedestrian, crowds and passengers), social rules, as well as smart navigation strategies that will manage interdependent behaviors of road users and of cybercars. The consortium is made of 3 academic partners: Inria (RITS, Chroma, Pervasive Interaction teams), LIG Laboratory (Hawai team) and LS2N laboratory (ARMEN and PACCE teams).

9.2.1.5. PIA Ademe "CAMPUS" (2017-20)

The CAMPUS project aims to identify, develop and deploy new functions for the autonomous cars in urban environments. In this project, Chroma will focus on finding solutions to navigate in complex situations such as crowded environments or dense traffic. The consortium is made of 1 academic partner: Inria (Rits and Chroma teams) and 3 companies: Safran electronics, Gemalto and Valeo.

9.2.2. FUI Projects

9.2.2.1. FUI Tornado (2017 – 2020)

Participants: Rabbia Asghar, Anne Spalanzani, Christian Laugier, Olivier Simonin.

The project Tornado is coordinated by Renault. The academic partners of the project are Inria Grenoble-Rhône Alpes, UTC, Institut Pascal, University of Pau, IFSTTAR. The industrial and application partners are Renault, Easymile, Neavia, Exoskills, 4D-Virtualiz, MBPC and Rambouillet Territoires. The objective of the project is to demonstrate the feasibility of a mobility service systems operating in the commercial zone of Rambouillet and on some public roads located in its vicinity, with several autonomous cars (Autonomous Renault Zoe). The *IRT Nanoelec* is also involved in the project as a subcontractor, for testing the perception, decision-making, navigation and controls components developed in the project.

9.2.2.2. FUI STAR (2018 – 2021)

Participants: Andres Gomez Hernandez, Olivier Simonin, Christian Laugier.

The Project STAR is coordinated by IVECO. The academic partners of the project are Inria Grenoble-Rhône-Alpes, IFSTTAR, ISAE-Supaéro. The industrial and application partners are IVECO, Easymile, Transpolis, Transdev and Sector Groupe. The goal of the project is to build an autonomous bus that will operate on a safe lane Inria is involved in helping design situation awareness perception, especialy in special case like docking at the bus stop and handling dynamicity of any obstacle. The *IRT Nanoelec* is also involved in the project as a subcontractor, for testing the perception, decision-making, navigation and controls components developed in the project.

9.2.3. DGA/Inria AI projects

9.2.3.1. "DYNAFLOCK" (2019-2023)

The DYNAFLOCK project, led by O. Simonin, aims to extend flocking-based decentralized control of swarm of UAVs by considering the link quality between communicating entities. The consortium is made of 2 Inria teams from Lyon : Chroma and Dante (involving Prof. I. Guerin-Lassous). The PhD student (Alexandre Bonnefond) recruited in this project aims at defining dynamic flocking models based on the link quality. In 2020, an engineer will be recruited to conduct experiments with a quadrotors platform.
Funding of Dynaflock : $\sim$ 250 K€.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. ICT Robotics project "BugWright2" (2020-23)

Success for European H2020 ICT Robotics project application 'BugWright2' (9M€), led by C. Pradalier (CNRS, GeorgiaTech Metz). Chroma is partner and responsible of WP6.

Title : Autonomous Robotic Inspection and Maintenance on Ship Hulls and Storage Tanks

1/01/2020 - 31/12/2023

O. Simonin leads the Multi-Robot Systems work-package (WP6). Chroma will work on multi-robot planning and experiment under environmental constraints. The Agora team is also involved (H. Rivano, O. Iova) to work on robot localization based on the Ultra-WideBand technology.

Funding for Chroma & Agora teams : 600K€

http://dream.georgiatech-metz.fr/research-projects/bugwright2/

9.3.2. Collaborations with Major European Organizations

- ETHZ, Zurich, Autonomous System laboratory, (Switzerland)
- University of Zurich, Robotics and Perception Group (Switzerland) Vision and IMU data Fusion for 3D navigation in GPS denied environment.
- Karlsruhe Institut fur Technologie (KIT, Germany) Autonomous Driving.
- University of Babes-Bolyai, Cluj-Napoca (Romania). Multi-robot patrolling and Machine Learning (PHC "DRONEM" 2017-18).
- Vislab Parma (Italy) Embedded Perception & Autonomous Driving (visits, projects submissions, and book chapter in the new edition of the Handbook of Robotics).

COML Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Collaboration with the Willow Team:

- co-advising with J. Sivic and I. Laptev of a PhD student: Ronan Riochet.
- construction of a naive physics benchmark (http://www.intphys.com)

Collaboration with the Almanach Team:

- co-advising with B. Sagot a PhD student: Robin Algayres.
- co-advising with B. Sagot a Master student: Charlotte Rochereau

8.2. National Initiatives

8.2.1. ANR

- **ANR-Transatlantic Platform Digging into Data - ACLEW** (2017–2020. 5 countries; Total budget: 1.4M€; coordinating PI : M. Soderstrom; Local PI: A. Cristia; Leader of tools development and co-PI : E. Dupoux) - Constructing tools for the Analysis of Children's Language Experiences Around the World.
- **CNRS Prematuration - BabyCloud**. (2018-2019; coordinating PIs : E. Dupoux and X.-N. Cao; 100€) - Enable the construction of a fully functionnal Baby Logger prototype; perform a market analysis and prepare the launch of a startup.
- **ANR GEOMPHON**. (2018-2021; coordinating PI : E. Dunbar; 299K€) - Study the effects of typologically common properties of linguistic sound systems on speech perception, human learning, and machine learning applied to speech.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

- Johns Hopkins University, Baltimore, USA: S. Kudanpur, H. Hermanksy
- RIKEN Institute, Tokyo, Japan: R. Mazuka

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Justine Cassell (CMU, ARP, PRAIRIE Chair starting from Oct 2019)

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

+ E. Dupoux, Research Scientist, JSALT Workshop, Montreal (July, 2019)

DEFROST Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- **INVENTOR** Innovative tool for soft robot design and its application for surgery. This project is financed by **I-Site ULNE EXPAND**, supported by “le programme d’Investissements d’Avenir” and “la Métropole Européenne de Lille”. The objective of this project is to develop an innovative tool for the facilitation of soft robot design.
- **COMOROS** Control of deformable robots for surgery Duration april 2017 to march 2020 Program: FEDER Coordinator: C. Duriez Abstract: Surgical procedures are often carried out using instruments made of stiff materials that interact with delicate biological tissues such as internal organs, blood vessel walls and small cavities. This incompatibility of stiffness is one of the sources of danger in many surgical procedures. The use of robots made of soft materials, also called soft robots, would limit such risks by reducing contact pressures and stress concentrations. Their intrinsic deformability would also increase the ability to manoeuvre in confined spaces. However, the promising concept of using soft robots for surgical procedures cannot be practically implemented, due to the lack of precise modelling and control methods for soft robots. This scientific obstacle, identified as a pending issue by major surveys in this field, becomes particularly challenging when interacting with an environment as complex as the human anatomy. Drawing on our background in soft tissue simulation, contact models, surgical applications and soft robotics, our ambition in this project is to:
  - Develop accurate and generic numerical methods for continuum mechanics, adapted to strong real-time constraints in order to demonstrate the ability to model soft mechatronics systems.
  - Reconsider parametrization methodologies of digital models of the patient anatomy through the observation of mechanical interactions with soft robots via embedded sensors and medical imaging
  - Rethink motion generation and teleoperation control with force feedback so as to be compatible with the large number of degrees of freedom of soft robots and be based on accurate, rapidly-computed deformable models and interaction models.

  The project also targets the development of software with the required performance and features, as well as the experimental validation of models and methods using prototypes in realistic environments.
- The PhD Thesis of Félix Vanneste is half-funded by the Hauts-de-France region.

9.2. National Initiatives

- **ROBOCOP**: Robotization of Cochlear implant. This is a 4-year project, supported by the ANR (French National Agency for Research) in the framework of PRCE, starting from 1 October 2019 until 30 September 2023. ROBOCOP aims at creating a new prototype of cochlear implant, and robotize (i.e. actuate and control) its insertion process to facilitate the work of surgeon, to increase the success ratio, and to decrease the probability of trauma.
- **SIMILAR** Soft robotIcs framework for modeling, simulation and control. This project is supported by **Inria ADT**, and the objective is to design new 3D interactive software to design soft-robots. This new software will be on the top of our existing software stack relying on SOFA for all numerical simulation aspects and 3D rendering aspects.

- **Tremplin ERC** Christian Duriez received a **ANR** grant “tremplin ERC” (150k€) given the result obtained last year on the ERC proposal (evaluated at “grade A”). The project has allowed to allocate new resources on the developments that were presented in this ERC.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

Meichun Lin was doing a project belonged to Interreg - 2 Seas Mers Zeeën on Cooperate Brachytherapy(CoBra), it is a 4 years project which gathers the experts from the countries between English Channel and southern North Sea aiming on finding an advance method for curing prostate cancer. (see more details on https://cobra-2seas.eu/) The project is divided by several fields which are - MR compatible robot design, radiation dose measurement, steerable needle design, mimic soft-tissue (phantom) design and virtual reality real-time training tool development etc. Meichun was working on developing virtual reality real-time training tool with Defrost team. The aim is to have a interactive platform for human and the robot. By using SOFA framework to simulate the soft tissue’s deformation and the interaction with needle insertion under the real-time, also with the Image modelling of MRI and soft-tissue modelling and so on and so forth.

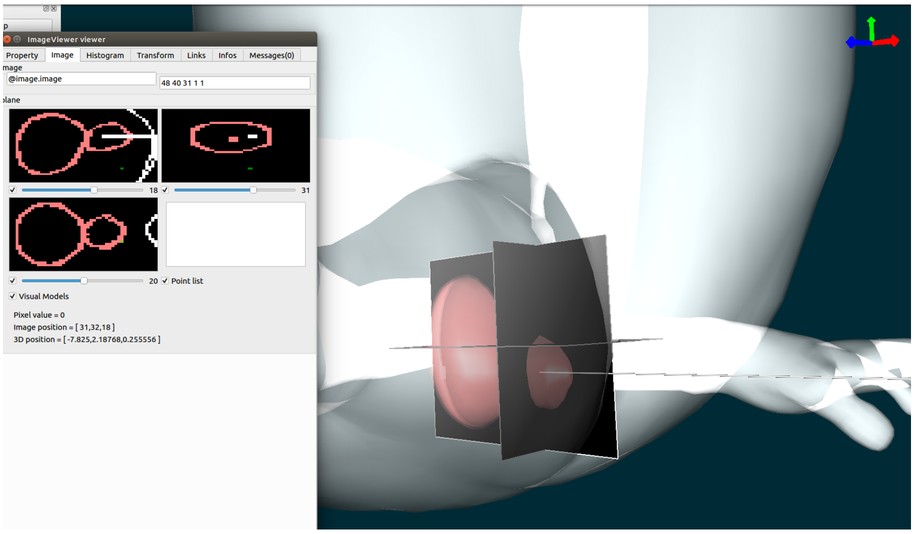

Figure 8. The virtual reality real-time simulation of the CoBra project

9.4. International Initiatives

9.4.1. Inria International Labs

9.4.1.1. AC/DC: A Charm lab / Defrost team Collaboration

Inria@SiliconValley Associate Team

Defrost team (Deformable Robotic Software, Inria Lille – Nord Europe) and the Charm Lab (Collaborative HAptics and Robotics in Medicine Lab, Stanford University, USA) on the topic of soft robots. On this topic, these two entities are very complementary because the Charm Lab is interested in the new design, the realization, the planning and the experimentation and the Defrost team is more centered on mechanical modeling, simulation and the algorithms of control. The collaboration is based on two axes: (1) the creation of flexible robots whose position and rigidity can be controlled, (2) the mechanical modeling and simulation of a robot that navigates in an environment through growth.

- Partner: Allison Okamura at the Department of Mechanical Engineering of Stanford University, USA
- Start year: 2019
- See also: https://team.inria.fr/defrost/collaboration-with-charm-lab-stanford/

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Federico Renda from Khalifa University of Abu Dhabi visited the DEFROST team for a month to work on the implementation of a Cosserat Implementation for Beam simulation in the SOFA framework.

9.5.2. Internships

- Van Pho Nguyen, PhD Candidate from Japan Advanced Institute of Science and Technology (JAIST), visited the team for 6 months to work on the topic of underwater robots.
- Margaret Koehler from the Charm Lab, Stanford University, USA, visited the team for a month to work on the simulation of a soft haptic device.

9.5.3. Visits to International Teams

9.5.3.1. Research Stays Abroad

- Gang Zheng has visited Nanjing University of Science and Technology (China) for 1 month in July 2019.

EX-SITU Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Virtual Reality for Interacting with Building Information Model at Paris-Saclay

Type: Equipment and human resources

Funding: STIC Paris-Saclay

Duration: 2018-2019

Coordinator: Jean-Marc Vézien (LIMSI-CNRS)

Partners: CNRS, Univ. Paris-Sud

Inria contact: Cédric Fleury

Abstract: The goal of this project is to develop interactive tools for BIM application in virtual reality using a user-centered design approach. The project will use as a case study the interior design of the *Learning Center* building on Paris-Saclay campus.

8.1.2. Projet numérique du Learning Center de l'Université

Type: Equipment and subcontracting

Funding: Learning Center Paris-Saclay

Duration: 2019

Coordinator: Michel Beaudouin-Lafon

Partners: Univ. Paris-Sud

Inria contact: Michel Beaudouin-Lafon

Abstract: The goal of this project (30k) is to create an interactive installation presenting the portraits of Ph.D. students from Université Paris-Saclay. It is a collaboration with portrait photographer Didier Goupy. The installation is designed to be exhibited in various sites of Université Paris-Saclay until it is permanently installed in the Learning Center of Université Paris-Saclay. The project was presented at the Ph.D. graduation ceremony of Université Paris-Saclay in June, 2019, and at the Fête de la Science in October, 2019, and will be permanently exhibited in the future Learning Center of Université Paris-Saclay.

8.1.3. Living Archive

Type: Equipment and human resources

Funding: STIC department grant

Duration: 2019-2020

Coordinator: Sarah Fdili Alaoui

Partners: Learning Center

Inria contact: Sarah Fdili Alaoui

Abstract: The project's ambition is to design interactive systems that allow practioners to easily document their dance using their own methods and personal artifacts emphasizing a first-person perspective and minimizing imposed choices from academic researchers.

8.2. National Initiatives

8.2.1. ANR

ELEMENT: Enabling Learnability in Human Movement Interaction

Type: Equipment and human resources

Funding: ANR

Duration: 2019-2022

Coordinator: Baptiste Caramiaux, Sarah Fdili Alaoui, Wendy Mackay

Partners: IRCAM, LIMSI

Inria contact: Baptiste Caramiaux

Abstract: The goal of this project is to foster innovation in multimodal interaction, from non-verbal communication to interaction with digital media/content in creative applications, specifically by addressing two critical issues: the design of learnable gestures and movements; and the development of interaction models that adapt to a variety of user's expertise and facilitate human sensorimotor learning.

8.2.2. Investissements d'Avenir

8.2.2.1. Digiscope - Collaborative Interaction with Complex Data and Computation

Type: EQUIPEX (Equipement d'Excellence)

Duration: 2011-2019

Coordinator: Michel Beaudouin-Lafon

Partners: Université Paris-Saclay (coordinator), Université Paris-Sud, CNRS, CEA, Inria, Institut Mines-Telecom, CentraleSupelec, Université Versailles - Saint-Quentin, ENS Paris-Saclay, Maison de la Simulation

Overall budget: 22.5 Meuros, including 6.7 Meuros public funding from ANR

Abstract: The goal of the project is to create ten high-end interactive rooms interconnected by high-speed networks and audio-video facilities to support remote collaboration across interactive visualization environments. The equipment will be open to outside users and targets four main application areas: scientific discovery, product lifetime management, decision support for crisis management, and education and training. Digiscope includes the existing WILD room, and funded the WILDER room. ExSitu contributes its expertise in the design and evaluation of advanced interaction techniques and the development of distributed software architectures for interactive systems. All ten rooms and the telepresence network are operational. The project was successfully evaluated by an international jury in June, 2017.

8.3. European Initiatives

8.3.1. European Research Council (ERC)

8.3.1.1. Creating Human-Computer Partnerships

Program: ERC Advanced Grant

Project acronym: CREATIV

Project title: Creating Human-Computer Partnerships

Duration: June 2013 - May 2019

Coordinator: Wendy Mackay

Abstract: CREATIV explores how the concept of co-adaptation can revolutionize the design and use of interactive software. Co-adaptation is the parallel phenomenon in which users both adapt their behavior to the system's constraints, learning its power and idiosyncrasies, and appropriate the system for their own needs, often using it in ways unintended by the system designer. A key insight in designing for co-adaptation is that we can encapsulate interactions and treat them as first class objects, called interaction instruments This lets us focus on the specific characteristics of how human users express their intentions, both learning from and controlling the system. By making instruments co-adaptive, we can radically change how people use interactive systems, providing incrementally learnable paths that offer users greater expressive power and mastery of their technology. The initial goal of the CREATIV project is to fundamentally improve the learning and expressive capabilities of advanced users of creative software, offering significantly enhanced methods for expressing and exploring their ideas. The ultimate goal is to radically transform interactive systems for everyone by creating a powerful and flexible partnership between human users and interactive technology.

8.3.1.2. Unified Principles of Interaction

Program: ERC Advanced Grant

Project acronym: ONE

Project title: Unified Principles of Interaction

Duration: October 2016 - September 2020

Coordinator: Michel Beaudouin-Lafon

Abstract: The goal of ONE is to fundamentally re-think the basic principles and conceptual model of interactive systems to empower users by letting them appropriate their digital environment. The project addresses this challenge through three interleaved strands: empirical studies to better understand interaction in both the physical and digital worlds, theoretical work to create a conceptual model of interaction and interactive systems, and prototype development to test these principles and concepts in the lab and in the field. Drawing inspiration from physics, biology and psychology, the conceptual model combines *substrates* to manage digital information at various levels of abstraction and representation, *instruments* to manipulate substrates, and *environments* to organize substrates and instruments into digital workspaces.

8.3.1.3. Humane AI (801)

Title: Toward AI Systems That Augment and Empower Humans by Understanding Us, our Society and the World Around Us

Program: FET Flagships

Duration: March 2019 - February 2020

Coordinator: DFKI (Germany)

Partners:

Aalto Korkeakoulusaatio SR (Finland)

Agencia Estatal Consejo Superior De Investigaciones Cientificas (Spain)

Albert-ludwigs-universitaet Freiburg (Germany)

Athina-erevnitiko Kentro Kainotomias Stis Technologies Tis Pliroforias, Ton Epikoinonion Kai Tis Gnosis (Greece)

Consiglio Nazionale Delle Ricerche (Italy)

Deutsches Forschungszentrum Fur Kunstliche Intelligenz GMBH (Germany)

Eidgenoessische Technische Hochschule Zürich (Switzerland)

Fondazione Bruno Kessler (Italy)

German Entrepreneurship GMBH (Germany)

INESC TEC - Instituto De Engenharia De Sistemas E Computadores, Tecnologia E Ciencia (Portugal)
ING Groep NV (Netherlands)
Institut Jozef Stefan (Slovenia)
Institut Polytechnique De Grenoble (France)
Knowledge 4 All Foundation LBG (United Kingdom)
Kobenhavns Universitet (Denmark)
Kozep-europai Egyetem (Hungary)
Ludwig-maximilians-universitaet Muenchen (Germany)
Max-planck-gesellschaft Zur Forderung Der Wissenschaften EV (Germany)
Technische Universitaet Kaiserslautern (Germany)
Technische Universitaet Wien (Austria)
Technische Universitat Berlin (Germany)
Technische Universiteit Delft (Netherlands)
Thales SIX GTS FRANCE SAS (France)
The University Of Sussex (United Kingdom)
Universidad Pompeu Fabra (Spain)
Universita Di Pisa (Italy)
Universiteit Leiden (Netherlands)
University College Cork - National University Of Ireland, Cork (Ireland)
Uniwersytet Warszawski (Poland)
Volkswagen AG (Germany)

Inria contact: Wendy Mackay

The presence and capabilities of artificial intelligence (AI) have grown significantly and will continue to do so. The Humane AI Flagship will develop the scientific foundations and technological breakthroughs needed to shape the ongoing AI revolution. The goal is to deploy AI systems that enhance human capabilities and empower individuals and societies, and ultimately extend human intelligence (rather than replace it). With 35 partners from 17 countries, Humane AI is undertaking a preparatory action to draft an ambitious research agenda to provide competitive advantages to European industry and substantial benefits to society. Partners are united by the vision of a new generation of ethical, value-oriented, and human-centric European approach to AI.

8.4. International Initiatives

8.4.1. Participation in Other International Programs

8.4.1.1. Inria International Chairs

IIC MCGRENERE Joanna

Title: Personalization through Co-Adaptive Human-Computer Interaction

International Partner (Institution - Laboratory - Researcher):

University of British Columbia (Canada) - Dept of Computer Science - Joanna McGrenere

Duration: 2017 - 2021

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Joanne McGrenere, Professor at the University of British Columbia, Canada and Inria Chair, visited for two months, to work with Wendy Mackay and Michel Beaudouin-Lafon.

Susanne Bødker, Professor at Aarhus University, Denmark, visited for a week to work with Wendy Mackay and Michel Beaudouin-Lafon.

8.5.1.1. Internships

Injung Lee, Ph.D. student from KAIST, South Korea, visited for five months to work with Michel Beaudouin-Lafon.

FLOWERS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Perseverons

Perseverons

Program: eFran

Duration: January 2016 - December 2019

Coordinator: PY Oudeyer, Inria Flowers

Partners: Inria Flowers

Funding: 140 keuros

The Perseverons project (Perseverance with / by digital objects), coordinated by the university via the ESPE (Higher School of Teaching and Education) of Aquitaine, and by the Rectorat of Bordeaux via the DANE (Academic Delegation digital education), aims to measure the real effectiveness of digital techniques in education to improve school motivation and perseverance, and, in the long term, reduce dropout. The project proposes to analyze the real effects of the use of two types of objects, robots, tablets, by comparing the school and non-school contexts of the *fablabs*. It is one of the 22 winners http://www.gouvernement.fr/efran-les-22-laureats of the "E-Fran" call for projects (training, research and digital animation spaces), following the Monteil mission on digital education, as part of the Investissement d'Avenir 2 program http://ecolenumerique.education.gouv.fr/2016/09/23/1244/. Formed of 12 sub-projects, "perseverons" has many partnerships, especially with the Poppy Education project of Inria Flowers. It is funding the PhD of Thibault Desprez.

9.1.1.1. Partner schools

In 2018, we have 36 partner schools (show Fig 39). 15 directly from the Poppy Education project. 19 new establishments were equipped in September 2017 by the Perseverons project. 21 of these establishments are located in Gironde. We have 27 high schools, 5 middle school.

9.2. National Initiatives

9.2.1. Myoelectric prosthesis - PEPS CNRS

PY Oudeyer collaborated with Aymar de Rugy, Daniel Cattaert, Mathilde Couraud, Sébastien Mick and Florent Paclet (INCIA, CNRS/Univ. Bordeaux) about the design of myoelectric robotic prostheses based on the Poppy platform, and on the design of algorithms for co-adaptation learning between the human user and the prosthesis. This was funded by a PEPS CNRS grant.

9.2.2. Poppy Station structure

- Since 1 september 2017 until february 2019, PerPoppy and Poppy Station Projects : D. Roy, P.-Y. Oudeyer. These projects aim to perpetuate the Poppy robot ecosystem by creating an external structure from outside Inria, with various partners. After the Poppy Robot Project, the Poppy Education Project has ended and Poppy Station structure is born. PerPoppy is the project which is building the new structure, and Poppy Station is the name of the new structure. Poppy Station, which includes Poppy robot ecosystem (hardware, software, community) from the beginning, is a place of excellence to build future educational robots and to design pedagogical activities to teach computer science, robotics and Artificial Intelligence. https://www.poppy-station.org

Attachement	Type	Name	Adresse	Tel	Web
Poppy Éducation	High School	Alfred Kastler	14 Avenue de l'Université,33402 Talence, France	+33 5 57 35 40 70	http://www.lyceekastler.fr/
Poppy Éducation	Middle School	Anatole France	28 Rue des Micocouliers,33410 Cadillac, France	+33 5 56 62 98 42	http://www.afcadillac.net/
PERSEVERONS	High School	André Malraux	3 Rue du 8 Mai 1945,64200 Biarritz, France	+33 5 59 01 20 40	http://lycee-malraux-biarritz.fr/
Poppy Éducation	High School	Camille Jullian	29 Rue de la Croix Blanche,33000 Bordeaux, France	+33 5 56 01 47 47	http://www.camillejullian.com/
Poppy Éducation	Middle School	de France	Rue du Cimetière Saint-Benoist,75005 Paris, France	+33 1 44 27 12 11	http://www.college-de-france.fr/
Poppy Éducation	High School	des Graves	238 Cours du Général de Gaulle,33170 Gradignan, France	+33 5 56 75 77 56	http://www.grandlebrun.com/
PERSEVERONS	High School	Élie Faure	63 Avenue de la Libération,33310 Lormont, France	+33 5 56 38 23 23	http://www.lyc-eliefaure.fr/
PERSEVERONS	High School	Elisée Reclus	7 Avenue de Verdun,33220 Pineuilh, France	+33 5 57 41 92 50	http://lycee-foyen.fr/
Poppy Éducation	High School	François Mauriac	1 Rue Henri Dunant,33000 Bordeaux, France	+33 5 56 38 52 82	http://lyceemauriac.fr/
PERSEVERONS	High School	Gaston Febus	20 Avenue Georges Moutet,64300 Orthez, France	+33 5 59 67 07 26	http://webetab.ac-bordeaux.fr/cite-gaston-febus-orthez/
PERSEVERONS	Middle School	Giraud de Borneil	10 Boulevard André Dupuy,24160 Excideuil, France	+33 5 53 62 21 16	http://www.gdeborneil.fr/
PERSEVERONS	High School	Grand Air	Avenue du Docteur Lorentz Monod,33120 Arcachon, France	+33 5 56 22 38 00	http://webetab.ac-bordeaux.fr/lycee-grand-air/
PERSEVERONS	High School	Gustave Eiffel	143 Rue Ferbos,33000 Bordeaux, France	+33 5 56 33 83 00	http://www.eiffel-bordeaux.org/
PERSEVERONS	High School	Jacques Monod	10 Rue du Parvis,64230 Lescar, France	+33 5 59 77 92 00	http://lyceejacquesmonod.fr/
Poppy Éducation	High School	Jean Moulin	Avenue de la République,33210 Langon, France	+33 5 56 63 62 30	http://webetab.ac-bordeaux.fr/lycee-jean-moulin-langon/
Poppy Éducation	Middle School	Jean Zay	41 Rue Henri Cochet,33380 Biganos, France	+33 5 57 17 01 70	http://collegebiganos.fr/
Poppy Éducation	High School	La Morlette	62 Rue du Docteur Roux,33150 Cenon, France	+33 5 57 80 37 00	http://lycee-lamorlette.fr/
PERSEVERONS	High School	Les Iris	13 Rue Sourbès,33310 Lormont, France	+33 5 57 80 10 60	http://www.lyceelesiris.fr/
PERSEVERONS	High School	Louis Barthou	2 Boulevard Barbanègre,64000 Pau, France	+33 5 59 98 98 00	http://www.cyberlycee.fr/
PERSEVERONS	High School	Louis de Foix	4 Avenue Jean Rostand,64100 Bayonne/Bayona/Baiona, France	+33 5 59 63 31 10	http://www.louisdefoix.com/
PERSEVERONS	High School	Maine de Biran	108 Rue Valette,24100 Bergerac, France	+33 5 53 74 50 00	http://webetab.ac-bordeaux.fr/lycee-maine-de-biran/
Poppy Éducation	Middle School	Mios	Route du Pujeau,33380 Mios, France	+33 5 56 03 00 77	http://www.villemios.fr/enfance-jeunesse/college/
PERSEVERONS	High School	Nord Bassin	128 Avenue de Bordeaux,33510 Andernos-les-Bains, France	+33 5 56 82 20 77	http://www.lyceenordbassin.com/
Forum Poppy	Primary School	Notre-Dame du Mur	19 Rue de Kermadiou,29600 Morlaix, France	+33 2 98 88 18 69	http://lycee.ecmorlaix.fr/
PERSEVERONS	High School	Pape Clément	1 Rue Léo Lagrange,33600 Pessac, France	+33 5 57 26 63 00	http://lyceepapeclement.fr/
PERSEVERONS	High School	Pays de Soule	Avenue Jean Monnet,64130 Chéraute, France	+33 5 59 28 22 28	http://www.lyceedupaysdesoule.fr/index.php
PERSEVERONS	High School	Pré De Cordy	5 Avenue Joséphine Baker,24200 Sarlat-la-Canéda, France	+33 5 53 31 70 70	http://lycee-predecordy-sarlat.com/
Poppy Éducation	High School	Raoul Follereau	9 Boulevard Saint-Exupéry,58000 Nevers, France	+33 3 86 60 36 00	http://lyc58-renardfollereau.ac-dijon.fr/
PERSEVERONS	High School	René Cassin	2 Rue de Lasseguette,64100 Bayonne/Bayona/Baiona, France	+33 5 59 58 42 00	http://webetab.ac-bordeaux.fr/lycee-rene-cassin/
PERSEVERONS	High School	Saint-Cricq	4 Piste Cyclable,64000 Pau, France	+33 5 59 30 50 55	http://www.lycee-saint-cricq.org/
Poppy Éducation	High School	Saint-Genès	160 Rue de Saint-Genès,33000 Bordeaux, France	+33 5 56 33 84 84	http://www.saint-genes.com/
PERSEVERONS	High School	Saint-John Perse	2 Chemin de Barincou,64000 Pau, France	+33 5 59 62 73 11	http://www.lycee-saint-john-perse.fr/
Poppy Éducation	High School	Sainte-Marie Grand Lebrun	164 Rue François Mauriac,33200 Bordeaux, France	+33 5 56 08 32 13	http://www.grandlebrun.com/
inria	High School	Sainte-Saintonge	12 Rue de Saintonge,33000 Bordeaux, France	+33 5 56 99 39 29	http://www.lyceesaintefamille.com/
Poppy Éducation	High School	Sud-Médoc	Piste du Médoc Bleu,33320 Le Taillan-Médoc, France	+33 5 56 70 10 10	http://www.lyceesudmedoc.fr/
Poppy Éducation	High School	Victor Louis	2 Rue de Mégret,33400 Talence, France	+33 5 56 80 76 40	http://lyceevictorlouis.fr/

Figure 39. List of partner schools

- Partners of Poppy Station : Inria, La Ligue de l'Enseignement, HESAM Université, SNCF Développement, IFÉ-ENS Lyon, MOBOTS – EPFL, Génération Robots, Pollen Robotics, KONEX-Inc, Mobsya, CERN Microclub, LINE Lab (Université Nice), Stripes, Canopé Martinique, Rights Tech Women, Editions Nathan.

9.2.3. Adaptiv'Math

Adaptiv'Math

Program: PIA

Duration: 2019 - 2020

Coordinator: EvidenceB

Partners:

EvidenceB

Nathan

APMEP

LIP6

Inria

ISOGRAD

Daesign

Schoolab

BlueFrog

The solution Adaptiv'Math comes from an innovation partnership for the development of a pedagogical assistant based on artificial intelligence. This partnership is realized in the context of a call for projects from the Ministry of Education to develop a pedagogical plateform to propose and manage mathematical activities intended for teachers and students of cycle 2. The role of Flowers team is to work on the AI of the proposed solution to personalize the pedagogical content to each student. This contribution is based on the work done during the Kidlearn Project and the thesis of Benjamin Clement [69], in which algorithms have been developed to manage and personalize sequence of pedagogical activities. One of the main goal of the team here is to transfer technologies developed in the team in a project with the perspective of industrial scaling.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, except FP7 & H2020

9.3.1.1. IGLU

Title: Interactive Grounded Language Understanding (IGLU)

Programm: CHIST-ERA

Duration: October 2015 - September 2018

Coordinator: University of Sherbrooke, Canada

Partners:

University of Sherbrooke, Canada

Inria Bordeaux, France

University of Mons, Belgium

KTH Royal Institute of Technology, Sweden

University of Zaragoza, Spain

University of Lille 1 , France

University of Montreal, Canada

Inria contact: Pierre-Yves Oudeyer

Language is an ability that develops in young children through joint interaction with their caretakers and their physical environment. At this level, human language understanding could be referred as interpreting and expressing semantic concepts (e.g. objects, actions and relations) through what can be perceived (or inferred) from current context in the environment. Previous work in the field of artificial intelligence has failed to address the acquisition of such perceptually-grounded knowledge in virtual agents (avatars), mainly because of the lack of physical embodiment (ability to interact physically) and dialogue, communication skills (ability to interact verbally). We believe that robotic agents are more appropriate for this task, and that interaction is a so important aspect of human language learning and understanding that pragmatic knowledge (identifying or conveying intention) must be present to complement semantic knowledge. Through a developmental approach where knowledge grows in complexity while driven by multimodal experience and language interaction with a human, we propose an agent that will incorporate models of dialogues, human emotions and intentions as part of its decision-making process. This will lead anticipation and reaction not only based on its internal state (own goal and intention, perception of the environment), but also on the perceived state and intention of the human interactant. This will be possible through the development of advanced machine learning methods (combining developmental, deep and reinforcement learning) to handle large-scale multimodal inputs, besides leveraging state-of-the-art technological components involved in a language-based dialog system available within the consortium. Evaluations of learned skills and knowledge will be performed using an integrated architecture in a culinary use-case, and novel databases enabling research in grounded human language understanding will be released. IGLU will gather an interdisciplinary consortium composed of committed and experienced researchers in machine learning, neurosciences and cognitive sciences, developmental robotics, speech and language technologies, and multimodal/multimedia signal processing. We expect to have key impacts in the development of more interactive and adaptable systems sharing our environment in everyday life. http://iglu-chistera.github.io/

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. NEUROCURIOSITY

Title: NeuroCuriosity

International Partner (Institution - Laboratory - Researcher):

Columbia Neuroscience (United States) - Cognitive Neuroscience - JACQUELINE GOTTLIEB

Start year: 2016

See also: https://flowers.inria.fr/neurocuriosityproject/

Curiosity can be understood as a family of mechanisms that evolved to allow agents to maximize their knowledge of the useful properties of the world. In this project we will study how different internal drives of an animal, e.g. for novelty, for action, for liking, are combined to generate the rich variety of behaviors found in nature. We will approach such challenge by studying monkeys, children and by developing new computational tools.

9.4.1.2. Idex Bordeaux-Univ. Waterloo collaborative project on curiosity in HCI

Title: Curiosity

International Partner (Institution - Laboratory - Researcher):

University of Waterloo (Canada), Edith Law's HCI Lab and Dana Kulic's Robotics lab.

Start year: 2018

Pierre-Yves Oudeyer collaborated with Edith Law's HCI research group at University of Waterloo on the topic of "Curiosity in HCI system". They obtained a grant from Univ. Bordeaux to set up a project with Inria Potioc team and with Dana Kulic, Robotics lab, Univ. Waterloo. They organized several cross visits and collaborated on the design and experimentation of an educational interactive robotic system to foster curiosity-driven learning. This led to two articles accepted at CHI 2019 and CHI2020 (see new results section).

To continue this collaborative research, a new proposal on « Curiosity-driven learning and personalized (re-)education technologies across the lifespan » have been successfully submitted to UB-UW IDEX call regarding the projects in the field of AI and health sciences (PI: E. Law, PY Oudeyer ; co-PI : M. Fernandes, H. Sauzéon & F. Lotte)

9.4.1.3. Idex Bordeaux-Univ. Waterloo collaborative project on Virtual realty-based study on spatial learning in aging

Title: Spatial learning with aging

International Partner (Institution - Laboratory - Researcher):

University of Waterloo (Canada), Myra Fernandes, Cognitive neurosciences Lab.

Start year: 2016 (end year 2019)

Helene Sauzéon collaborated with Myra Fernandes's cognitive neuroscience Lab at University of Waterloo on the topic of "VR based study of spatial learning in older adults". They obtained a grant from Univ. Bordeaux to set up a project with Quincy Almeida, head of Movement Disorders Research and Rehabilitation Centre, Laurier University. They organized several cross visits and collaborated on the design and experimentation of a virtual reality application allowing to investigate intrinsic motivation (i.e., Active exploration) as cognitive support for older adults' spatial learning. This led to an article published in Brain Science in 2019 (see new results section).

9.4.1.4. Informal International Partners

Pierre-Yves Oudeyer and Didier Roy have created a collaboration with LSRO EPFL and Pr Francesco Mondada, about Robotics and education. The two teams co-organize the annual conference "Robotics and Education"in Bordeaux. Didier Roy teaches "Robotics and Education" in EPFL several times a year.

Didier Roy has created a collaboration with HEP Vaud (Teachers High School) and Bernard Baumberger and Morgane Chevalier, about Robotics and education. Scientific discussions and shared professional training.

Didier Roy has created a collaboration with Biorob - EPFL, LEARN - EPFL, and Canton de Vaud, about Robotics and Computer Science education. Scientific discussions and shared professional training.

Didier Roy has created a collaboration with Mauritius Research Council, Mauritius Education Institute and AUF, about Robotics, AI and Computer Science projects, teaching and learning. Scientific discussions and shared professional training. With Gérard Giraudon (Advisor to the President of Inria, with in particular a mission on "Digital & Training").

A collaboration with Johan Lilius and Sebastien Lafond from Abo Akademi University, Turku (Finland) is ongoing to sign an Erasmus contract for researchers and students visits on the topic of autonomous boats.

Funding applications have been submitted jointly with Davide Maltoni and Vincenzo Lomonaco from University of Bologna (Italy) on the topic of continual learning. Also the project https://www.continualai.org/ is being further developed jointly and on the way to become a non-profit organization.

9.4.2. Participation in Other International Programs

David Filliat participates in the ITEA3 DANGUN project with Renault S.A.S. in france and partners in Korea. The purpose of the DANGUN project is to develop a Traffic Jam Pilot function with autonomous capabilities using low-cost automotive components operating in France and Korea. By incorporating low-cost advanced sensors and simplifying the vehicle designs as well as testing in different scenarios (France & Korea), a solution that is the result of technical cooperation between both countries should lead to more affordable propositions to respond to client needs in the fast moving market of intelligent mobility.

Natalia Díaz Rodríguez collaborates with the Abo Akademi University in Turku, Finland on the autonomous navigation systems project, involving the sailing schools of Novia and Naval Group (France). She also collaborates with the Andalusian Research Institute in Data Science and Computational Intelligence https://dasci.es (DaSCI) and the University of Granada (Spain) on explainable AI.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Kevvyn Collins-Thompson, Univ. Michigan (sept.-dec. 2019)
- Franck Guerin, Univ. Aberyswith (dec 2019)
- Justus Piater, Univ. Innsbrucj (dec 2019)
- Verena Hafner, Univ. Berlin (dec 2019)
- Jochen Triesch, Univ. Frankfurt (dec 2019)
- Nivedita Mani, Univ. Gottingen (dec 2019)
- Oksana Hagen, Plymouth University (Oct. 2019)

9.5.2. Internships

- Medhi Alaimi [Inria, until Jul 2019]
- Timothee Anne [Inria, from Feb 2019 until Jun 2019]
- Anouche Banikyan [Inria, from Feb 2019 until Jul 2019]
- Lucie Galland [Ecole Normale Supérieure Paris, from Jun 2019 until Aug 2019]
- Tallulah Gilliard [Inria, from Feb 2019 until Jul 2019]
- Marion Schaeffer [Inria, from Jul 2019 until Sep 2019]
- Martin Serret [Inria, from Feb 2019 until Aug 2019]
- Maria Teodorescu [Inria, from Sep 2019]

GRAPHDECO Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. EpicNPoc

Participants: Bastien Wailly, Adrien Bousseau.

EpicNPoc is a startup working on user interface design for the car industry. Together with two InriaTech engineers, we developed a small proof-of-concept that adapts our drawing recognition technology [9] to their needs. We first adapted our drawing synthesis algorithms to generate artificial sketches of user interface widgets, which include typical distortions and inaccuracies present in real sketches. The two engineers from InriaTech then used this technology to generate a large dataset of drawings, and to train a deep neural network to recognize the widgets in real drawings. The two engineers also integrated the trained network into a real-time system that recognizes widgets as they are drawn on a white board. We advised the engineers in their choice of a deep network architecture and on how to train this network to work on drawings. The result of this collaboration helped EpicNPoc appreciate the robustness of this technology, as well as to evaluate remaining challenges, such as convert the recognized widgets into working user-interface source code.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. D^3: Drawing Interpretation for 3D Design

Participants: Yulia Gryaditskaya, Tibor Stanko, Bastien Wailly, David Jourdan, Adrien Bousseau, Felix Hähnlein.

Line drawing is a fundamental tool for designers to quickly visualize 3D concepts. The goal of this ERC project is to develop algorithms capable of understanding design drawings. The first 30 months of the project allowed us to make significant progress in our understanding of how designers draw, and to propose preliminary solutions to the challenge of reconstructing 3D shapes from design drawings.

To better understand design sketching, we have collected a dataset of more than 400 professional design sketches [17]. We manually labeled the drawing techniques used in each sketch, and we registered all sketches to reference 3D models. Analyzing this data revealed systematic strategies employed by designers to convey 3D shapes, which will inspire the development of novel algorithms for drawing interpretation. In addition, our annotated sketches and associated 3D models form a challenging benchmark to test existing methods.

We proposed several methods to recover 3D information from drawings. A first family of method employs deep learning to predict what 3D shape is represented in a drawing. We applied this strategy in the context of architectural design, where we reconstruct 3D building by recognizing their constituent components (building mass, facade, window). We also presented an interactive system that allows users to create 3D objects by drawing from multiple viewpoints [14]. The second family of methods leverages geometric properties of the lines drawn to optimize the 3D reconstruction. In particular, we exploited properties of developable surfaces to reconstruct sketches of fashion items.

A long-term goal of our research is to evaluate the physical validity of a concept directly from a drawing. We obtained promising results towards this goal for the particular case of mechanical objects. We proposed an interactive system where users design the shape and motion of an articulated object, and our method automatically synthesize a mechanism that animates the object while avoiding collisions [18]. The geometry synthesized by our method is ready to be fabricated for rapid prototyping.

8.2.1.2. ERC FunGraph

Participants: George Drettakis, Thomas Leimkühler, Sébastien Morgenthaler, Rada Deeb, Stavros Diolatzis, Siddhant Prakash, Simon Rodriguez, Julien Philip.

The ERC Advanced Grant FunGraph proposes a new methodology by introducing the concepts of rendering and input uncertainty. We define output or rendering uncertainty as the expected error of a rendering solution over the parameters and algorithmic components used with respect to an ideal image, and input uncertainty as the expected error of the content over the different parameters involved in its generation, compared to an ideal scene being represented. Here the ideal scene is a perfectly accurate model of the real world, i.e., its geometry, materials and lights; the ideal image is an infinite resolution, high-dynamic range image of this scene.

By introducing methods to estimate rendering uncertainty we will quantify the expected error of previously incompatible rendering components with a unique methodology for accurate, approximate and image-based renderers. This will allow FunGraph to define unified rendering algorithms that can exploit the advantages of these very different approaches in a single algorithmic framework, providing a fundamentally different approach to rendering. A key component of these solutions is the use of captured content: we will develop methods to estimate input uncertainty and to propagate it to the unified rendering algorithms, allowing this content to be exploited by all rendering approaches.

The goal of FunGraph is to fundamentally transform computer graphics rendering, by providing a solid theoretical framework based on uncertainty to develop a new generation of rendering algorithms. These algorithms will fully exploit the spectacular – but previously disparate and disjoint – advances in rendering, and benefit from the enormous wealth offered by constantly improving captured input content.

8.2.1.3. Emotive

Participants: Julien Philip, Sebastiàn Vizcay, George Drettakis.

https://emotiveproject.eu/

Type: COOPERATION (ICT)

Instrument: Reseach Innovation Action

Objectif: Virtual Heritage

Duration: November 2016 - October 2019

Coordinator: EXUS SA (UK)

Partner: Diginext (FR), ATHENA (GR), Noho (IRL), U Glasgow (UK), U York (UK)

Inria contact: George Drettakis

Abstract: Storytelling applies to nearly everything we do. Everybody uses stories, from educators to marketers and from politicians to journalists to inform, persuade, entertain, motivate or inspire. In the cultural heritage sector, however, narrative tends to be used narrowly, as a method to communicate to the public the findings and research conducted by the domain experts of a cultural site or collection. The principal objective of the EMOTIVE project is to research, design, develop and evaluate methods and tools that can support the cultural and creative industries in creating Virtual Museums which draw on the power of 'emotive storytelling'. This means storytelling that can engage visitors, trigger their emotions, connect them to other people around the world, and enhance their understanding, imagination and, ultimately, their experience of cultural sites and content. EMOTIVE did this by providing the means to authors of cultural products to create high-quality, interactive, personalized digital stories. The project was evaluated in December with very positive initial feedback.

GRAPHDECO contributed by developing novel image-based rendering techniques to help museum curators and archeologists provide more engaging experiences. We developed a mixed reality plugin for Unity that allows the use of IBR and we developed, in collaboration with ATHENA, a VR experience used in one of the EMOTIVE user experiences using a VIVE HMD. This demo was presented at a public event in November in Glasgow, and used by over 25 museum professionals with very positive feedback.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

We maintain close collaborations with international experts, including

- McGill (Canada) (A. Gruson)
- UBC (Canada), (A. Sheffer)
- TU Delft (NL) (M. Sypesteyn, J. W. Hoftijzer and S. Pont)
- EPFL (Switzerland) (W. Jakob)
- U Bern (Switzerland) (D. Bommes)
- University College London (UK) (G. Brostow, P. Hedman)
- NVIDIA Research (USA, Finland), (C. Wyman, P. Shirley, M. Aittala)
- Adobe Research (USA), (A. Hertzmann, S. Paris, M. Gharbi)
- UC Berkeley (USA) (A. Efros)
- Purdue University (USA) (D. Aliaga, G. Nishida)
- U Texas, Austin (USA), (E. Vouga)
- George Mason University (USA) (Y. Gingold)

8.3.1.2. Inria International Chairs

Fredo Durand, Massachusetts Institute of Technology (United States)

Duration: 2016 - 2020

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Justin Solomon (MIT) in March.
- Mikhail Bessmeltsev (University of Montreal) in June.
- Aaron Hertzmann (Adobe Research) in June.
- Pierre Benard (U. Bordeaux), Daniel Sykora (U. Prague) and TT Wong (Hong Kong Polytechnic) in June.
- Tobias Ritschel (MPI Saarbrucken), Hendrik Lensch (U. Tuebingen) and Yann Gousseau (Telecom Paris) in June.
- Peter Hedman (UCL), September and October.
- Guillaume Coordonnier (ETH Zurich) in October.
- Alyosha Efros (U. Berkeley)
- Holly Rushmeier (Yale) and Abhijeet Ghosh (Imperial College London) in November.
- Niloy Mitra (UCL), Adrien Gruson (McGill) and Michael Gharbi (Adobe) in November.

8.4.1.1. Internships

J. Philip at Adobe Research, June 1st- September 28th, 2019. San Francisco.

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

T. Stanko spent two weeks at University of Montreal to collaborate with Mikhail Bessmeltsev, and S. Rodriguez spent 5 weeks at NVIDIA research in Seattle (host C. Wyman).

GRAPHIK Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. CQFD (ANR PRC, Jan. 2019-Dec. 2022)

Participants: Jean-François Baget, Michel Leclère, Marie-Laure Mugnier, Federico Ulliana.

CQFD (Complex ontological Queries over Federated heterogeneous Data), coordinated by Federico Ulliana (GraphIK), involves participants from Inria Saclay (CEDAR team), Inria Paris (VALDA team), Inria Nord Europe (SPIRALS team), IRISA, LIG, LTCI, and LaBRI. The aim of this project is tackle two crucial challenges in OMQA (Ontology Mediated Query Answering), namely, heterogeneity, that is, the possibility to deal with multiple types of data-sources and database management systems, and federation, that is, the possibility of cross-querying a collection of heterogeneous datasources. By featuring 8 different partners in France, this project aims at consolidating a national community of researchers around the OMQA issue.

8.1.2. ICODA (Inria Project Lab, 2017-2021)

Participants: Jean-François Baget, Michel Chein, Marie-Laure Mugnier.

The iCODA project (Knowledge-mediated Content and Data Interactive Analytics—The case of data journalism), coordinated by Guillaume Gravier and Laurent Amsaleg (LINKMEDIA), takes together four Inria teams: LINKMEDIA, CEDAR, ILDA and GraphIK, as well as three press partners: Ouest France, Le Monde (les décodeurs) and AFP.

Taking data journalism as an emblematic use-case, the goal of the project is to develop the scientific and technological foundations for knowledge-mediated user-in-the-loop big data analytics jointly exploiting data and content, and to demonstrate the effectiveness of the approach in realistic, high-visibility use-cases.
https://project.inria.fr/icoda/

8.1.3. Docamex (CASDAR project, 2017-2020)

Participants: Patrice Buche, Madalina Croitoru, Jérôme Fortin, Clément Sipieter.

DOCaMEx (Développement de prOgiciels de Capitalisation et de Mobilisation du savoir-faire et de l'Expérience fromagers en filière valorisant leur terroir), let by CFTC (centre technique des fromages de Franche-Comté) involves 7 research units (including IATE and LIRMM), 8 technical centers and 3 dairy product schools. It represents five cheese-making chains (Comté, Reblochon, Emmental de Savoie, Salers, Cantal).

Traditional cheese making requires a lot of knowledge, expertise, and experience, which are usually acquired over a long time. This know-how is today mainly transmitted by apprenticeship and a concrete risk of knowledge forgetting is raised by the evolution of practices in the sector. The main goal of the project is to develop a new approach for expert knowledge elicitation and capitalization, and a dedicated software for decision making. The novel part of the decision making tool consists in the representation power and reasoning efficiency in the context of the logic used to describe the domain knowledge.
http://www.rmtfromagesdeterroirs.com/projets-de-r-et-d/docamex/

8.1.4. Convergence Institute #DigitAg (2017-2023)

Participants: Patrice Buche, Madalina Croitoru, Marie-Laure Mugnier, Rallou Thomopoulos, Federico Ulliana.

Located in Montpellier, #DigitAg (for Digital Agriculture) gathers 17 founding members: research institutes, including Inria, the University of Montpellier and higher-education institutes in agronomy, transfer structures and companies. Its objective is to support the development of digital agriculture. GraphIK is involved in this project on the issues of designing data and knowledge management systems adapted to agricultural information systems, and of developing methods for integrating different types of information and knowledge (generated from data, experts, models). A starting PhD thesis (Elie Najm) will investigate knowledge representation and reasoning for agro-ecological systems, in collaboration with the research laboratory UMR SYSTEM (Tropical and mediterranean cropping system functioning and management).
https://www.hdigitag.fr/en/

8.1.5. Vitamin (Méta-programme Did'It 2017-2018)

Participant: Rallou Thomopoulos.

The goal is to get a better understanding of factors influencing individuals in their transition to stop or reduce their animal product consumption. We use comprehensive individual interviews, questionnaires as well as diverse modelling techniques (mainly multi-agents & argumentation systems) to collect and analyse this topic. We develop agent-based models integrating argumentation systems about vegetarian transitions, at the long and short term. We have proposed a generic framework implemented in the GAMA platform allowing to explicitly represent exchanges of arguments between actors in the context of an opinion dynamic model. More precisely, we propose to formalize the inner attitude towards an opinion of each agent as an argumentation graph and give them the possibility to share arguments with other agents. The application to food choices allows studying the possible evolution of the vegetarian diet.
https://www.researchgate.net/project/VITAMIN-VegetarIan-Transition-Argument-ModellINg

8.1.6. Informal National Partners

We continue to work informally with the following partners:

- Pierre Bourhis (SPIRALS Inria team) and Sophie Tison (LINKS Inria team) Ontology-Mediated Query Answering [22].
- Michael Thomazo (VALDA Inria team) on Ontology-Mediated Query Answering [29].
- Jérôme Bonnet and Sarah Guiziou, from the Center for Structural Biochemistry of Montpellier (CBS), on the encoding of Boolean functions in biological systems [30]
- Srdjan Vesic (CRIL) on logical argumentation systems. In particular, Srdjan Vesic was a co-supervisor of Bruno Yun's PhD thesis, defended in July 2019 [33].
- Jean-Claude Léon (IMAGINE Inria team) on the development of an ontology-mediated query answering system applied to the field of CAD (Computer Aided Design).
- Slawek Staworko (LINKS Inria team) on data cleaning and argumentation techniques for repairing.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. NoAW (H2020, Oct. 2016-Sept. 2020)

Participants: Patrice Buche, Pierre Bisquert, Madalina Croitoru, Rallou Thomopoulos.

NoAW (No Agricultural Waste) is led by INRA-IATE. Driven by a "near zero-waste" society requirement, the goal of NoAW project is to generate innovative efficient approaches to convert growing agricultural waste issues into eco-efficient bio-based products opportunities with direct benefits for both environment, economy and EU consumer. To achieve this goal, the NoAW concept relies on developing holistic life cycle thinking able to support environmentally responsible R&D innovations on agro-waste conversion at different TRLs, in the light of regional and seasonal specificities, not forgetting risks emerging from circular management of agro-wastes (e.g. contaminants accumulation). GraphIK contributes on two aspects. On the one hand we participate in the annotation effort of knowledge bases (using the @Web tool). On the other hand we further investigate the interplay of argumentation with logically instantiated frameworks and its relation with social choice in the context of decision making.

http://cordis.europa.eu/project/rcn/203384_en.html

8.2.1.2. GLOPACK (H2020, June. 2018- July. 2022)

Participants: Patrice Buche, Pierre Bisquert, Madalina Croitoru.

GLOPACK is also led by INRA-IATE. It proposes a cutting-edge strategy addressing the technical and societal barriers to spread in our social system, innovative eco-efficient packaging able to reduce food environmental footprint. Focusing on accelerating the transition to a circular economy concept, GLOPACK aims to support users and consumers' access to innovative packaging solutions enabling the reduction and circular management of agro-food, including packaging, wastes. Validation of the solutions including compliance with legal requirements, economic feasibility and environmental impact will push forward the technologies tested and the related decision-making tool to TRL 7 for a rapid and easy market uptake contributing therefore to strengthen European companies' competitiveness in an always more globalised and connected world.
https://glopack2020.eu/

8.2.2. Collaborations in European Programs, Except FP7 & H2020

8.2.2.1. FoodMC (European COST action, 2016-2020)

Participants: Patrice Buche, Madalina Croitoru, Rallou Thomopoulos.

COST actions aim to develop European cooperation in science and technology. FoodMC (CA 15118) is a cost action on Mathematical and Computer Science Methods for Food Science and Industry. Rallou Thomopoulos is co-leader of this action for France, and member of the action Management Committee, and other members of GraphIK (Patrice Buche, Madalina Croitoru) are participants. The action is organised in four working groups, dealing respectively with the modelling of food products and food processes, modelling for eco-design of food processes, software tools for the food industry, and dissemination and knowledge transfer. http://www6.inra.fr/foodmc

8.3. International Research Visitors

8.3.1. Visits of International Scientists

Carlos Saez, postdoctoral researcher at the Biomedical Data Science Lab of the ITACA Institute of the Universitat Politècnica de València (UPV, Spain) stayed one week (from 10/12/2019 to 14/12/2019) to work on data quality issues for machine learning techniques and how OBDA and argumentation could help improve the quality of data.

8.3.2. Visits to International Teams

8.3.2.1. Research Stays Abroad

Madalina Croitoru obtained a SICSA Distinguished Visitor Program Funding and stayed at the University of Aberdeen from the 1st of April 2019 to the 31st of May 2019. She worked with Professor Nir Oren on ethical decision making in a multi-agent setting.

HEPHAISTOS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

- the project **Craft** on collaborative cable-driven parallel robot has been funded by ANR. It involves LS2N (Nantes) and the Cetim. This project will start in 2019

8.1.1. FHU

- the team has been involved for the FHU *INOVPAIN : Innovative Solutions in Refractory Chronic Pain* that has been labeled in December 2016

8.2. International Initiatives

8.2.1. Inria International Partners

8.2.1.1. Informal International Partners

We have numerous international collaborations but we mention here only the one with activities that go beyond joint theoretical or experimental works:

- University of Bologna, Italy: 2 joint PhD student, publications
- University Innsbruck, Austria: joint conference organization
- Fraunhofer IPA, Stuttgar, Germany: joint conference organization
- Duisburg-Essen University, Germany: joint conference organization
- University of New-Brunswick, Canada: 1 joint PhD student
- University Laval, Québeç Canada: joint book
- University of Tokyo, Japan: joint conference organization
- Tianjin University, China: joint book

8.3. International Research Visitors

8.3.1. Visits of International Scientists

- W. Godoy, Pr. Univ Sao Paolo, from Dec 2019
- M. Tome, PhD student, Univ Sao Paolo, from Dec 2019
- I.D. Weber, Master student, Univ Sao Paolo, from Dec 2019
- M. Tuda, PhD student, Univ Sao Paolo, from Jun 2019 until July 2019
- H. Lins Vieira, PhD student, Univ Sao Paolo, from January until Aug 2019

8.4. Transfert

- J-P. Merlet is scientific advisor of the startup *Farmboy Labs* that is currently being created by our former PhD student L. Blanchet. The purpose of this startup is to propose cable-driven parallel robots for agriculture (monitoring, maintenance, weeding, ...). .

HYBRID Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Labex Cominlabs SUNSET

Participants: Bruno Arnaldi, Valérie Gouranton [contact], Alexandre Audinot, Adrien Reuzeau.

SUNSET is a 4-year Labex Cominlabs project (2016-2020). SUNSET partners are MediCIS-LTSI (coordinator), Hybrid, Hycomes (IRISA/Inria), and CHU Rennes. SUNSET aims at developing an innovative training software suite based on immersive and collaborative virtual reality technology for training and evaluating non-technical skills. This approach will be implemented and evaluated in the context of training neurosurgical scrub nurses. We will notably integrate methods and systems developed in the S3PM project (see bellow). By relying on Human Factors approaches, the project also addresses training and evaluation of interpersonal skills. Whereas the developed technologies and approaches will be generic and adaptable to any surgical specialty, the project will evaluate the developed system within training sessions performed with scrub nurses. We ambition to propose novel approaches for surgical non-technical skill learning and assessment, and to install the developed training factory at the University Hospital of Rennes, and evaluate it with real-scale user studies.

9.1.2. Labex Cominlabs RobotX

Participants: Bruno Arnaldi, Valérie Gouranton [contact], Alexandre Audinot.

RobotX (ROBOT for Intelligent Collaborative Surgery) is a one year Labex Cominlabs project (2019). The partners are MediCIS team from LTSI (INSERM and University of Rennes 1), Hybrid, Rainbow and Hycomes teams from IRISA and Inria Rennes, LP3C Lab - University Rennes 2, REV, ROMAS and PACCE teams from LS2N - Nantes, CHU Rennes, CHU Nantes, ICO (Institut de Cancerologie de l'Ouest). The objective of this exploratory action RobotX was to explore this issue and study initial feasibility of some methodological solutions. The long-term is to develop a new generation of intelligent and collaborative safe surgical robots.

Our contribution in the project was to study the development of Virtual Reality based simulated environments for surgical robotic systems for helping designing, evaluation and training of such systems. The objective was also to evaluate simulations of both technical and non technical. We developed a prototype of the Da Vinci robot with an haptic interface and different simulated tasks. We second studied the relevance of the software environments (#5 and #7) developed in previous projects (S3PM and SUNSET). We set up interactions by adding #5 semantics, which allow the robot arm to pick up objects. We also implemented a "Pick and place" exercise. A #7 scenario has been added to manage the user's actions and know when the exercise is over (Fig. 20).

9.1.3. Labex Cominlabs HEMISFER

Participants: Mathis Fleury, Anatole Lécuyer [contact], Giulia Lioi.

HEMISFER is a 6-year project (2013-2019) funded by Labex CominLabs. It involves 4 Inria/IRISA teams (Hybrid, Visages (lead), Panama, Athena) and 2 medical centers: the Rennes Psychiatric Hospital (CHGR) and the Reeducation Department of Rennes Hospital (CHU Pontchaillou). The goal of HEMISFER is to make full use of neurofeedback paradigm in the context of rehabilitation and psychiatric disorders. The major breakthrough will come from the use of a coupling model associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to "enhance" the neurofeedback protocol. Clinical applications concern motor, neurological and psychiatric disorders (stroke, attention-deficit disorder, treatment-resistant mood disorders, etc).

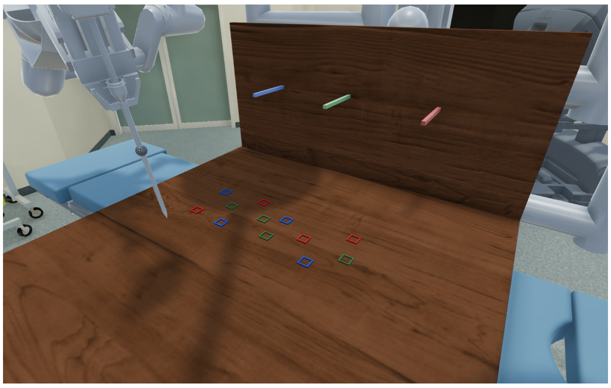

Figure 20. Pick and place exercise using #5 and #7 software

9.1.4. IRT b<>com

Participants: Ferran Argelaguet, Bruno Arnaldi [contact], Valérie Gouranton, Anatole Lécuyer, Maud Marchal, Florian Nouviale.

b<>com is a French Institute of Research and Technology (IRT). The main goal of this IRT is to fasten the development and marketing of tools, products and services in the field of digital technologies. Our team has been regularly involved in collaborations with b<>com within various 3-year projects, such as ImData (on Immersive Interaction) and GestChir (on Augmented Healthcare) which both ended in 2016. Follow-up projects called NeedleWare (on Augmented Healthcare) and VUXIA (on Human Factors) have started respectively in 2016 and 2018.

9.1.5. CNPAO Project

Participants: Valérie Gouranton [contact], Ronan Gaugne.

CNPAO ("Conservatoire Numérique du Patrimoine Archéologique de l'Ouest") is an on-going research project partially funded by the Université Européenne de Bretagne (UEB) and Université de Rennes 1. It involves IRISA/Hybrid and CReAAH. The main objectives are: (i) a sustainable and centralized archiving of 2D/3D data produced by the archaeological community, (ii) a free access to metadata, (iii) a secure access to data for the different actors involved in scientific projects, and (iv) the support and advice for these actors in the 3D data production and exploration through the latest digital technologies, modeling tools and virtual reality systems. This project involves a collaboration with Quentin Petit (SED Inria Rennes).

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. ANR LOBBY-BOT

Participants: Anatole Lécuyer [contact], Maud Marchal, Victor Mercado.

LOBBY-BOT is a 4-year project (2017-2021) funded by the French National Research Agency (ANR). The objective of LOBBY-BOT is to address the scientific challenges of encountered-type haptic devices (ETHD), which are an alternative category of haptic devices relying on a mobile physical prop, usually actuated by a robot, that constantly follows the user hand, and encounter it only when needed. The project follows two research axes: a first one dealing with robot control, and the second one dealing with interaction techniques adapted to ETHD. The involvement of Hybrid relates to the second research axis of the project. The final project prototype will be used to assess the benefits of ETHD when used in an industrial use-case : the perceived quality in an automotive interior.

9.2.2. Inria projects

9.2.2.1. IPL BCI-LIFT

Participants: Anatole Lécuyer [contact], Hakim Si Mohammed.

BCI-LIFT is a 4-year "Inria Project Lab" initiative (2015-2019) funded by Inria for supporting a national research effort on Brain-Computer Interfaces. This joint lab involves several Inria teams: Hybrid, Potioc, Athena, Neurosys, Loki, Demar; as well as external partners: INSERM-Lyon, and INSA Rouen. This project aims at improving several aspects of Brain-Computer Interfaces: learning and adaptation of BCI systems, user interfaces and feedback, training protocols, etc.

9.2.2.2. IPL AVATAR

Participants: Anatole Lécuyer [contact], Ferran Argelaguet, Diane Dewez, Rebecca Fribourg.

AVATAR is a 4-year "Inria Project Lab" initiative (2018-2022) funded by Inria for supporting a national research effort on Avatars and Virtual Embodiment. This joint lab involves several Inria teams: Hybrid, Potioc, Loki, Mimetic, Graphdeco, Morpheo; as well as external partners: Univ. Bacelona, Faurecia and Technicolor companies. This project aims at improving several aspects of Avatars in immersive applications: reconstruction, animation, rendering, interaction, multi-sensory feedback, etc.

9.2.2.3. IPL NAVISCOPE

Participants: Ferran Argelaguet [contact], Gwendal Fouché.

NAVISCOPE is a 4-year "Inria Project Lab" initiative (2018-2022) funded by Inria for supporting a national research effort on image-guided navigation and visualization of large data sets in live cell imaging and microscopy. This joint lab involves several Inria teams: Serpico, Aviz, Beagle, Hybrid, Mosaic, Parietal, Morpheme; as well as external partners: INRA and Institute Curie. This project aims at improving visualization and machine learning methods in order to provide systems capable to assist the scientist to obtain a better understanding of massive amounts of information.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. IMAGINE

Participants: Maud Marchal [contact], Thierry Gaugry, Romain Lagneau, Antonin Bernardin.

Title: IMAGINE - Robots Understanding Their Actions by Imagining Their Effects

Programm: H2020

Duration: January 2017 - December 2020

Coordinator: Univ. Innsbruck (Austria)

Partners:

- Univ. Innsbruck (Austria)
- Univ. Göttingen (Germany)
- Karlsruhe Institute of Technology (Germany)
- INSA Rennes (France)
- Institute of Robotics and Industrial Informatics (Spain)
- Univ. Bogazici (Turkey)
- Electro Cycling (Germany)

Inria contact: Maud Marchal

Abstract: Today's robots are good at executing programmed motions, but they do not understand their actions in the sense that they could automatically generalize them to novel situations or recover from failures. IMAGINE seeks to enable robots to understand the structure of their environment and how it is affected by its actions. "Understanding" here means the ability of the robot (a) to determine the applicability of an action along with parameters to achieve the desired effect, and (b) to discern to what extent an action succeeded, and to infer possible causes of failure and generate recovery actions. The core functional element is a generative model based on an association engine and a physics simulator. "Understanding" is given by the robot's ability to predict the effects of its actions, before and during their execution. This allows the robot to choose actions and parameters based on their simulated performance, and to monitor their progress by comparing observed to simulated behavior. This scientific objective is pursued in the context of recycling of electromechanical appliances. Current recycling practices do not automate disassembly, which exposes humans to hazardous materials, encourages illegal disposal, and creates significant threats to environment and health, often in third countries. IMAGINE will develop a TRL-5 prototype that can autonomously disassemble prototypical classes of devices, generate and execute disassembly actions for unseen instances of similar devices, and recover from certain failures. For robotic disassembly, IMAGINE will develop a multi-functional gripper capable of multiple types of manipulation without tool changes. IMAGINE raises the ability level of robotic systems in core areas of the work programme, including adaptability, manipulation, perception, decisional autonomy, and cognitive ability. Since only one-third of EU e-waste is currently recovered, IMAGINE addresses an area of high economical and ecological impact.

9.3.1.2. H-REALITY

Participants: Anatole Lécuyer, Maud Marchal [contact], Thomas Howard, Gerard Gallagher.

Title: H-REALITY

Programm: H2020 - Fet Open

Duration: 2018 - 2021

Coordinator: Univ. Birmingham (UK)

Partners:

Univ. Birmingham (UK)

CNRS (France),

TU Delft (Netherlands),

ACTRONIKA (France),

ULTRAHAPTICS (UK)

Inria contact: Maud Marchal

Abstract: The vision of H-REALITY is to be the first to imbue virtual objects with a physical presence, providing a revolutionary, untethered, virtual-haptic reality: H-Reality. This ambition will be achieved by integrating the commercial pioneers of ultrasonic "non-contact" haptics, state-of-the-art vibrotactile actuators, novel mathematical and tribological modelling of the skin and mechanics of touch, and experts in the psychophysical rendering of sensation. The result will be a sensory experience where digital 3D shapes and textures are made manifest in real space via modulated, focused, ultrasound, ready for the unteathered hand to feel, where next-generation wearable haptic rings provide directional vibrotactile stimulation, informing users of an object's dynamics, and where computational renderings of specific materials can be distinguished via their surface properties. The implications of this technology will transform online interactions; dangerous machinery will be operated virtually from the safety of the home, and surgeons will hone their skills on thin air.

9.3.1.3. TACTILITY

Participants: Ferran Argelaguet [contact], Anatole Lécuyer, Maud Marchal, Sebastian Vizcay.

Title: Tactility

Programm: H2020 - ICT 25

Duration: July 2019 - June 2022

Coordinator: Fundación Tecnalia Research and Innovation (Spain)

Partners:

Aalborg University (Netherlands)

Universita Degli Studi di Genova (Itali),

Tecnalia Servia (Servia),

Universitat de Valencia (Spain),

Manus Machinae B.V. (Netherlands),

Smartex S.R.L (Italy),

Immersion (France)

Inria contact: Ferran Argelaguet

Abstract: TACTILITY is a multidisciplinary innovation and research action with the overall aim of including rich and meaningful tactile information into the novel interaction systems through technology for closed-loop tactile interaction with virtual environments. By mimicking the characteristics of the natural tactile feedback, it will substantially increase the quality of immersive VR experience used locally or remotely (tele-manipulation). The approach is based on transcutaneous electro-tactile stimulation delivered through electrical pulses with high resolution spatio-temporal distribution. To achieve it, significant development of technologies for transcutaneous stimulation, textile-based multi-pad electrodes and tactile sensation electronic skin, coupled with ground-breaking research of perception of elicited tactile sensations in VR, is needed. The key novelty is in the combination of: 1) the ground-breaking research of perception of electrotactile stimuli for the identification of the stimulation parameters and methods that evoke natural like tactile sensations, 2) the advanced hardware, that will integrate the novel high-resolution electrotactile stimulation system and state of the art artificial electronic skin patches with smart textile technologies and VR control devices in a wearable mobile system, and 3) the novel firmware, that handles real-time encoding and transmission of tactile information from virtual objects in VR, as well as from the distant tactile sensors (artificial skins) placed on robotic or human hands. Proposed research and innovation action would result in a next generation of interactive systems with higher quality experience for both local and remote (e.g., tele-manipulation) applications. Ultimately, TACTILITY will enable high fidelity experience through low-cost, user friendly, wearable and mobile technology.

9.3.1.4. Interreg ADAPT

Participants: Valérie Gouranton [contact], Bruno Arnaldi, Ronan Gaugne, Florian Nouviale, Yoren Gaffary, Alexandre Audinot.

Program: Interreg VA France (Channel) England

Project acronym: ADAPT

Project title:Assistive Devices for empowering disAbled People through robotic Technologies

Duration: 01/2017 - 06/2021

Coordinator: ESIGELEC/IRSEEM Rouen

Other partners: INSA Rennes - IRISA, LGCGM, IETR (France), Université de Picardie Jules Verne - MIS (France), Pôle Saint Hélier (France), CHU Rouen (France), Réseau Breizh PC (France), Ergovie (France), Pôle TES (France), University College of London - Aspire CREATE (UK), University of Kent (UK), East Kent Hospitals Univ NHS Found. Trust (UK), Health and Europe Centre (UK), Plymouth Hospitals NHS Trust (UK), Canterbury Christ Church University (UK), Kent Surrey Sussex Academic Health Science Network (UK), Cornwall Mobility Center (UK).

Inria contact: Valérie Gouranton

Abstract: The ADAPT project aims to develop innovative assistive technologies in order to support the autonomy and to enhance the mobility of power wheelchair users with severe physical/cognitive disabilities. In particular, the objective is to design and evaluate a power wheelchair simulator as well as to design a multi-layer driving assistance system.

Collaboration with Rainbow team.

9.4. International Initiatives

9.4.1. Informal International Partners

- Dr. Takuji Narumi and Prof. Michitaka Hirose from University of Tokyo (Japan), on "Virtual Embodiment"
- Dr. Hannes Kaufmann from Technical University Wien (Austria), on "3D Navigation in Virtual Environments"
- Prof. Reinhold Scherer from Graz University (Austria), on "Brain-Computer Interfaces and Augmented Reality"
- Prof. Jose Millan from Ecole Polytechnique Fédérale de Lausanne (Switzerland), on "Brain-Computer Interfaces and Sports"
- Dr. Mai Otsuki from AIST (Japan) on "Mixed Reality for Cultural Heritage"
- Dr. Karina Rodriguez Echavarria from University of Brighton (UK) on "Mixed Reality for Cultural Heritage"
- Prof. Franz Fischnaller from Albertina Academia of Fine Art of Torino (Italy) on "Immersive Art"
- Dr. Yuta Itoh from Tokyo Institute of Technology (Japan) on "Perception in Augmented Reality"

9.4.2. Participation in Other International Programs

9.4.2.1. ANR-FRQSC INTROSPECT

Participants: Valérie Gouranton [contact], Bruno Arnaldi, Ronan Gaugne, Flavien Lécuyer, Adrien Reuzeau.

INTROSPECT is a 3-year project funded by French ANR and "Fonds de Recherche Société et Culture" (FRQSC) from Quebec region, Canada. This international collaboration involves researchers in computer science and archeology from France and Canada : Hybrid (Inria-IRISA), CReAAH, Inrap, company Image ET, University Laval and INRS-ETE. INTROSPECT aims to develop new uses and tools for archaeologists that facilitate access to knowledge through interactive numerical introspection methods that combine computed tomography with 3D visualization technologies, such as Virtual Reality, tangible interactions and 3D printing. The scientific core of the project is the systematization of the relationship between the artefact, the archaeological context, the digital object and the virtual reconstruction of the archaeological context that represents it and its tangible double resulting from the 3D printing. This axiomatization of its innovative methods makes it possible to enhance our research on our heritage and to make use of accessible digital means of dissemination. This approach changes from traditional methods and applies to specific archaeological problems. Several case studies will be studied in various archaeological contexts on both sides of the Atlantic. Quebec museums are also partners in the project to spread the results among the general public.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Visit from Yutaro Hirao, Master Student at University of Tokyo (topic: “Virtual Embodiment”). Feb. 2019.
- Visit from Felix Putze, Researcher at University of Bremen (topic: “BCI and AR”). Feb. 2019.

- Visit from Franz Fischnaller, Professor at Academia of Fine Arts Albertina, Torino, Italy (topic: "Cultural Heritage"). From Jun. until Jul. 2019
- Visit from Marie-Anne Paradis, Master Student at University Laval, Québec, Canada (topic: "Cultural Heritage"). From Sept. 2018 until Mar. 2019.
- Visit from Nadia Zenati, Researcher at CDTA, Algeria (topic: "VR and AR"). Oct. 2019

9.5.2. Visits to International Teams

- Jean-Marie Normand spent 2 weeks (1 week in July 2019 and 1 week in September 2019) in the Augmented Vision Laboratory, Tokyo Institute of Technology, Tokyo, Japan.
- Valérie Gouranton and Ronan Gaugne spent 2 weeks, in May 2019, in the Eau-Terre-Environment laboratory of INRS, Québec, Canada where they presented INTROSPECT results in the GMPCA conference organized by the University of Montreal, and in the days of the Canadian Association of Archaeology, organized by the University Laval of Québec.

9.5.2.1. Research Stays Abroad

- Etienne Peillard spent 4 months (from June to October 2019) in the Augmented Vision Laboratory, Tokyo Institute of Technology, Tokyo, Japan.
- Flavien Lécuyer spent 3 months (From May to August 2019) in Vision and Numeric Systems Laboratory (LVSN), Québec, Canada.

ILDA Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Inria Project Lab (IPL)

ILDA participates to Inria Project Lab iCODA : Data Journalism : knowledge-mediated Content and Data Interactive Analytics, that started in 2017. A key issue in data science is the design of algorithms that enable analysts to infer information and knowledge by exploring heterogeneous information sources, structured data, or unstructured content. With journalism data as a landmark use-case, iCODA aims to develop the scientific and technological foundation for collaborative, heterogeneous data analysis, guided by formalized, user-centric knowledge. The project relies on realistic scenarios in data-journalism to assess the contribution of the project to this area. iCODA is at the crossroads of several research areas (content analysis, data management, knowledge representation, visualization) and is part of a club of partners of the world of the press. Equipes-projets Inria : Graphik, Ilda, Linkmedia, Cedar. Press partners: Le Monde, OuestFrance, AFP. Participants: Anastasia Bezerianos (PI), Emmanuel Pietriga, Tong Xue, Vanessa Peña-Araya, Nicole Barbosa Sultanum.

9.2. European Initiatives

9.2.1. Collaborations with Major European Organizations

Deutsches Elektronen-Synchrotron (DESY): Scientific collaboration on the design and implementation of user interfaces for array operations monitoring and control for the Cherenkov Telescope Array (CTA) project, to be built in the Canary Islands (Spain) and in the Atacama desert (Chile), 2 years, contract started May 2018.

9.3. International Initiatives

9.3.1. Inria International Labs

Inria Chile. From 2012 to 2015, Emmanuel Pietriga was the scientific leader of the Massive Data team at Inria Chile, working on projects in collaboration with the ALMA radio-telescope and the Millenium Institute of Astrophysics. He is now scientific advisor to Inria Chile's visualization projects, and is actively involved in the collaboration between Inria Chile and the LSST on the design and development of user interfaces for operations monitoring and control.

9.3.2. Inria International Partners

Association of Universities for Research in Astronomy (AURA): contract, jointly with Inria Chile, on the design and implementation of user interfaces for telescope operations monitoring and control for the Large Synoptic Survey Telescope (LSST) project, under construction in the Atacama desert (Chile), started 2017. Participants: Emmanuel Pietriga (ILDA), Sebastian Fehlandt (Inria Chile), José Galaz (Inria Chile), Sebastian Pereira (Inria Chile), Grazia Prato (Inria Chile).

9.3.2.1. Informal International Partners

We have had multiple collaboration projects with Microsoft Research in Redmond, USA. Hugo Romat visited the EPIC team for three months, and this collaboration led to the following publications at CHI 2018 [75], CHI 2019 [22] and UIST 2019 [9]. Anastasia Bezerianos also continues working with that team on topics related to smartwatch interaction and visualization that appeared in TVCG 2019 (InfoVis 2018) [11].

Our long-term collaboration with University of Konstanz, Germany continues. After publications at TVCG/InfoVis in 2014 and 2018 [46], [47], Anastasia Bezerianos has co-authored a paper at Eurographics 2019 with these colleagues [18].

Finally, our ongoing collaboration with Northwestern University, USA continues. Anastasia Bezerianos and past PhD student Evanthia Dimara (PhD defended in 2017) have worked on publications in TVCG 2019 [12] [42].

IMAGINE Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Performance Lab (January 2018 - June 2021)

Participants: Rémi Ronfard, Qianqian Fu, Mélina Skouras, Maxime Garcia, Pierre Casati, Vaishnavi Ameya Murukutla, Rémi Colin de Verdière.

Performance Lab is a cross-disciplinary project (CDP) by IDEX Univ. Grenoble Alpes, started in January 2018, which is funding the Phd thesis of Qianqian Fu.

Conceived as an international platform, the Performance Lab brings together a community of researchers who are exploring contemporary issues that link embodiment, society and technology. The ambition of the project is to renew the ways in which research is conceived and practiced at Univ. Grenoble Alpes by developing new methods inspired by Anglo-Saxon notions of Performance as Research (PAR), research creation, practice-led and based research.

As part of the Performance Lab, IMAGINE is actively involved in the research group on "digital dramaturgies" co-led by Remi Ronfard and Julie Valero.

9.2. National Initiatives

9.2.1. InriaHub ADT Kino Ai (October 2018-September 2020)

Participants: Rémi Ronfard, Rémi Colin de Verdière, Qianqian Fu.

This two-year contract is a follow up to the one-year InriaHub ULTRAHD project which was successfully completed in December 2017. Kino Ai is a joint research project of the IMAGINE team at Inria Grenoble Alpes, and the Performance Lab at Univ. Grenoble Alpes. Following our previous work in “multiclip video editing” and “Split Screen Video Generation”, we are working to provide a user-friendly environment for editing and watching ultra-high definition movies online, with an emphasis on recordings of live performances.

The code from Vineet Gandhi’s PhD thesis was entirely re-designed for supporting ultra high definition video. The software was extensively tested in 2017 on a large dataset of 4K video recordings of theatre rehearsals, in collaboration with the Litt&Arts team at Univ. Grenoble Alpes, theatre director Jean-Francois Peyret in Paris, Theatre de l’Hexagone in Meylan and Theatre de Vidy in Lausanne. The goal of the Kino AI ADT is to allow the Kino Ai python code to run in a web server, and to provide a redesigned user interface (in javascript) running on a web client. The user interface was also designed, tested and evaluated with the Litt&Arts team at Univ. Grenoble Alpes, as part of CDP project Performance Lab.

9.2.2. FUI Collodi 2 (December 2016 - April 2019)

Participants: Rémi Ronfard, Maguelonne Beaud de Brive, Julien Daval.

This 2-year contract with two industrial partners: TeamTo and Mercenaries Engineering (software for production rendering), was a follow-up and a generalization of Dynam’it and Collodi 1. The goal was to propose an integrated software for the animation and final rendering of high-quality movies, as an alternative to the ever-ageing Maya. The project was funding 2 engineers for 2 years.

The project was extended for four additional months from January to April 2019 to allow extended expert evaluation of our sketch-based animation toolkit. Three short animations were created for this purpose by a professional animator from film examples of dancers (Gene Kelly in "Singing in the rain", Fred Astaire and Cyd Charisse in "The band wagon"). Those examples demonstrate that sketch-based animation can be used to create complex character animation even in very challenging situations. Those results were presented during the two final reviews of the COLLODI2 project in Valence and Paris in December 2019 and published as a research report.

9.2.3. FUI 3D-Oncochip (October 2018 - September 2021)

Participants: Jean-Claude Léon, Musaab Khalid Osman Mohammed.

3D-Oncochip project is a collaboration with Microlight 3D, with the objective of fabricating nanoscale 3D microtumors, which are human biological models of real tumors. This 3-year contract is funding the postdoc position of Musaab Khalid Osman Mohammed.

9.2.4. ANR E-ROMA (November 2017 - October 2020)

Participants: Rémi Ronfard, Stefanie Hahmann, Pierre Casati.

The eRoma project aims at revisiting the digitization and virtual restoration of archaeological and fine arts artefacts by taking advantage of the sites from which they were retrieved and the eras they belong to. To do so, e-Roma will develop a new virtual representation both versatile and unified enough to be used for both restoration and animation of digitized artworks. Traditional cardboard models with a fixed and rigid representation will therefore be replaced by interactive dynamic virtual prototypes, to help restore statues and illustrate changes over time.

This 3-year contract is a joint project with GeoMod team at LIRIS and the musée gallo-romain in Lyon. The contract started in November 2017 and is funding the PhD thesis of Pierre Casati.

9.2.5. ANR FOLD-DYN (November 2017 - October 2020)

Participant: Thomas Buffet.

The FOLDDyn project (Field-Oriented Layered Dynamics animating 3D characters) proposes the study of new theoretical approaches for the effective generation of virtual characters deformations, when they are animated. These deformations are twofolds: character skin deformations (skinning) and garment simulations. We propose to explore the possibilities offered by a novel theoretical way of addressing character deformations: the implicit skinning. This method jointly uses meshes (the standard representation for 3D animations) and volumetric scalar functions (an unusual representation in this community).

This 3-year contract is a joint project with the University of Toulouse.The contract started in November 2017 and is funding the PhD thesis of Thomas Buffet.

9.2.6. ANR ANATOMY2020 (November 2017 - October 2020)

Participants: Olivier Palombi, Rémi Ronfard, Vaishnavi Ameya Murukutla.

Anatomy2020 aims at developing an innovative educational platform to facilitate learning of functional anatomy. This platform will integrate recent advances in computer graphics, human-computer interaction together with recent insights in educational and cognitive sciences to design and test optimal scenarios for anatomy learning. The approach is based on evidences that body movements could improve learning of different knowledge by "augmenting" or "enriching" traces in long-term memory. This "embodied" perspective is particularly relevant for learning of functional anatomy as the knowledge to acquire could be specifically related to the learner's body in motion.

This 3-year contract is a joint project with TIMC (Computer-Assisted Medical Intervention team), Anatoscope, Gipsa-Lab (speech and cognition dept.), LIBM and LIG (Engineering Human-Computer Interaction team). The contract started in November 2017 and is funding the PhD thesis of Ameya Murukutla.

LACODAM Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

- **HyAIAI: Hybrid Approaches for Interpretable AI**
  Participants: E. Fromont (leader), A. Termier, L. Galárraga
  The Inria Project Lab HyAIAI is a consortium of Inria teams (Sequel, Magnet, Tau, Orpailleur, Multispeech, and LACODAM) that work together towards the development of novel methods for machine learning, that combine numerical and symbolic approaches. The goal is to develop new machine learning algorithms such that (i) they are as efficient as current best approaches, (ii) they can be guided by means of human-understandable constraints, and (iii) its decisions can be better understood.
- **Hyptser: Hybrid Prediction of Time Series**
  Participants: T. Guyet, S. Malinowski (LinkMedia), V. Lemaire (Orange)
  HYPTSER is a collaborative project between Orange Labs and LACODAM funded by the Fondation Mathématique Jacques Hadamard (PGMO program). It aims at developping new hybrid time series prediction methods in order to improve capacity planning for server farms. Capacity planning is the process of determining the infrastructure needed to meet future customer demands for online services. A well-made capacity planning helps to reduce operational costs, and improves the quality of the provided services. Capacity planning requires accurate forecasts of the differences between the customer demands and the infrastructure theoretical capabilities. The HYPTSER project makes the assumption that this information is captured by key performance indicators (KPI), that are measured continuously in the service infrastructure. Thus, we expect to improve capacity planning capabilities by making accurate forecasts of KPI time series. Recent methods about time series forecasting make use of ensemble models. In this project, we are interested in developing hybrid models for time series forecasting. Hybrid models aim at jointly partitioning the data, learning forecasting models in each partition and learning how to combine their outputs. We are currently developing two different approaches for that purpose, one based on the MODL framework and the other based on neural networks. We describe these approaches below:
  - MODL is a mathematical framework that turns the learning task into a model selection problem. It aims at finding the most probable model given the data. The MODL approach has been applied on numerous learning tasks. In all cases, this approach leads to a regularized optimization criterion. We formalize a new MODL criterion able to learn hybrid models on time series in order to: i) make a partition of time series; ii) learn local regression models. This approach formalizes these two steps in a unified way.
  - We are also developing an hybrid neural network structure that is able to learn automatically a soft partitioning of the data together with local models on each partition.

  In the next steps of this project, we will analyze the performance of this two strategies on KPI time series provided by Orange and compare them to classical ensemble methods.
- **#DigitAg: Digital Agriculture**
  Participants: A. Termier, V. Masson, C. Largouët, A.I. Graux
  #DigitAg is a “Convergence Institute” dedicated to the increasing importance of digital techniques in agriculture. Its goal is twofold: First, make innovative research on the use of digital techniques in agriculture in order to improve competitiveness, preserve the environment, and offer correct living conditions to farmers. Second, prepare future farmers and agricultural policy makers to successfully exploit such technologies. While #DigitAg is based on Montpellier, Rennes is a satellite of the institute focused on cattle farming.

LACODAM is involved in the “data mining” challenge of the institute, which A. Termier co-leads. He is also the representative of Inria in the steering comittee of the institute. The interest for the team is to design novel methods to analyze and represent agricultural data, which are challenging because they are both heterogeneous and multi-scale (both spatial and temporal).

9.1.1. ANR

- **FAbLe: Framework for Automatic Interpretability in Machine Learning**
  Participants: L. Galárraga (holder), C. Largouët
  How can we fully automatically choose the best explanation for a given use case in classification?. Answering this question is the raison d’être of the JCJC ANR project FAbLe. By “best explanation” we mean the explanation that yields the best trade-off between interpretability and fidelity among a universe of possible explanations. While fidelity is well-defined as the accuracy of the explanation w.r.t the answers of the black-box, interpretability is a subjective concept that has not been formalized yet. Hence, in order to answer our prime question we first need to answer the question: “How can we formalize and quantify interpretability across models?”. Much like research in automatic machine learning has delegated the task of accurate model selection to computers [26], FAbLe aims at fully delegating the selection of interpretable explanations to computers. Our goal is to produce a suite of algorithms that will compute suitable explanations for ML algorithms based on our insights of what is interpretable. The algorithms will choose the best explanation method based on the data, the use case, and the user’s background. We will implement our algorithms so that they are fully compatible with the body of available software for data science (e.g., Scikit-learn).

9.1.2. National Platforms

- **PEPS: Pharmaco-epidemiology for Health Products**
  Participants: J. Bakalara, Y. Dauxais, T. Guyet, V. Masson, R. Quinou, A. Samet
  The PEPS project (Pharmaco-epidemiology des Produits de Santé) is funded by the ANSM (National Agency for Health Security). The project leader is E. Oger from the clinical investigation center CIC-1414 INSERM/CHU Rennes. The other partners located in Rennes are the Institute of Research and Technology (IRT), B<>Com, EHESP and the LTSI. The project started in January 2015 and is funded for 4 years. The PEPS project consists of two parts: a set of clinical studies and a research program dedicated to the development of innovative tools for pharmaco-epidemiological studies with medico-administrative databases. Our contribution to this project will be to propose pattern mining algorithms and reasoning techniques to analyse the typical care pathways of specific groups of insured patients. Since last year we have been working on the design and development of algorithms [25], [24] to mine patterns on care pathways.

9.2. International Research Visitors

9.2.1. Internships

From September to December 2019 we hosted Vaishnavi Bhargava, a computer science student from the Birla Institute of Technology and Science in Pilani, who worked on “Automatic Neighborhood Design for Localized Model-interpretation”. Her work aimed at finding a set of metrics and procedures to determine the best parameterization of the method LIME for local post-hoc interpretability of machine learning models. The goal of this effort is to inform users of the parameter values (if any) for which a LIME explanation should be trusted because it can faithfully reproduce the behavior of the black-box it tries to explain.

LARSEN Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. LUE C-Shift

Program: LUE Impact (Lorraine Université d'Excellence)

Project acronym: C-Shift

Project title: Cobots in the Service of Human activity at work In consistence with the challenges of Industry of the FuTure

Duration: October 2019 - December 2022

Coordinator: Benoit Iung (University of Lorraine)

PI for Inria/Loria: Serena Ivaldi

Abstract:

Le projet IMPACT « C-SHIFT » (Cobots in the Service of Human activity at work In consistence with the challenges of Industry of the FuTure) labélisé LUE (Lorraine Université d'Excellence) en collaboration avec les laboratoires de recherches LORIA, CRAN, CEREFIGE, PErSEUS, DevAH, LGIPM et les centres d'expertise et ressources AIPL-SMART et Ergosim et qui vise à étudier l'impact de la mise en œuvre de dispositifs collaboratifs intelligents tels que les cobots dans le cadre des défis de l'industrie du futur.

9.1.2. LUE Acceptability

Program: LUE PhD program (Lorraine Université d'Excellence)

Project title: elderly-technology interaction: accessibility and acceptability of assistive technology at home

Partners : Inria-Loria and Psychology and neuroscience lab - EA7489 (2LPN)

participants : Jérome Dinet, François Charpillet, Eloïse Zehner

Duration: October 2018 - September 2021

Abstract:

This PhD program is funded by the LUE PhD program, which among other has the objective to strength cooperation with associated institutions or companies supporting one of the six socio-economic challenges, here "Ageing and Health" challenge. This Ph.D. thesis, is aiming:

- at identifying sustainable actions to promote seniors' quality of life, intended to investigate this kind of interaction in terms of accessibility and acceptability that senior citizen experience with technological devices autonomy at home;
- at understanding more of technology use by older people. We have insight in the actual situation on older people's use and acceptance of technology, but locally and segmented, and more descriptive than explanatory. Most attention goes to the role of technology in the home with a particular focus on the interaction between people and assistive robots.

9.1.3. Project Psyphine Hors les Murs

Title: Psyphine Hors les Murs

Program: PEPS blanc 2019 de l'INS2I

Duration: January 2017 - January 2019

Coordinator: LORIA UMR (UMR 7503)

LARSEN member: Amine Boumaza

Psyphine is an interdisciplinary and exploratory project that gathers philosophers, psychologists, ethnologist, and computer scientists. The long term goal of the project is to explore the idea of assignments of intelligence or intentionality. Assuming that our intersubjectivity and our natural tendency to anthropomorphize plays a central role in this process, the project members investigate the elements that drive humans to attribute intelligence to robotic devices. Some of the questions that we aim to answer are: is it possible to give the illusion of cognition and/or intelligence through a technical device? How elaborate must be the control algorithms or "behaviors" of such a device so as to fool the observer? How many degrees of freedom must it have?

Partner institutions: InterPsy (EA 4432), ATILF (UMR 7118), Archives Henri-Poincaré (UMR7117), Inria Bordeaux Sud-Ouest, Loria (UMR7503) and MSH Lorraine (USR3261).

9.2. National Initiatives

9.2.1. ANR : The Flying Co-Worker

Program: ANR

Project acronym: Flying Co-Worker

Project title: Flying Co-Worker

Duration: October 2019 - october 2023

Coordinator: Daniel Sidobre (Laas Toulouse)

PI for Inria: François Charpillet

Abstract: Bringing together the recent progresses in physical and decisional interaction between humans and robots with the control of aerial manipulators, this project addresses the flying coworker, an aerial manipulator robot that act as a teammate of a human worker to transport a long bar or to realise complex tasks. Safety and human-aware robot abilities are at the core of the proposed research to progressively build robots capable to do cooperative handling and to assist a worker by notably delivering objects directly in a safe, efficient, pertinent and acceptable manner. The methodologies developed for ground manipulators cannot be directly used for aerial manipulator systems because of the floating base, of a limited payload, and of strong actuation and energy constraints. From the perception and the interpretation of the human activity, the objective of the project is to build an aerial manipulator capable to plan and control human aware motions to achieve collaborative tasks.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. RESIBOTS

Title: Robots with animal-like resilience

Program: H2020

Type: ERC

Duration: May 2015 - April 2020

Coordinator: Inria

Inria contact: Jean Baptiste Mouret

Despite over 50 years of research in robotics, most existing robots are far from being as resilient as the simplest animals: they are fragile machines that easily stop functioning in difficult conditions. The goal of this proposal is to radically change this situation by providing the algorithmic foundations for low-cost robots that can autonomously recover from unforeseen damages in a few minutes. It is here contended that trial-and-error learning algorithms provide an alternate approach that does not require diagnostic, nor pre-defined contingency plans. In this project, we will develop and study a novel family of such learning algorithms that make it possible for autonomous robots to quickly discover compensatory behaviors.

9.3.1.2. ANDY

Title: Advancing Anticipatory Behaviors in Dyadic Human-Robot Collaboration

Programme: H2020

Type: ICT RIA (No. 731540)

Duration: January 2017 - December 2020

Coordinator: IIT

PI for Inria: Serena Ivaldi

Recent technological progress permits robots to actively and safely share a common workspace with humans. Europe currently leads the robotic market for safety-certified robots, by enabling robots to react to unintentional contacts. AnDy leverages these technologies and strengthens European leadership by endowing robots with the ability to control physical collaboration through intentional interaction.

To achieve this interaction, AnDy relies on three technological and scientific breakthroughs. First, AnDy will innovate the way of measuring human whole-body motions by developing the wearable AnDySuit, which tracks motions and records forces. Second, AnDy will develop the AnDyModel, which combines ergonomic models with cognitive predictive models of human dynamic behavior in collaborative tasks, which are learned from data acquired with the AnDySuit. Third, AnDy will propose the AnDyControl, an innovative technology for assisting humans through predictive physical control, based on AnDyModel.

By measuring and modeling human whole-body dynamics, AnDy provides robots with an entirely new level of awareness about human intentions and ergonomy. By incorporating this awareness online in the robot's controllers, AnDy paves the way for novel applications of physical human-robot collaboration in manufacturing, health-care, and assisted living.

AnDy will accelerate take-up and deployment in these domains by validating its progress in several realistic scenarios. In the first validation scenario, the robot is an industrial collaborative robot, which tailors its controllers to individual workers to improve ergonomy. In the second scenario, the robot is an assistive exoskeleton which optimizes human comfort by reducing physical stress. In the third validation scenario, the robot is a humanoid, which offers assistance to a human while maintaining the balance of both.

Partners: Italian Institute of Technology (IIT, Italy, coordinator), Josef Stefan Institute (JSI, Slovenia), DLR (Germany), IMK Automotive Gmbh (Germany), XSens (Netherlands), AnyBody Technologies (Denmark)

9.3.2. Collaborations in European Programs, Except FP7 & H2020

9.3.2.1. HEAP

- Program: CHIST-ERA
- Project acronym: HEAP
- Project title: HEAP: Human-Guided Learning and Benchmarking of Robotic Heap Sorting
- Duration: March 2019–Feb. 2022

- Coordinator: Gerhard Neumann (Univ. of Lincoln, UK)
- PI for Inria: Serena Ivaldi
- Other partners: Italian Insitute of Technology (Italy), Technische Universitat Wien (Austria), Idiap Research Institute (Switzerland), Inria
- This project will provide scientific advancements for benchmarking, object recognition, manipulation and human-robot interaction. We focus on sorting a complex, unstructured heap of unknown objects –resembling nuclear waste consisting of a set of broken deformed bodies– as an instance of an extremely complex manipulation task. The consortium aims at building an end-to-end benchmarking framework, which includes rigorous scientific methodology and experimental tools for application in realistic scenarios. Benchmark scenarios will be developed with off-the-shelf manipulators and grippers, allowing to create an affordable setup that can be easily reproduced both physically and in simulation. We will develop benchmark scenarios with varying complexities, i.e., grasping and pushing irregular objects, grasping selected objects from the heap, identifying all object instances and sorting the objects by placing them into corresponding bins. We will provide scanned CAD models of the objects that can be used for 3D printing in order to recreate our benchmark scenarios. Benchmarks with existing grasp planners and manipulation algorithms will be implemented as baseline controllers that are easily exchangeable using ROS. The ability of robots to fully autonomously handle dense clutters or a heap of unknown objects has been very limited due to challenges in scene understanding, grasping, and decision making. Instead, we will rely on semi-autonomous approaches where a human operator can interact with the system (e.g. using tele-operation but not only) and giving high-level commands to complement the autonomous skill execution. The amount of autonomy of our system will be adapted to the complexity of the situation. We will also benchmark our semi-autonomous task execution with different human operators and quantify the gap to the current SOTA in autonomous manipulation. Building on our semi-autonomous control framework, we will develop a manipulation skill learning system that learns from demonstrations and corrections of the human operator and can therefore learn complex manipulations in a data-efficient manner. To improve object recognition and segmentation in cluttered heaps, we will develop new perception algorithms and investigate interactive perception in order to improve the robot's understanding of the scene in terms of object instances, categories and properties.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

This year we had the visit of Professor Sozo Inoue from Kyushu Institute of Technology (https://sozolab.jp) for one week in September. He was accompanied with one PhD student and two Master students, and a Postdoc. The objective was to organise together the collection of a Dataset and propose an international challenge for testing action and activity recognition algorithms.

9.4.1.1. Internships

- Luan Wei (University of Osnabrück, Germany), 5 months (supervisor: Jean-Baptiste Mouret)
- Ivan Bergonzi (University of Roma — La Sapienza, Italy), 5 months (supervisor: Jean-Baptiste Mouret)
- Lorenzo Vianello (University of Roma — La Sapienza, Italy), 6 months (supervisor: Serena Ivaldi)
- Andrea Macrí (University of Roma — La Sapienza, Italy), 5 months (supervisor: Serena Ivaldi)
- Lina Achaji (University Lebanese University – Faculty of Engineering – Tripoli), 3 months (supervision: François Charpillet)
- Niyati Rawal (Rovira i Virgili University & Open University of Catalonia (Spain)), 5 months (supervision: Francis Colas, Serena Ivaldi, Vincent Thomas)
- Yang You (Cranfield University), 5 months (supervision Vincent Thomas, Olivier Buffet, François Charpillet).

9.4.2. PhD students

- Niels Justesen (IT University of Copenhagen), 3 months (supervisor: Jean-Baptiste Mouret)
- Anji Ma (Bejing Institute of Technology), 1 year (supervisor: Serena Ivaldi)
- Moe Matsuki (Kyushu Institute of Technology) 2 weeks (supervisor: François Charpillet).

LINKMEDIA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Computer vision for smart phones (MobilAI)

Participants: Yannis Avrithis, Mateusz Budnik.

Duration: 2 years, started in September 2018
Partners: Lamark, Quai des Apps, AriadNext

The ability of our mobile devices to process visual information is currently not limited by their camera or computing power but by the network. Many mobile apps suffer from long latency due to data transmitted over the network for visual search. MobilAI aims to provide fast visual recognition on mobile devices, offering quality user experience whatever the network conditions. The idea is to transfer efficient deep learning solutions for image classification and retrieval onto embedded platforms such as smart phones. The intention is to use such solutions in B2B and B2C application contexts, for instance recognizing products and ordering online, accessing information about artifacts in exhibitions, or identifying identity documents. In all cases, visual recognition is performed on the device, with minimal or no access to the network.

9.1.2. CominLabs Project BigCLIN

Participants: Vincent Claveau, Ewa Kijak, Clément Dalloux.

Duration: 3 years, started in September 2016
Partners: STL-CNRS, Inserm/CHU Rennes, Inria
URL: https://bigclin.cominlabs.u-bretagneloire.fr/fr

Data collected or produced during clinical care process can be exploited at different levels and across different domains. Yet, a well-known challenge for secondary use of health big data is that much of detailed patient information is embedded in narrative text, mostly stored as unstructured data. The project proposes to address the essential needs when reusing unstructured clinical data at a large scale. We propose to develop new clinical records representation relying on fine-grained semantic annotation thanks to new NLP tools dedicated to French clinical narratives. To efficiently map this added semantic information to existing structured data for further analysis at big scale, the project also addresses distributed systems issues: scalability, management of uncertain data and privacy, stream processing at runtime, etc.

9.2. National Initiatives

9.2.1. Inria Project Lab Knowledge-driven data and content collaborative analytics (iCODA)

Participants: Laurent Amsaleg, Cheikh Brahim El Vaigh, Guillaume Gravier, Cyrielle Mallart, Pascale Sébillot.

Duration: 4.5 years, started in April 2017
Partners: Inria project-teams Linkmedia, CEDAR, GraphIK and ILDA, with Ouest-France, Le Monde and AFP

One of today's major issues in data science is the design of algorithms that allow analysts to efficiently infer useful information and knowledge by collaboratively inspecting heterogeneous information sources, from structured data to unstructured content. Taking data journalism as an emblematic use-case, the goal of the project is to develop the scientific and technological foundations for knowledge- mediated user-in-the-loop collaborative data analytics on heterogeneous information sources, and to demonstrate the effectiveness of the approach in realistic, high-visibility use-cases. The project stands at the crossroad of multiple research fields—content analysis, data management, knowledge representation, visualization—that span multiple Inria themes, and counts on a club of major press partners to define usage scenarios, provide data and demonstrate achievements.

9.2.2. Inria-BNF: Classification d'images patrimoniales (CIP)

Participants: Florent Michel, Laurent Amsaleg, Guillaume Gravier, Ewa Kijak, Yannis Avrithis.

Duration: 1 year, started in Dec 2018

This project is within the context of the collaborations between Inria and the French Ministry of Culture. In that context, we have started a collaboration with the French National Library (BNF) which collects, preserves and makes known the national documentary heritage. This collaboration aims at facilitating the automatic classification of heritage images through the use of recent deep-learning techniques. Such images are quite specific: they are not at all similar with what deep-learning techniques are used to work with, that is, the classification of heritage images does not target modern categories such as planes, cars, cats and dogs because this is irrelevant and because heritage collections do not include images of contemporary objects. Furthermore, heritage images come in vast quantities, but they are little annotated and deep-learning techniques can hardly rely on massive annotations to easily learn. Last, the learning has to be continuous as curators may need to add or modify existing classes, without re-learning everything from scratch.

The techniques of choice to reach that goal include the semi-supervised learning, low-shot learning techniques, knowledge transfer, fine tuning existing models, etc.

9.2.3. ANR Archival: Multimodal machine comprehension of language for new intelligent interfaces of scientific and cultural mediation

Participants: Laurent Amsaleg, Guillaume Gravier, Pascale Sébillot.

Duration: 3.5 year, started in Dec. 2019

The multidisciplinary and multi-actor ARCHIVAL project aims at yielding collaborations between researchers from the fields of Information and Communication Sciences as well as Computer Sciences around archive value enhancing and knowledge sharing for arts, culture and heritage. The project is structured around the following questionings: What part can machine comprehension methods play towards the reinterpretation of thematic archive collections? How can content mediation interfaces exploit results generated by current AI approaches?

ARCHIVAL teams will explore heterogeneous document collection structuration in order to explicitly reveal implicit links, to explain the nature of these links and to promote them in an intelligible way towards ergonomic mediation interfaces that will guarantee a successful appropriation of contents. A corpus has been delimited from the FMSH "self-management" collection, recently awarded as Collex, which will be completed from the large Canal-U academic audiovisual portal. The analysis and enhancement of this collection is of particular interest for Humanities and Social Sciences in a context where it becomes a necessity to structurally reconsider new models of socioeconomic development (democratic autonomy, social and solidarity-based economy, alternative development,. . .).

9.3. European Initiatives

9.3.1. EIT Digital CREEP2

Program: EIT Digital

Project acronym: CREEP 2

Project title: Cyberbullying effects prevention

Duration: 01/2019 - 12/2019

Coordinator: FBK, Italy

Other partners: Expert Systems (IT), Inria (FR), Engineering (IT)

Abstract: Project CREEP (Cyberbulling Effects Prevention) aims at identifying and preventing the possible negative impacts of cyberbullying on young people. It seeks to realise advanced technologies for the early detection of cyberbullying phenomena through the monitoring of social media and the communication of preventive advices and personalized recommendations tailored to adolescents' needs through a virtual coaching system (chatbot).

9.3.2. JPI CH READ-IT

Program: Joint Programming Initiative on Cultural Heritage

Project acronym: READ-IT

Project title: Reading Europe Advanced Data Investigation Tool

Duration: 05/2018 - 04/2021

Coordinator: Université Le Mans (FR)

Other partners: CNRS-IRISA (FR), Open University (UK), Universiteit Utrecht (NL), Institute of Czech Litterature (CZ)

Abstract: READ-IT is a transnational, interdisciplinary R&D project that will build a unique large-scale, user- friendly, open access, semantically-enriched investigation tool to identify and share groundbreaking evidence about 18th-21st century Cultural Heritage of reading in Europe. READ-IT will ensure the sustainable and reusable aggregation of qualitative data allowing an in-depth analysis of the Cultural Heritage of reading. State-of-the art technology in Semantic Web and information systems will provide a versatile, end-users oriented environment enabling scholars and ordinary readers to retrieve information from a vast amount of community-generated digital data leading to new understanding about the circumstances and effects of reading in Europe.

9.3.3. CHIST-ERA ID_IOT

Program: CHIST ERA

Project acronym: ID_IOT

Project title: Identification for the Internet of things

Duration: 3 years, started in Oct 2016.

Coordinator: Boris Skoric (Eindhoven Univ. of Technology (NL))

Other partners: Inria-RBA (Teddy Furon, Marzieh Gheisari Khorasgani), Univ. of Geneva (CH)

Abstract: The IoT will contain a huge number of devices and objects that have very low or nonexistent processing and communication resources, coupled to a small number of high-power devices. The weakest devices, which are most ubiquitous, will not be able to authenticate themselves using cryptographic methods. This project addresses these issues using physical unclonable functions (PUFs). PUFs, and especially quantum readout PUFs, are ideally suited to the IoT setting because they allow for the authentication and identification of physical objects without requiring any crypto or storage of secret information.

Furthermore, we foresee that back-end systems will not be able to provide security and privacy via cryptographic primitives due to the sheer number of IoT devices. Our plan is to address these problems using privacy preserving database structures and algorithms with good scaling behaviour. Approximate nearest neighbour (ANN) search algorithms, which have remarkably good scaling behaviour, have recently become highly efficient, but do not yet have the right security properties and have not yet been applied to PUF data. Summarised in a nutshell, the project aims to improve the theory and practice of technologies such as PUFs and ANN search in the context of generic IoT authentication and identification scenarios.

9.3.4. Collaborations with Major European Organizations

Program: ConFAP-CNRS Project

Project acronym: FIGTEM

Project title: FIne-Grain TExt Mining for clinical data

Duration: 01/2016 - 05/2019

Coordinator: CNRS-IRISA

Other partners: PUCPR, Curitiba, Brasil; CNRS-STL Lille; Inserm LTSI/CHU Rennes

Abstract: FIGTEM is a research project that involves STL-CNRS, CHU Rennes, PUC Parana, Curitiba and led by LINKMEDIAThis project aimed at developing natural language processing methods, including information extraction and indexing, dedicated to the clinical trial domain. The goal was to populate a formal representation of patients (via their electronic patient records) and clinical trial data in different languages (French, English, Portuguese). The main outcomes of the project was NLP tools for these 3 languages and annotated datasets made available for research purposes. It ended in May 2019.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- Michael Houle, NII, Japan
- Marcel Worring, UvA, Netherlands
- Martha Larson, Radboud U., Netherlands

9.4.2. Participation in Other International Programs

9.4.2.1. STIC AmSud TRANSFORM

Program: STIC AmSud

Project acronym: TRANSFORM

Project title: Transforming multimedia data for indexing and retrieval purposes

Duration: 01/2018 - 31/2019

Partners: CNRS-IRISA (FR), PUC Minas (BR), UChile (CL)

9.4.2.2. CAPES/COFECUB HIMMD

Program: CAPES/COFECUB

Project acronym: HIMMD

Project title: Hierarchical graph-based analysis of image, video, and multimedia data

Duration: 01/2019 - 31/2022

Partners: LIGM (FR), IRISA (FR), INPG (FR), PUC Minas (BR), UNICamp (BR), UFMG (BR)

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Silvio Guimaraes (PUC Minas, Brazil) visited the team in July (1 week). His visit was related to the Stic-Amsud project.
- Benjamin Bustos (Univ. Chile, Chile) visited the team in July (1 week). His visit was related to the Stic-Amsud project.

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Yannis Avrithis, National and Kapodistrian University of Athens, 3 visits on April (1 week), June (1 week) and September-October 2019 (3 weeks).

LINKS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- Links is member of the CPER Data (2016-19)
- Lozano's PhD project (2016-19) is co-funded by the Region Nord-Pas de Calais
- Sakho's PhD project is co-funded by the Region Nord-Pas de Calais
- Gallot's PhD project (2017-20) is co-funded by the Region Nord-Pas de Calais
- Crosetti's PhD project (2018-21) is co-funded by the Region Haut de France. This is joined work with J. Ramon from the Inria project Magnet

9.2. National Initiatives

ANR Aggreg (2014-19): Aggregated Queries.
Participants: Joachim Niehren [correspondent], Aurélien Lemay, Adrien Boiret [University of Mons, Belgium], Florent Capelli.

- The coordinator is J. Niehren and the partners are the Université Paris 7 (A. Durand) including members of the Inria project DAHU (L. Ségoufin), the Université de Marseille (N. Creignou) and Université de Caen (E. Grandjean).
- Objective: the main goal of the Aggreg project is to develop efficient algorithms and to study the complexity of answering aggregate queries for databases and data streams of various kinds.

ANR Colis (2015-20): Correctness of Linux Scripts.
Participants: Joachim Niehren [correspondent], Aurélien Lemay, Sophie Tison, Adrien Boiret [University of Mons, Belgium], Vincent Hugot [INSA Centre-Val de Loire], Nicolas Bacquey [Twig], Paul Gallot, Sylvain Salvati.

- The coordinator is R. Treinen from the Université Paris 7 and the other partner is the Tocata project of Inria Saclay (C. Marché).
- Objective: This project aims at verifying the correctness of transformations on data trees defined by shell scripts for Linux software installation. The data trees here are the instance of the file system which are changed by installation scripts.

ANR DataCert (2015-20):
Participants: Iovka Boneva [correspondent], Sophie Tison, Jose Martin Lozano.

- Partners: The coordinator is E. Contejean from the Université Paris-Sud and the other partner is the Université de Lyon.
- Objective: the main goals of the Datacert project are to provide deep specification in Coq of algorithms for data integration and exchange and of algorithms for enforcing security policies, as well as to design data integration methods for data models beyond the relational data model.

ANR Headwork (2016-21):
Participants: Joachim Niehren [correspondent], Momar Sakho, Nicolas Crosetti, Florent Capelli.

- Scientific partners: The coordinateur is D. Gross-Amblard from the Druid Team (Rennes 1). Other partners include the Dahu team (Inria Saclay) and Sumo (Inria Bretagne).
- Industrial partners: Spipoll, and Foulefactory.

- Objective: The main object is to develop data-centric workflows for programming crowd sourcing systems in flexible declarative manner. The problem of crowd sourcing systems is to fill a database with knowledge gathered by thousands or more human participants. A particular focus is to be put on the aspects of data uncertainty and for the representation of user expertise.

ANR Delta (2016-21):
Participants: Joachim Niehren [correspondent], Sylvain Salvati, Aurélien Lemay, Nicolas Bacquey [Twig], Lily Gallois.

- Partners: The coordinator is M. Zeitoun from LaBRI, other partners are LIF (Marseille) and IRIF (Paris-Diderot).
- Objective: Delta is focused on the study of logic, transducers and automata. In particular, it aims at extending classical framework to handle input/output, quantities and data.

ANR Bravas (2017-22):
Participant: Sylvain Salvati [correspondent].

- Scientific Partners: The coordinator is Jérôme Leroux from LaBRI, Université de Bordeaux. The other partner is LSV, ENS Cachan.
- Objective: The goal of the BraVAS project is to develop a new and powerful approach to decide the reachability problems for Vector Addition Systems (VAS) extensions and to analyze their complexity. The ambition here is to crack with a single hammer (ideals over well-orders) several long-lasting open problems that have all been identified as a barrier in different areas, but that are in fact closely related when seen as reachability.

9.3. European Initiatives

Oxford, UK: An exchange project with the computer science lab of the University of Oxford is funded by the Université de Lille via the CRIStAL Lab. Links' members produced many common publications over the years with Oxford. Links' contact is C. Paperman.

Wroclaw, Poland: S. Staworko has regular exchange with the University of Wroclaw. This has led to a publication at *PODS* [10] together with P. Wieczorek.

Saint-Petersburg, Russia: S. Salvati and J. Niehren started a cooperation with the Saint-Petersburg State University, via a month-long visit by R. Azimov and S. Grigorev.

Oviedo, Spain: I. Boneva has an active cooperation with the University of Oviedo.

9.4. International Initiatives

9.4.1. Informal International Partners

Santiago de Chile, Chile: S. Staworko and I. Boneva have a collaboration with C. Riveros from the Pontifical Catholic University of Chile since 2018.

LOKI Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. GeneaLire (CPER MAuVE, 2018-2020)

Participants: Stéphane Huot, Thomas Pietrzak [contact person].

Interactive tools for the interpretation of manuscripts

The goal of this project is to design, implement and evaluate interactive tools for helping transcription of scanned handwritten documents. Current solutions focus on automatic recognition, with recent advances thanks to deep learning methods. However these solutions still require a significant learning base that has to be made by hand. Not only this means that part of the work cannot be done automatically, but it also means that this technique is not a solution for small collections of documents. The tools we propose to create will ingeniously take advantage of interactive and automatic techniques. The interactive tools include a text selection technique [32], as well as advanced annotation techniques that will support collaborative work. This tool will be invaluable for bootstrapping the transcription of large collections, as well as helping transcribing small collections. We will use user-centered design, in order to make sure the tool fits historians and genealogists activities and workflow.

Partners: Inria Saclay's AVIZ team, École Polytechnique de l'Université de Tours, Laboratoire de Démographie et d'Histoire Sociale at l'École des hautes études en sciences sociales, and Geneanet.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. TurboTouch (PRC, 2014-2019)

Participants: Géry Casiez [contact person], Sylvain Malacria, Mathieu Nancel, Thomas Pietrzak.

High-performance touch interactions

Touch-based interactions with computing systems are greatly affected by two interrelated factors: the transfer functions applied on finger movements, and latency. This project aims at transforming the design of touch transfer functions from black art to science to support high-performance interactions. We are working on the precise characterization of the functions used and the latency observed in current touch systems. We are developing a testbed environment to support multidisciplinary research on touch transfer functions and will use this testbed to design latency reduction and compensation techniques, and new transfer functions.

Partners: Inria Lille's VALSE team (formerly NON-A) and the "Perceptual-motor behavior group" from the Institute of Movement Sciences.

Web site: http://mjolnir.lille.inria.fr/turbotouch/

Related publications in 2019: [13], [12]

9.2.1.2. Causality (JCJC, 2019-2023)

Participants: Géry Casiez, Stéphane Huot, Sylvain Malacria, Mathieu Nancel [contact person], Philippe Schmid.

Integrating Temporality and Causality to the Design of Interactive Systems

The project addresses a fundamental limitation in the way interfaces and interactions are designed and even thought about today, an issue we call *procedural information loss*: once a task has been completed by a computer, significant information that was used or produced while processing it is rendered inaccessible regardless of the multiple other purposes it could serve. It hampers the identification and solving of identifiable usability issues, as well as the development of new and beneficial interaction paradigms. We will explore, develop, and promote finer granularity and better-described connections between the causes of those changes, their context, their consequences, and their timing. We will apply it to facilitate the real-time detection, disambiguation, and solving of frequent timing issues related to human reaction time and system latency; to provide broader access to all levels of input data, therefore reducing the need to "hack" existing frameworks to implement novel interactive systems; and to greatly increase the scope and expressiveness of command histories, allowing better error recovery but also extended editing capabilities such as reuse and sharing of previous actions.

Web site: http://loki.lille.inria.fr/causality/

9.2.1.3. Discovery (JCJC, 2020-2024)

Participant: Sylvain Malacria [contact person].

Promoting and improving discoverability in interactive systems

This project addresses a fundamental limitation in the way interactive systems are usually designed, as in practice they do not tend to foster the discovery of their input methods (operations that can be used to communicate with the system) and corresponding features (commands and functionalities that the system supports). Its objective is to provide generic methods and tools to help the design of discoverable interactive systems: we will define validation procedures that can be used to evaluate the discoverability of user interfaces, design and implement novel UIs that foster input method and feature discovery, and create a design framework of discoverable user interfaces. This project investigates, but is not limited to, the context of touch-based interaction and will also explore two critical timings when the user might trigger a reflective practice on the available inputs and features: while the user is carrying her task (discovery in-action); and after having carried her task by having informed reflection on her past actions (discovery on-action). This dual investigation will reveal more generic and context-independent properties that will be summarized in a comprehensive framework of discoverable interfaces. Our ambition is to trigger a significant change in the way all interactive systems and interaction techniques, existing and new, are thought, designed, and implemented with both performance and discoverability in mind.

Web site: http://ns.inria.fr/discovery/

Related publications in 2019: [21].

9.2.2. Inria Project Labs

9.2.2.1. BCI-LIFT (2015-2019)

Participant: Géry Casiez [contact person].

Brain Computer Interfaces: Learning, Interaction, Feedback, Training

The goal of this large-scale initiative is to design a new generation of non-invasive Brain-Computer Interfaces (BCI) that are easier to appropriate, more efficient, and suited for a larger number of people.

Partners: Inria's ATHENA, NEUROSYS, POTIOC, HYBRID & DEMAR teams, *Centre de Recherche en Neurosciences de Lyon* (INSERM) and INSA Rouen.

Web site: https://bci-lift.inria.fr/

Related publication in 2019: [24]

9.2.2.2. AVATAR (2018-2022)

Participants: Géry Casiez, Stéphane Huot, Thomas Pietrzak [contact person].

The next generation of our virtual selves in digital worlds

This project aims at delivering the next generation of virtual selves, or *avatars*, in digital worlds. In particular, we want to push further the limits of perception and interaction through our avatars to obtain avatars that are better embodied and more interactive. Loki's contribution in this project consists in designing novel 3D interaction paradigms for avatar-based interaction and to design new multi-sensory feedbacks to better feel our interactions through our avatars.

Partners: Inria's GRAPHDECO, HYBRID, MIMETIC, MORPHEO & POTIOC teams, Mel Slater (Event Lab, University Barcelona, Spain), Technicolor and Faurecia.

Web site: https://avatar.inria.fr/

Related publication in 2019: [19], [14]

9.2.3. Others

9.2.3.1. ParkEvolution (Carnot Inria - Carnot STAR, 2015-2019)

Participant: Géry Casiez [contact person].

Longitudinal analysis of fine motor control for patients with Parkinson disease

This project studies the fine motor control of patients with Parkinson disease in an ecological environment, at home, without the presence of experimenters. Through longitudinal studies, we collect raw information from pointing devices to create a large database of pointing behavior data. From the analysis of this big dataset, the project aims at inferring the individual's disease progression and influence of treatments.

Partners: the "Perceptual-motor behavior group" from the Institute of Movement Sciences and Hôpital de la Timone.

Web site: http://parkevolution.org/

9.2.3.2. IRDICS (Projets Exploratoires Premier Soutien CNRS, 2018-2019)

Participants: Géry Casiez, Stéphane Huot, Sylvain Malacria, Thomas Pietrzak [contact person].

Interface de recueil de données imparfaites pour le crowd-sourcing

Many crowdsourcing studies involve asking hundreds of participants to answer questionnaires. There is typically a trade-off between precision and certitude of participants. Usually, investigators prefer participants to be certain, at the cost of precision. The idea is that the lack of precision can be compensated by the high number of answers. In this project we are interested in studying this trade-off. We performed a first study, in which we asked participants to rate their confidence in their answer. In the next studies, we will allow participants to give several answers, but make sure the right answer is among them. In the last study, participants will be able to rank their answers based on confidence.

Partners: IRISA's DRUID team.

Related publication in 2019: [31]

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

Andy Cockburn, University of Canterbury, Christchurch, NZ [25], [23]
Carl Gutwin, University of Saskatchewan, Saskatoon, CA [25]
Nicolai Marquardt, University College London, London, UK [18]
Antti Oulasvirta, Aalto University, Helsinki, FI
Daniel Vogel, University of Waterloo, Waterloo, CA
Audrey Girouard, Carleton University, Ottawa, CA

9.3.2. Participation in Other International Programs

9.3.2.1. Inria International Chairs

Expert interaction with devices for musical expression

Marcelo M. Wanderley – *Professor at Schulich School of Music/IDMIL, McGill University (Canada)*

Period: 2017 - 2021

The main topic of this project is the expert interaction with devices for musical expression and consists of two main directions: *the design of digital musical instruments* (DMIs) and *the evaluation of interactions with such instruments*. It will benefit from the unique, complementary expertise available at the Loki Team, including the design and evaluation of interactive systems, the definition and implementation of software tools to track modifications of, visualize and haptically display data, as well as the study of expertise development within human-computer interaction contexts. The project's main goal is to bring together advanced research on devices for musical expression (IDMIL – McGill) and cutting-edge research in Human-computer interaction (Loki Team).

Rich, Reliable Interaction in Ubiquitous Environments
Edward Lank – *Professor at Cheriton School of Computer Science, University of Waterloo (Canada)*

Period: 2019 - 2023

The objectives of the research program are:

1. Designing Rich Interactions for Ubiquitous and Augmented Reality Environments
2. Designing Mechanisms and Metaphors for Novices, Experts, and the Novice to Expert Transition
3. Integrating Intelligence with Human Action in Richly Augmented Environments.

9.3.2.2. Université de Lille - International Associate Laboratory

Reappearing Interfaces in Ubiquitous Environments (Réapp)
with Edward Lank, Daniel Vogel & Keiko Katsuragawa at University of Waterloo (Canada) - Cheriton School of Computer Science

Duration: 2019 - 2023

The LIA Réapp is an International Associated Laboratory between Loki and Cheriton School of Computer Science from the University of Waterloo in Canada. It is funded by the University of Lille to ease shared student supervision and regular inter-group contacts. The University of Lille will also provide a grant for a co-tutelle PhD thesis between the two universities.

We are at the dawn of the next computing paradigm where everything will be able to sense human input and augment its appearance with digital information without using screens, smartphones, or special glasses—making user interfaces simply disappear. This introduces many problems for users, including the discoverability of commands and use of diverse interaction techniques, the acquisition of expertise, and the balancing of trade-offs between inferential (AI) and explicit (user-driven) interactions in aware environments. We argue that interfaces must reappear in an appropriate way to make ubiquitous environments useful and usable. This project tackles these problems, addressing (1) the study of human factors related to ubiquitous and augmented reality environments, and the development of new interaction techniques helping to make interfaces reappear; (2) the improvement of transition between novice and expert use and optimization of skill transfer; and, last, (3) the question of delegation in smart interfaces, and how to adapt the trade-off between implicit and explicit interaction.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

Edward Lank, Professor at the University of Waterloo, who has been awarded an Inria International Chair in our team in 2019, spent 4 months in our group this year (September to December).

Marcelo M. Wanderley, Professor at McGill University, who has been awarded an Inria International Chair in our team in 2017, spent 2 months in our group this year (July to August).

9.4.1.1. Internships

Carola Trahms, PhD student, Christian-Albrecht University of Kiel, Sep. 2019.

MAGNET Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

We participate to the *Data Advanced data science and technologies* project (CPER Data). This project is organized following three axes: internet of things, data science, high performance computing. MAGNET is involved in the data science axis to develop machine learning algorithms for big data, structured data and heterogeneous data. The project MyLocalInfo is an open API for privacy-friendly collaborative computing in the internet of things.

MAGNET also has various collaborations with research groups in linguistics and psycholinguistics at Université de Lille, in particular UMR STL (with an ongoing joint ANR project) and UMR SCALab (co-supervision of students).

8.2. National Initiatives

8.2.1. ANR Pamela (2016-2020)

Participants: MARC TOMMASI [correspondent], AURÉLIEN BELLET, RÉMI GILLERON, JAN RAMON, MAHSA ASADI

The Pamela project aims at developing machine learning theories and algorithms in order to learn local and personalized models from data distributed over networked infrastructures. Our project seeks to provide first answers to modern information systems built by interconnecting many personal devices holding private user data in the search of personalized suggestions and recommendations. More precisely, we will focus on learning in a collaborative way with the help of neighbors in a network. We aim to lay the first blocks of a scientific foundation for these new types of systems, in effect moving from graphs of data to graphs of data and learned models. We argue that this shift is necessary in order to address the new constraints arising from the decentralization of information that is inherent to the emergence of big data. We will in particular focus on the question of learning under communication and privacy constraints. A significant asset of the project is the quality of its industrial partners, Snips and Mediego, who bring in their expertise in privacy protection and distributed computing as well as use cases and datasets. They will contribute to translate this fundamental research effort into concrete outcomes by developing personalized and privacy-aware assistants able to provide contextualized recommendations on small devices and smartphones.

https://project.inria.fr/pamela/

8.2.2. ANR JCJC GRASP (2016-2020)

Participants: PASCAL DENIS [correspondent], AURÉLIEN BELLET, RÉMI GILLERON, MIKAELA KELLER, MARC TOMMASI

The GRASP project aims at designing new graph-based Machine Learning algorithms that are better tailored to Natural Language Processing structured output problems. Focusing on semi-supervised learning scenarios, we will extend current graph-based learning approaches along two main directions: (i) the use of structured outputs during inference, and (ii) a graph construction mechanism that is more dependent on the task objective and more closely related to label inference. Combined, these two research strands will provide an important step towards delivering more adaptive (to new domains and languages), more accurate, and ultimately more useful language technologies. We will target semantic and pragmatic tasks such as coreference resolution, temporal chronology prediction, and discourse parsing for which proper Machine Learning solutions are still lacking.

https://project.inria.fr/grasp/

8.2.3. ANR DEEP-Privacy (2019-2023)

Participants: MARC TOMMASI [correspondent], AURÉLIEN BELLET, PASCAL DENIS, JAN RAMON, BRIJ SRIVASTAVA

DEEP-PRIVACY proposes a new paradigm based on a distributed, personalized, and privacy-preserving approach for speech processing, with a focus on machine learning algorithms for speech recognition. To this end, we propose to rely on a hybrid approach: the device of each user does not share its raw speech data and runs some private computations locally, while some cross-user computations are done by communicating through a server (or a peer-to-peer network). To satisfy privacy requirements at the acoustic level, the information communicated to the server should not expose sensitive speaker information.

8.2.4. ANR-NFS REM (2016-2020)

Participants: PASCAL DENIS [correspondent], BO LI, MATHIEU DEHOUCK

With colleagues from the linguistics departments at Université de Lille and University of Neuchâtel (Switzerland), PASCAL DENIS is a member of another ANR project (REM), funded through the bilateral ANR-NFS Scheme. This project, co-headed by I. Depreatere (Université de Lille) and M. Hilpert (Neufchâtel), proposes to reconsider the analysis of English modal constructions from a multidisciplinary perspective, combining insights from theoretical, psycho-linguistic, and computational approaches.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

Participants: Aurelien Bellet, Marc Tommasi, Brij Mohan Lal Srivastava.

Program: H2020 ICT-29-2018 (RIA)

Project acronym: COMPRISE

Project title: Cost-effective, Multilingual, Privacy-driven voice-enabled Services

Duration: Dec 2018 - Nov 2021

Coordinator: Emmanuel Vincent [Inria Nancy - Grand Est]

Other partners: Inria Multispeech, Ascora GmbH, Netfective Technology SA, Rooter Analysis SL, Tilde SIA, University of Saarland

Abstract: COMPRISE will define a fully private-by-design methodology and tools that will reduce the cost and increase the inclusiveness of voice interaction technologies.

8.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: Bilateral ANR project with Luxembourg

Project acronym: SLANT

Project title: Spin and Bias in Language Analyzed in News and Texts

Duration: Dec 2019 - June 2023

Coordinator: Philippe Muller [Université Paul Sabatier]

Other partners: IRIT (Toulouse), SnT (Luxembourg)

Abstract: There is a growing concern about misinformation or biased information in public communication, whether in traditional media or social forums. While automating fact-checking has received a lot of attention, the problem of fair information is much larger and includes more insidious forms like biased presentation of events and discussion. The SLANT project aims at characterizing bias in textual data, either intended, in public reporting, or unintended in writing aiming at neutrality. An abstract model of biased interpretation using work on discourse structure, semantics and interpretation will be complemented and concretized by finding relevant lexical, syntactic, stylistic or rhetorical differences through an automated but explainable comparison of texts with different biases on the same subject, based on a dataset of news media coverage from a diverse set of sources. We will also explore how our results can help alter bias in texts or remove it from automated representations of texts.

8.4. International Initiatives

8.4.1. Inria International Labs

Inria@SiliconValley

Associate Team involved in the International Lab:

8.4.1.1. LEGO

Title: LEarning GOod representations for natural language processing

International Partner (Institution - Laboratory - Researcher):

University of Southern California (United States) - Theoretical and Empirical Data Science (TEDS) research group Department of Computer Science - Fei Sha

Start year: 2019

See also: https://team.inria.fr/lego/

LEGO lies in the intersection of Machine Learning and Natural Language Processing (NLP). Its goal is to address the following challenges: what are the right representations for text data and how to learn them in a robust and transferable way? How to apply such representations to solve real-world NLP tasks, specifically in scenarios where linguistic resources are scarce? The past years have seen an increasing interest in learning continuous vectorial embeddings, which can be trained together with the prediction model in an end-to-end fashion, as in recent sequence-to-sequence neural models. However, they are unsuitable to low-resource languages as they require massive amounts of data to train. They are also very prone to overfitting, which makes them very brittle, and sensitive to bias present in the original text as well as to confounding factors such as author attributes. LEGO strongly relies on the complementary expertise of the two partners in areas such as representation learning, structured prediction, graph-based learning, multi-task/transfer learning, and statistical NLP to offer a novel alternative to existing techniques. Specifically, we propose to investigate the following two research directions: (a) optimize the representations to make them robust to bias and adversarial examples, and (b) learn transferable representations across languages and domains, in particular in the context of structured prediction problems for low-resource languages. We will demonstrate the usefulness of the proposed methods on several NLP tasks, including multilingual dependency parsing, machine translation, question answering and text summarization.

8.4.2. Inria Associate Teams Not Involved in an Inria International Labs

North-European Associate Team PAD-ML: Privacy-Aware Distributed Machine Learning.

International Partner: the PPDA team at the Alan Turing Institute.

Start year: 2018

In the context of increasing legislation on data protection (e.g., the recent GDPR), an important challenge is to develop privacy-preserving algorithms to learn from datasets distributed across multiple data owners who do not want to share their data. The goal of this joint team is to devise novel privacy-preserving, distributed machine learning algorithms and to assess their performance and guarantees in both theoretical and practical terms.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Several international researchers have been invited to give a talk at the MAGNET seminar:

- A. Korba (University College London, UK): Two families of (non-parametric) methods for label ranking
- M. Perrot (Max Planck Institute, Germany): Comparison-Based Learning: Hierarchical Clustering and Classification

8.5.2. Visits to International Teams

8.5.2.1. Research Stays Abroad

- FABIO VITALE was on leave at Department of Computer Science of Sapienza University (Rome, Italy) in the Algorithms Randomization Computation group with Prof. Alessandro Panconesi and Prof. Flavio Chierichetti. His current work on machine learning in graphs and published the following papers [6], [12], [10].
- AURÉLIEN BELLET and CÉSAR SABATER visited the Alan Turing Institute (London, UK) for one week in March 2019. They worked with Adrià Gascón, Brooks Paige, Daphne Ezer and Matt Kusner on privacy-preserving machine learning and privacy attacks in genomics.

MAGRIT Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

The project *Imagerie et Robotique Médicale Grand Est (IRMGE)* started in 2018. Clinical and interventional imagery is a major public health issue. Teams from the Grand-Est region involved in medical imaging (Inria, ICuve, CRESTIC) have thus proposed a research project to broaden and strenghten cooperation. The three axes of the project are about optic imagery, nuclear imagery and medical image processing. The Magrit team is especially involved in the third axis, with the aim to improve interventional procedures.

8.2. National Initiatives

8.2.1. ANR JCJC ICaRes

Participant: F. Sur

This 3-year project (2019-2022) headed by B. Blaysat (Université Clermont-Auvergne), is supported by the Agence Nationale de la Recherche. It addresses residual stresses, which are introduced in the bulk of materials during processing or manufacturing. Since unintended residual stresses often initiate early failure, it is of utmost importance to correctly measure them. The goal of the ICaRes project is to improve the performance of residual stress estimation through the so-called virtual digital image correlation (DIC) which will be developed. The basic idea of virtual DIC is to mark the specimen with virtual images coming from a controlled continuous image model, instead of the standard random pattern. Virtual DIC is expected to outperform standard DIC by, first, matching real images of the materials with the virtual images, then, to run DIC on the virtual images on which strain fields are estimated, giving ultimately residual stresses.

8.2.2. Projet RAPID EVORA

(2016-2010) Participants: M.-O. Berger, V. Gaudillière, G. Simon.

This 4-years project is supported by DGA/DGE and led by the SBS-Interactive company. The objective is to develop a prototype for location and object recognition in large-scale industrial environments (factories, ships...), with the aim to enrich the operator's field of view with digital information and media. The main issues concern the size of the environment, the nature of the objects (often non textured, highly specular...) and the presence of repeated patterns.

This year we have built a demonstrator to locate a camera in a factory modeled by a set of registered RGB-D panoramic images. The panoramic image closest to the current image is selected using a CNN descriptor calculated inside proposed boxes. Points and edges are then detected and matched between the current image and the selected panoramic image by using our method published at ICIP 2018 [31]. The camera pose can finally be obtained with regard to the scene by transitivity (image $\longleftrightarrow$ panoramic view $\longleftrightarrow$ scene).

8.3. International Initiatives

8.3.1. Inria International Labs

Inria@EastCoast

Associate Team involved in the International Lab:

8.3.1.1. CURATIVE

Title: CompUteR-based simulAtion Tool for mItral Valve rEpair

International Partner (Institution - Laboratory - Researcher):

Harvard University (United States) - Harvard Biorobotics Lab (HBL)- Robert Howe

Start year: 2017

See also: https://team.inria.fr/curative/

The mitral valve of the heart ensures one-way flow of oxygenated blood from the left atrium to the left ventricle. However, many pathologies damage the valve anatomy producing undesired backflow, or regurgitation, decreasing cardiac efficiency and potentially leading to heart failure if left untreated. Such cases could be treated by surgical repair of the valve. However, it is technically difficult and outcomes are highly dependent upon the experience of the surgeon.

One way to facilitate the repair is to simulate the mechanical behavior of the pathological valve with subject-specific data. Our main goal is to provide surgeons with a tool to study solutions of mitral valve repairs. This tool would be a computer-based model that can simulate a potential surgical repair procedure in order to evaluate its success. The surgeons would be able to customize the simulation to a patient and to a technique of valve repair. Our methodology will realistically simulate valve closure based on segmentation methods faithful enough to capture subject-specific anatomy and based on a biomechanical model that can accurately model the range of properties exhibited by pathological valves.

8.3.2. Inria International Partners

8.3.2.1. Informal International Partners

- Pierre-Frédéric Villard is a co-investigator in the INVIVE project (http://www.it.uu.se/research/scientific_computing/project/rbf/biomech) funded by the Swedish Research Council and realized within a collaboration with Uppsala University and Karolinska Institute. Within this project, he is the co-supervisor of Igor Tominec (Uppsala University) with Elisabeth Larsson (Uppsala University) as the main advisor.
- Gabriele Steidl (Technische Universität Kaiserslautern, Germany) invited Fabien Pierre during two days in her team to work on convolution on Riemannian manifolds for color images. The goal of this collaboration is the design of a CNN to process images which values are on a Manifolds.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Pete Hammer, a senior researcher at Harvard University (http://www.childrenshospital.org/researchers/peter-e-hammer), visited the MAGRIT team in July 2019. He gave a talk to the Department 1 in Loria, he helped out with mechanical modeling of the mitral valve and he provided advice to Daryna Panicheva during one week.
- Douglas Perrin, a senior researcher at Harvard University (http://www.childrenshospital.org/researchers/douglas-perrin), visited the MAGRIT team in September 2019. He gave a talk to the Department 1 in Loria, he worked on the segmentation of the mitral valve leaflet and he provided advice to Daryna Panicheva during one week.
- Ioana Ilea, Technical University Cluj-Napoca visited the Magrit team in October. She gave a talk entitled “Robust classification on covariance matrix space: Application to texture”.

8.4.1.1. Internships

Anastasiia Onanko from Kiev Polytechnique Institute was hosted to fulfill her Master internship (Erasmus mobility program). She worked to initiate a new research line in collaboration with our partners from CHRU Nancy, who were interested in having faster, more automated, but still faithful, means of detecting intracranial aneurysms from 3D magnetic resonance angiography (MRA) images. The deep learning approach that was followed addressed three challenges: the impossibility to use full-sized 3D MRA as input to a deep Convolutional Neural Network (CNN), the difficulty to collect annotated data, and the scarcity of aneurysms within the whole brain vasculature (about 50 voxels in a volume that counts millions of voxels). We designed two patch-based classification approaches, with roughly annotated data, and experimented with various data augmentation protocols. Results are preliminary and need to be consolidated. In particular, the current (limited) database will be expanded in the next few months.

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

- Pierre-Frédéric Villard spent one month (May 2019) at Uppsala University working on the INVIVE project. His work there includes supervising PhD student Igor Tominec, meeting with a physiologist expert in respiration muscles and working on an implicit surface representation of the diaphragm.
- Daryna Panicheva and Pierre-Frédéric Villard stayed in Harvard University in Cambridge (USA) respectively 2 weeks and 1 month in the context of the CURATIVE team. Each of them gave a talk to the Harvard Biorobotics Lab. An acquisition of a porcine mitral valve was done with 4 different amounts of pressure with a microCT scan. Biomechanical simulations on the mitral valve were also studied in term of stability and convergence.

MANAO Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. "Young Researcher" VIDA (2017-2021)

LP2N-CNRS-IOGS Inria
Leader R. Pacanowski (LP2N-CNRS-IOGS)
Participant P. Barla
This project aims at establishing a framework for direct and inverse design of material appearance for objects of complex shape. Since the manufacturing processes are always evolving, our goal is to establish a framework that is not tied to a fabrication stage.

9.1.1.2. MATERIALS (2015-2019)

MAVERICK, LP2N-CNRS (MANAO), Musée d'Ethnographie de Bordeaux, OCÉ-Print
Leader N. Holzschuch (MAVERICK)
Participant A. Lucat
Museums are operating under conflicting constraints: they have to preserve the artifacts they are storing, while making them available to the public and to researchers. Cultural artifacts are so fragile that simply exposing them to light degrades them. 3D scanning, combined with virtual reality and 3D printing has been used for the preservation and study of sculptures. The approach is limited: it acquires the geometry and the color, but not complex material properties. Current 3D printers are also limited in the range of colors they can reproduce. Our goal in this project is to address the entire chain of material acquisition and restitution. Our idea is to scan complex cultural artifacts, such as silk cloths, capturing all the geometry of their materials at the microscopic level, then reproduce them for study by public and researchers. Reproduction can be either done through 2.5D printing or virtual reality displays.

9.1.1.3. FOLD-Dyn (2017-2021)

IRIT, IMAGINE, MANAO, TeamTo, Mercenaries
Leader L. Barthe (IRIT)
Local Leader G. Guennebaud
The FOLD-Dyn project proposes the study of new theoretical approaches for the effective generation of virtual characters deformations, when they are animated. These deformations are two-folds: character skin deformations (skinning) and garment simulations. We propose to explore the possibilities offered by a novel theoretical way of addressing character deformations: the implicit skinning. This method jointly uses meshes and volumetric scalar functions. By improving the theoretical properties of scalar functions, the study of their joint use with meshes, and the introduction of a new approach and its formalism - called multi-layer 3D scalar functions - we aim at finding effective solutions allowing production studios to easily integrate in their pipeline plausible character deformations together with garment simulations.

9.1.1.4. CaLiTrOp (2017-2021)

IRIT, LIRIS, MANAO, MAVERICK
Leader: M. Paulin (IRIT)
Participant D. Murray

What is the inherent dimensionality, topology and geometry of light-paths space? How can we leverage this information to improve lighting simulation algorithms? These are the questions that this project wants to answer from a comprehensive functional analysis of light transport operators, with respect to the 3D scene's geometry and the reflectance properties of the objects, but also, to link operators with screen-space visual effects, with respect to the resulting picture.

9.2. International Research Visitors

9.2.1. Visits of International Scientists

Masatake Sawayama, Research Scientist, NTT Communication Science Laboratories, Japan (from March 2019 until October 2019)

MAVERICK Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

We have frequent exchanges and on-going collaborations with Cyril Crassin from nVIDIA-Research, and Eric Heitz, Laurent Belcour, Jonathan Dupuy and Kenneth Vanhoey from Unity-Research.

7.2. National Initiatives

7.2.1. ANR: Materials

Participants: Nicolas Holzschuch [contact], Romain Vergne.

We are funded by the ANR for a joint research project on acquisition and restitution of micro-facet based materials. This project is in cooperation with Océ Print Logic technologies, the Museum of Ethnography at the University of Bordeaux and the Manao team at Inria Bordeaux. The grant started in October 2015, for 48 months.

7.2.2. CDP: Patrimalp 2.0

Participants: Nicolas Holzschuch [contact], Romain Vergne.

The main objective and challenge of Patrimalp 2.0 is to develop a cross-disciplinary approach in order to get a better knowledge of the material cultural heritage in order to ensure its sustainability, valorization and diffusion in society. Carried out by members of UGA laboratories, combining skills in human sciences, geosciences, digital engineering, material sciences, in close connection with stakeholders of heritage and cultural life, curators and restorers, Patrimalp 2.0 intends to develop of a new interdisciplinary science: Cultural Heritage Science. The grant starts in January 2018, for a period of 48 months.

7.2.3. ANR: CaLiTrOp

Participant: Cyril Soler [contact].

Computing photorealistic images relies on the simulation of light transfer in a 3D scene, typically modeled using geometric primitives and a collection of reflectance properties that represent the way objects interact with light. Estimating the color of a pixel traditionally consists in integrating contributions from light paths connecting the light sources to the camera sensor at that pixel.

In this ANR we explore a transversal view of examining light transport operators from the point of view of infinite dimensional function spaces of light fields (imagine, e.g., reflectance as an operator that transforms a distribution of incident light into a distribution of reflected light). Not only are these operators all linear in these spaces but they are also very sparse. As a side effect, the sub-spaces of light distributions that are actually relevant during the computation of a solution always boil down to a low dimensional manifold embedded in the full space of light distributions.

Studying the structure of high dimensional objects from a low dimensional set of observables is a problem that becomes ubiquitous nowadays: Compressive sensing, Gaussian processes, harmonic analysis and differential analysis, are typical examples of mathematical tools which will be of great relevance to study the light transport operators.

Expected results of the fundamental-research project CALiTrOp, are a theoretical understanding of the dimensionality and structure of light transport operators, bringing new efficient lighting simulation methods, and efficient approximations of light transport with applications to real time global illumination for video games.

7.3. European Initiatives

Together with Stefanie Hahmann and Melina Skouras from project-team IMAGINE, Georges-Pierre Bonneau is part of the H2020 FET-Open Challenging Current Thinking project $ADAM^2$, grant ID 862025, accepted in June 2019 and starting officially January 1st 2020. The Imagine and Maverick teams at Inria are in charge of modelling of micro-structured geometries and design of meta-metarials. More information is available at www.adam2.eu.

7.4. International Initiatives

7.4.1. ASICIAO: Erasmus+ capacity building project

Joëlle Thollot is an active member of the ASICIAO Erasmus+ project. In this project four European higher education institutions support six schools from Senegal and Togo in their pursuit of autonomy by helping them to develop their own method of improving quality in order to obtain the CTI accreditation and the EUR-ACE label and, by doing so, to reach international standards.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

7.5.1.1. Internships

Anmol Hanagodimath spent 6 months of internship in our team as part of his master thesis of Delft university. He was supervised by Romain Vergne and Joëlle Thollot in Grenoble and Elman Eisemann in Delft.

MFX Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Project Orthosis4D (2019-2022)

- Acronym: Orthosis4D.
- Title: Passive and active 3D printed orthosis: modeling, simulation and applications.
- Duration: 2019-2022.
- Funding: Lorraine Université d'Excellence.
- Coordinator: Sylvain Lefebvre.
- Participants: SylvainLefebvre, ThibaultTricard, Pierre-AlexandreHugron, Jean-BaptisteAustruy
- Other partners: IJL, LRGP, ERPI, IRR and Nancy CHU
- Abstract: The project considers the creation of flexible plates with controlled elasticity for use in medical applications (orthoses, insoles). It exemplifies our approach of doing focused collaborations around application domains of our research, to ensure that our techniques answer actual practical challenges and maximize the chances that they are deployed in the near future. On our side the project funds a PhD student, Thibault Tricard, who started in October 2018, a project manager, Jean-Baptiste Austruy, who started in May 2019 and a design engineer, Pierre-Alexandre Hugron, who started in April 2019.

  The project resulted in several publications this year [17], [11], [14]. We are also actively working with Bernhard Thomaszewski (University of Montréal) and Mélina Skouras (Inria Grenoble) within the scope of this project.

  Pierre-Alexandre Hugron started to interact with the medical partners, following the manufacturing process of orthopedic insoles at the IRR Louis Pierquin as well as producing and discussing 3D printed samples with practitioners to better understand their expectations and requirements. In particular, extensive tests have been conducted on the fabrication of different structures and density samples to mimic the current materials of insoles. Some of these samples are currently reviewed by the CHRU. These tests have resulted in an optimization of our 3D printing processes for a better accuracy and speed.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. Project MuFFin

- Acronym: MuFFin.
- Title: Procedural Stochastic Microstructures for Functional Fabrication.
- Duration: 2018-2021.
- Funding: ANR JCJC.
- Coordinator: Jonàs Martínez.
- Participants: Jonàs Martínez, Sylvain Lefebvre, Samuel Hornus, Semyon Efremov.

- Abstract:

  MuFFin aims at contributing a unified pipeline for the efficient and scalable synthesis, visualization, and modeling of additively manufactured microstructures with tailored macroscopic physical behavior. In an interdisciplinary effort, MuFFin will blend together computer and material science perspectives to deliver an integrated approach that is both computationally and physically sound.

  We have ongoing interdisciplinary collaborations with researchers in topology optimization (Perle Geoffroy-Donders and Grégoire Allaire at École Polytechnique), material science in the context of aeronautics (Mohamed amin Ben Lassoued, Ahmed Abbad, and Guilhem Michon at ISAE-SUPAREO, Annie Ross at Polytechnique Montréal), and deformable robotics (Félix Vanneste and Olivier Goury in the DEFROST Inria team).

9.2.1.2. Project IMPRIMA

- Acronym: IMPRIMA.
- Title: Implicit modeling for additive manufacturing.
- Duration: 2019-2023.
- Funding: ANR JCJC.
- Coordinator: Cédric Zanni.
- Participants: Cédric Zanni, Sylvain Lefebvre, Melike Aydinlilar.
- Abstract:

  Project IMPRIMA seek to explore novel implicit representations in order to provide a unified approach for the modeling and slicing of both macro geometry, microstructures and gradient of material. Additionally, this research aims at a complete, tight integration of both standard boundary representations and novel implicit volume representations, allowing the best choice of representation for different parts of a design.

  We have hired Melike Aydinlilar as a PhD student, starting from November 2019. We have an ongoing collaboration on skeleton-based implicit surfaces with Évelyne Hubert and Alvaro Fuentes in the AROMATH Inria team.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

We continued our informal international collaborations, in particular with Bernhard Thomaszewski (University of Montréal) on clay support structures [13] and microstructure design [14].

We are pursuing our joint research effort on slicing and curved 3D printing [11] with Charlie C.L. Wang (The Chinese University of Hong Kong), Sara McMains (University of California Berkeley), Brian Wyvill (University of Victoria), Daniele Panozzo (NYU), and Marc Alexa (TU-Berlin).

We have an ongoing collaboration with Tim Kuipers (TU Delft/Ultimaker) on algorithms for process planning.

9.3.2. Visits of International Scientists

We have invited Tim Kuipers, a developer at Ultimaker in the Netherlands, and a PhD student at TU Delft, to join us on an ongoing project in which Samuel Hornus and Sylvain Lefebvre are involved together with the GAMBLE team of Inria Nancy. Tim visited us in Nancy for 3 weeks in September.

MIMETIC Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Liv-Lab Breizh Digital Sport

Participants: Richard Kulpa [contact], Benoit Bideau, Franck Multon.

Our project aims, through new virtual reality and augmented reality technologies, to bring people who do not practice physical activity back into sport, whether for economic reasons, or for issues related to social and/or geographical isolation. To achieve this, the Brittany Region, accompanied by identified partners with complementary skills, proposes the development and networking of dedicated rooms at regional level. These existing rooms are chosen to be as close as possible to the target population, i.e. in priority areas: in the City Political District (QPV) for Rennes and Brest, and in the Rural Area to be Revitalized (ZRR) for Auray and Rostrenen. They will be redesigned to integrate these new technologies and attract target populations through the development of remote entertainment and collaborative applications. Indeed, the rooms will be connected to each other allowing participants to train together and create a community of practitioners. They will be equipped with simple sensors to evaluate their practices using a multidisciplinary cross-disciplinary approach, with biomechanical, physiological and psychological analyses (M2S/MimeTIC, CREAD and VIPS[2] laboratories). These evaluations will be used to propose physical activities that are progressive and adapted to the level of the practitioner. Access to objective data on their performance will be an additional motivating factor to keep these target audiences active. Support to local structures will allow them to extend their sporting experience after leaving Liv-Lab. Finally, subjects suffering from pathologies that are too disabling will be redirected to a health network, such as Rennes in the Living Lab ISAR (Innovation Santé Autonomie Rennes).

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. ANR PRCE Cineviz

Participants: Marc Christie [contact], Quentin Galvane.

Cineviz is a 3-year ANR LabCom project (2016-2019). Amount: 300kE. Parnters: SolidAnim, UR1.

The project is a bilateral collaboration with the SolidAnim company. The objective is to jointly progress on the design and implementation of novel tools for the preproduction in the film industry. The project will address the challenges related to (i) proposing expressive framing tools, (ii) integrating the technical aspects of shooting (how to place the cameras, lights, green sets) directly at the design stage), and (iii) novel interaction metaphors for designing and controlling the staging of lights in preproduction, using an example-based approach.

9.2.1.2. ANR PRC Capacities

Participants: Charles Pontonnier [contact], Georges Dumont, Pierre Puchaud, Claire Livet, Anthony Sorel.

This project is leaded by Christophe Sauret, from INI/CERAH. The project objective is to build a series of biomechanical indices characterizing the biomechanical difficulty for a wide range of urban environmental situations. These indices will rely on different biomechanical parameters such as proximity to joint limits, forces applied on the handrims, mechanical work, muscle and articular stresses, etc. The definition of a more comprehensive index, called Comprehensive BioMechanical (CBM) cost, including several of the previous indices, will also be a challenging objective. The results of this project would then be used in the first place in VALMOBILE application to assist MWC users in selecting optimal route in Valenciennes agglomeration (project founded by the French National Agency for Urban Renewal and the North Department of France). The MimeTIC team is involved on the musculoskeletal simulation issues and the biomechanical costs definition.

9.2.1.3. ANR JCJC Per2

Participants: Ludovic Hoyet [contact], Benjamin Niay, Anne-Hélène Olivier, Richard Kulpa, Franck Multon.

Per2 is a 42-month ANR JCJC project (2018-2022) entitled *Perception-based Human Motion Personalisation* (Budget: 280kE; website: https://project.inria.fr/per2/)

The objective of this project is to focus on how viewers perceive motion variations to automatically produce natural motion personalisation accounting for inter-individual variations. In short, our goal is to automate the creation of motion variations to represent given individuals according to their own characteristics, and to produce natural variations that are perceived and identified as such by users. Challenges addressed in this project consist in (i) understanding and quantifying what makes motions of individuals perceptually different, (ii) synthesising motion variations based on these identified relevant perceptual features, according to given individual characteristics, and (iii) leveraging even further the synthesis of motion variations and to explore their creation for interactive large-scale scenarios where both performance and realism are critical.

This work is performed in collaboration with Julien Pettré from Rainbow team.

9.2.1.4. ANR PRCI HoBis

Participants: Franck Multon [contact], Armel Crétual, Georges Dumont, Charles Pontonnier, Anthony Sorel.

Hobis is a 42-month ANR collaborative (PRCI) project (2018-2022) entitled *Hominin BipedalismS: Exploration of bipedal gaits in Hominins thanks to Specimen-Specific Functional Morphology*. HoBis is leaded by the Museum Nationale d'Histoires Naturelles (CNRS), with CNRS/LAAS, and Antwerpen University (Belgium), with a total of 541KE budget (140KE for MimeTIC).

HoBiS (Hominin BipedalismS) is a pluridisciplinary research project, fundamental in nature and centred on palaeoanthropological questions related to habitual bipedalism, one of the most striking features of the human lineage. Recent discoveries (up to 7 My) highlight an unexpected diversity of locomotor anatomies in Hominins that lead palaeoanthropologists to hypothesize that habitual bipedal locomotion took distinct shapes through our phylogenetic history. In early Hominins, this diversity could reveal a high degree of locomotor plasticity which favoured their evolutionary success in the changing environments of the late Miocene and Pliocene. Furthermore, one can hypothesize based on biomechanical theory that differences in gait characteristics, even slight, have impacted the energy balance of hominin species and thus their evolutionary success. However, given the fragmented nature of fossil specimens , previous morphometric and anatomo-functional approaches developed by biologists and palaeoanthropologists, do not allow the assessment of the biomechanical and energetic impacts of such subtle morphological differences, and the manners in which hominin species walked still remains unknown. To tackle this problem, HoBiS proposes as main objective a totally new specimen-specific approach in evolutionary anthropology named Specimen-Specific Functional Morphology: inferring plausible complete locomotor anatomies based on fossil remains, to link these reconstructed anatomies and corresponding musculoskeletal models (MSM) with plausible gaits using simulations. Both sub-objectives will make use of an extensive comparative anatomical and gait biomechanical data bases (challenges). To this end, we will integrate anatomical and functional studies, tools for anatomical modelling, optimization and simulation rooted in informatics, biomechanics, and robotics, to build an in-silico decision-support system (DSS). This DSS will provide biomechanical simulations and energetic estimations of the most plausible bipedal gaits for a variety of hominin species based on available remains, from partial to well-preserved specimens. To achieve this main objective, the project will address the following sub-objectives and challenges

MimeTIC is Leader of WP3 "Biomechanical simulation", aiming at predicting plausible bipedal locomotion based on paleoanthropological heuristics and a given MSM.

9.2.1.5. Labex CominLabs : Moonlight

Participants: Guillaume Nicolas [contact], Nicolas Bideau.

Moonlight is a 2-year Labex Cominlabs project (2018-2019). Amount: 55kE (including a one-year postdoctoral fellowship). Partners: Granit Team IRISA (http://www-granit.irisa.fr/fr/), M2S Lab.

The Moonlight project is part of an effort to transpose the tools and methodologies used in motion capture from optoelectronic equipment to inertial unit devices. More specifically, the overall objective of Moonlight project is to design a new embedded system in order to analyze cyclists' movements in real conditions, i.e. outside of the laboratory. This requires to estimate reliable 3D joint angles, lower limb kinematics and pedals orientation. IMUs are used as an alternative to optoelectronical motion capture but some challenges have to be addressed as regards to sensor-to-segment misalignment and drift. Indeed, a real time accurate orientation of the crank is necessary to get limb position. To achieve this goal, data fusion algorithms between IMU data and pedal orientation are implemented. A wireless sensor network with accurate time synchronization mechanism is needed to process data fusion from all sensor's nodes on a tablet. Finally, the system deals with size, energy consumption and ease-to-use constraints.

9.2.2. National scientific collaborations

9.2.2.1. Cavaletic

Participant: Franck Multon [contact].

The Cavaletic collaborative project is leaded by University Bretagne Sud and also involves University Rennes2 (CREAD Lab.). It has been funded by the National IFCE (Institut Français du Cheval et de l'Equitation) in order to develop and evaluate technological assistance in horse riding learning, thanks to a user-centered approach. MimeTIC is involved in measuring expert and non-expert horse riders' motions in standardized situations in order to develop metrics to measure riders' performance. It will be used to develop a technological system embedded on users to evaluate their performance and provide them with real-time feedback to correct potential errors.

The project funded by IFCE ended in 2018 but we got a 30K€ budget from SATT Ouest Valorisation in order to finish the development of the technological prototype, and to evaluate the possibility to patent the process, and transfer it to private companies. This project is in collaboration with LEGO lab. in University Bretagne Sud, and CAIRN Inria team.

9.2.2.2. French Federation of Tennis

Participants: Richard Kulpa [contact], Benoit Bideau, Pierre Touzard.

An exclusive contract has been signed between the M2S laboratory and the French Federation of Tennis for three years. The goal is to perform biomechanical analyses of 3D tennis serves on a population of 40 players of the Pôle France. The objective is to determine the link between injuries and biomechanical constraints on joints and muscles depending on the age and gender of the players. At the end, the goal is to evaluate their training load.

9.2.3. Chaire Safran-Saint-Cyr "the enhanced soldier in the digital battlefield"

Participants: Charles Pontonnier [contact], Pierre Puchaud.

The chaire has the goal to answer to scientific questions accompanying the evolution of the technologies equipping the soldiers in mission. In this scheme, the MimeTIC team is involved in generic and specific musculoskeletal models for the prototyping of load carriage assistive devices (exoskeletons). Chair sponsored by SAFRAN group, led by Yvon Erhel (Professor, Ecoles de Sainr-Cyr Coëtquidan).

9.2.4. AUTOMA-PIED

Participants: Anne-Hélène Olivier [contact], Armel Crétual, Anthony Sorel.

The AUTOMA-PIED project is driven by IFSTTAR. Using a set-up in virtual reality, the first objective of the project aims at comparing pedestrian behaviour (young and older adults) when interacting with traditional or autonomous vehicles in a street crossing scenario. The second objective is to identify postural cues that can predict whether or not the pedestrian is about to cross the street.

9.2.5. IPL Avatar

Participants: Ludovic Hoyet [contact], Franck Multon.

This project aims at design avatars (i.e., the user's representation in virtual environments) that are better embodied, more interactive and more social, through improving all the pipeline related to avatars, from acquisition and simulation, to designing novel interaction paradigms and multi-sensory feedback. It involves 6 Inria teams (GraphDeco, Hybrid, Loki, MimeTIC, Morpheo, Potioc), Prof. Mel Slater (Uni. Barcelona), and 2 industrial partners (InterDigitak and Faurecia).

Website: http://avatar.inria.fr

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. H2020 ICT-25 PRESENT

Participants: Marc Christie, Ludovic Hoyet [contact], Anne-Hélène Olivier, Alberto Jovane, Adèle Colas.

This European project aims at creating virtual characters that are realistic in looks and behaviour, and who can act as trustworthy guardians and guides in the interfaces for AR, VR and more traditional forms of media. It is conducted in collaboration with industrial partners The Framestore Ltd, Cubic Motion Ltd, InfoCert Spa, Brainstorm Multimedia S.L., Creative Workers - Creatieve Werkers VZW, and academic partners Universidad Pompeu Fabra and Universität Augsburg.

9.3.1.2. JPI-CH SCHEDAR

Participants: Franck Multon [contact], Richard Kulpa.

SCHEDAR (Safeguarding the Cultural HEritage of Dance through Augmented Reality) is a Joint Program Initiative for preserving immaterial cultural heritage. The project started in June 2018 and will finish December 2021. It is coordinated by University of Cyprus, in collaboration with Algolysis LTD (Cyprus), University of Warwick (UK), University of Reims Champagne Ardennes (France).

Dance is an integral part of any culture. Through its choreography and costumes dance imparts richness and uniqueness to that culture. Over the last decade, technological developments have been exploited to record, curate, remediate, provide access, preserve and protect tangible CH. However, intangible assets, such as dance, has largely been excluded from this previous work. Recent computing advances have enabled the accurate 3D digitization of human motion. Such systems provide a new means for capturing, preserving and subsequently re-creating ICH which goes far beyond traditional written or imaging approaches. However, 3D motion data is expensive to create and maintain, encompassed semantic information is difficult to extract and formulate, and current software tools to search and visualize this data are too complex for most end-users. SCHEDAR will provide novel solutions to the three key challenges of archiving, re-using and re-purposing, and ultimately disseminating ICH motion data. In addition, we will devise a comprehensive set of new guidelines, a framework and software tools for leveraging existing ICH motion databases. Data acquisition will be undertaken holistically; encompassing data related to the performance, the performer, the kind of the dance, the hidden/untold story, etc. Innovative use of state-of-the-art multisensory Augmented Reality technology will enable direct interaction with the dance, providing new experiences and training in traditional dance which is key to ensure this rich culture asset is preserved for future generations. MimeTIC is responsible for WP3 "Dance Data Enhancement".

9.4. International Initiatives

9.4.1. Inria Associate Teams Not Involved in an Inria International Labs

9.4.1.1. BEAR

Title: from BEhavioral Analysis to modeling and simulation of interactions between walkeRs

International Partner: Michael Cinelli (Wilfrid Laurier University, Canada) and Michael Barnett Cowann (University of Waterloo, Canada)

Start year: 2019

See also: https://sites.google.com/view/inriabearproject/home

Interactions between individuals are by definition at the very core of our society since they represent the basic synergies of our daily life. When walking in the street or in more dynamical and strategic situations such as sports motion, we take in information about our surrounding environment in order to interact with people, move without collision, alone or in a group, intercept, meet or escape other people. In this context, the BEAR project is a collaboration between researchers from Inria Rennes (Computer Sciences) and Waterloo universities (Kinesiology-Neuroscience). The project aims at providing more realistic models and simulations of interactions between pedestrians, for various applications such as rehabilitation, computer graphics, or robotics. The originality of the project is to investigate the complexity of human interactions from a human motor control perspective, considering the strong coupling between pedestrians' visual perception and their locomotor adaptations. We will investigate how people gather the relevant information to control their motion. To provide generic models considering the inter-individual variability of humans, we will consider both normal populations and specific populations (children, older adults, injured, diseased ...) for whom an altered perception can modify their motion. The strength of this project is the complementarity of theinvolved teams. While all researchers will equally perform experiments on interactions between pedestrians, the researchers from Waterloo will take the lead to identify the relevant behavioral variables that will be used mainly by the researchers from Rennes to design the new models and simulations.

9.4.2. International Mobility Grant

- Mitacs Globalink grant: Perception-Action Integration in Collision Avoidance in Older Adults, Robyn Grundberg, University Wilfrid Laurier, Canada (April-July 2019)
- Mitacs Globalink grant: Influence of walking speed and trunk sway on collision avoidance with a virtual human, Sheryl Bourgaize, University Wilfrid Laurier, Canada (April-July 2019).

9.4.3. Inria International Partners

9.4.3.1. Informal International Partners

- Dr. Rachel McDonnell, Trinity College Dublin, Ireland (on-going collaboration with Ludovic Hoyet)
- Prof. Carol O Sullivan, Trinity College Dublin, Ireland (on-going collaboration with Ludovic Hoyet)
- Prof Michael Cinelli, University Wilfrid Laurier, Waterloo, Canada (on-going collaboration with Anne-Hélène Olivier)
- Prof Michael Barnet-Cowann, University of Waterloo, Waterloo, Canada (on-going collaboration with Anne-Hélène Olivier)
- Prof. Hui Huang, Shenzhen University (on-going collaboration with Marc Christie)
- Prof. Baoquan Chen, Pekin University (on-going collaboration with Marc Christie)
- Dr. Bin Wang, Beijing Film Academy University (on-going collaboration with Marc Christie)

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Michael Barnett-Cowan (from Waterloo University, Canada): Visiting Professor, Research Chair of America, Rennes 2 (September 2019): multisensory integration of perceptual information.
- Kristoffer Larsen Norheim (from Aalborg University, Denmark): Doctoral stay (September-November 2019): biomechanical analysis of virtual hammering tasks.

9.5.1.1. Internships

- Sheryl Bourgaize, PhD Student, Wilfrid Laurier University, Canada (April-July 2019)
- Robyn Grunberg, Master Student, Wilfrid Laurier University, Canada (April-July 2019)

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Simon Hilt: doctoral stay at Aalborg University Denmark (May-July 2019): biomechanical analysis of hammering tasks.

MOEX Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR Elker

Program: ANR-PRC

Project acronym: ELKER

Project title: Extending link keys: extraction and reasoning

Web site: https://project.inria.fr/elker/

Duration: October 2017 - September 2021

Coordinator: LIG/Manuel Atencia

Participants: Manuel Atencia Arcas, Jérôme David, Jérôme Euzenat

Other partners: Inria Lorraine, Université de Vincennes+Université Paris 13

Abstract: The goal of ELKER is to extend the foundations and algorithms of link keys (see §3.2) in two complementary ways: extracting link keys automatically from datasets and reasoning with link keys.

7.1.2. PEPS RegleX-LD

Program: Projets Exploratoires Premier Soutien (CNRS, INS2I)

Project acronym: REGLEX-LD

Project title: Découverte de règles expressives de correspondances complexes et de liage de données

Duration: January 2019 – December 2019

Coordinator: IRIT/Cássia Trojahn

Participants: Manuel Atencia Arcas, Jérôme David, Jérôme Euzenat

Other partners: IRIT Toulouse, INRA Paris, LRI Orsay

Abstract: RegleX-LD aims at discovering expressive ontology correspondences and data interlinking patterns using unsupervised or weakly supervised methods.

7.2. International Research Visitors

7.2.1. Visits of International Scientists

7.2.1.1. Internships

- Nacira Abbas (U. Lorraine) visited mOeX between 2019-02-04 and 2019-02-15 in the framework of the Elker project, working on link keys extraction with formal concept analysis.
- Hiba Belhadi, PhD student at Université des Sciences et de la Technologie Houari Boumediene (UTHB), Algiers, visited mOeX between 2019-10-15 and 2019-11-15 to work on selecting and matching properties for data interlinking.

MORPHEO Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Data Driven 3D Vision

Edmond Boyer obtained a chair in the new Multidisciplinary Institute in Artificial Intelligence (MIAI) of Grenoble Alpes University. The chair entitled Data Driven 3D Vision is for 4 years and aims at investigating deep learning for 3D artificial vision in order to break some of the limitations in this domain. Applications are especially related to humans and to the ability to capture and analyze their shapes, appearances and motions, for upcoming new media devices, sport and medical applications.

9.2. National Initiatives

9.2.1. ANR

9.2.1.1. ANR PRCE CaMoPi – Capture and Modelling of the Shod Foot in Motion

The main objective of the CaMoPi project is to capture and model dynamic aspects of the human foot with and without shoes. To this purpose, video and X-ray imagery will be combined to generate novel types of data from which major breakthroughs in foot motion modelling are expected. Given the complexity of the internal foot structure, little is known about the exact motion of its inner structure and the relationship with the shoe. Hence the current state-of-the art shoe conception process still relies largely on ad-hoc know-how. This project aims at better understanding the inner mechanisms of the shod foot in motion in order to rationalise and therefore speed up and improve shoe design in terms of comfort, performance, and cost. This requires the development of capture technologies that do not yet exist in order to provide full dense models of the foot in motion. To reach its goals, the CaMoPi consortium comprises complementary expertise from academic partners : Inria (combined video and X-ray capture and modeling) and Mines St Etienne (finite element modeling), as well as industrial : CTC Lyon (shoe conception and manufacturing, dissemination). The project has effectively started in October 2017 and is currently handled by Tomas Svaton, recruited as an engineer in April 2018.

9.2.1.2. ANR JCJC SEMBA – Shape, Motion and Body composition to Anatomy

Existing medical imaging techniques, such as Computed Tomography (CT), Dual Energy X-Ray Absorption (DEXA) and Magnetic Resonance Imaging (MRI), allow to observe internal tissues (such as adipose, muscle, and bone tissues) of in-vivo patients. However, these imaging modalities involve heavy and expensive equipment as well as time consuming procedures. External dynamic measurements can be acquired with optical scanning equipment, e.g. cameras or depth sensors. These allow high spatial and temporal resolution acquisitions of the surface of living moving bodies. The main research question of SEMBA is: "can the internal observations be inferred from the dynamic external ones only?". SEMBA's first hypothesis is that the quantity and distribution of adipose, muscle and bone tissues determine the shape of the surface of a person. However, two subjects with a similar shape may have different quantities and distributions of these tissues. Quantifying adipose, bone and muscle tissue from only a static observation of the surface of the human might be ambiguous. SEMBA's second hypothesis is that the shape deformations observed while the body performs highly dynamic motions will help disambiguating the amount and distribution of the different tissues. The dynamics contain key information that is not present in the static shape. SEMBA's first objective is to learn statistical anatomic models with accurate distributions of adipose, muscle, and bone tissue. These models are going to be learned by leveraging medical dataset containing MRI and DEXA images. SEMBA's second objective will be to develop computational models to obtain a subject-specific anatomic model with an accurate distribution of adipose, muscle, and bone tissue from external dynamic measurements only.

9.2.1.3. ANR JCJC 3DMOVE - Learning to synthesize 3D dynamic human motion

It is now possible to capture time-varying 3D point clouds at high spatial and temporal resolution. This allows for high-quality acquisitions of human bodies and faces in motion. However, tools to process and analyze these data robustly and automatically are missing. Such tools are critical to learning generative models of human motion, which can be leveraged to create plausible synthetic human motion sequences. This has the potential to influence virtual reality applications such as virtual change rooms or crowd simulations. Developing such tools is challenging due to the high variability in human shape and motion and due to significant geometric and topological acquisition noise present in state-of-the-art acquisitions. The main objective of 3DMOVE is to automatically compute high-quality generative models from a database of raw dense 3D motion sequences for human bodies and faces. To achieve this objective, 3DMOVE will leverage recently developed deep learning techniques. The project also involves developing tools to assess the quality of the generated motions using perceptual studies. This project currently involves one Ph.D. student who was hired in November 2019.

9.2.2. Competitivity Clusters

9.2.2.1. FUI24 SPINE-PDCA

The goal of the SPINE-PDCA project is to develop a unique medical platform that will streamline the medical procedure and achieve all the steps of a minimally invasive surgery intervention with great precision through a complete integration of two complementary systems for pre-operative planning (EOS platform from EOS IMAGING) and imaging/intra-operative navigation (SGV3D system from SURGIVISIO). Innovative low-dose tracking and reconstruction algorithms will be developed by Inria, and collaboration with two hospitals (APHP Trousseau and CHU Grenoble) will ensure clinical feasibility. The medical need is particularly strong in the field of spinal deformity surgery which can, in case of incorrect positioning of the implants, result in serious musculoskeletal injury, a high repeat rate (10 to 40% of implants are poorly positioned in spine surgery) and important care costs. In paediatric surgery (e. g. idiopathic scoliosis), the rate of exposure to X-rays is an additional major consideration in choosing the surgical approach to engage. For these interventions, advanced linkage between planning, navigation and postoperative verification is essential to ensure accurate patient assessment, appropriate surgical procedure and outcome consistent with clinical objectives. The project has effectively started in October 2018 with Di Meng's recruitment as a PhD candidate.

9.3. International Research Visitors

The Morpheo team is hosting Professor Stephane Durocher during his sabbatical from July 2019 to June 2020. He is involved in the team research activities, in particular on the development of efficient algorithms to cluster a set of moving objects based on their trajectories, as obtained using the Kinovis platform. This will allow to perform motion analysis tasks, such as clustering objects into components that follow similar motions, which can help in analyzing the relative motion of body parts.

9.3.1. Visits to International Teams

9.3.1.1. Research Stays Abroad

1. Victoria Fernández Abrevaya did an internship with a British company in London, from July 2019 until September 2019.
2. Nitika Verma did an intership with Google at New York, from May 2019 until September 2019.

MULTISPEECH Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. CPER LCHN

Project acronym: CPER LCHN

Project title: CPER "Langues, Connaissances et Humanités Numériques"

Duration: 2015-2020

Coordinator: Bruno Guillaume (LORIA) & Alain Polguère (ATILF)

Participants: Dominique Fohr, Denis Jouvet, Odile Mella, Yves Laprie

Abstract: The main goal is related to experimental platforms for supporting research activities in the domain of languages, knowledge and numeric humanities engineering. MULTISPEECH contributes to automatic speech recognition, speech-text alignment and prosody aspects.

9.1.2. CPER IT2MP

Project acronym: CPER IT2MP

Project title: CPER "Innovation Technologique Modélisation et Médecine Personalisée"

Duration: 2015-2020

Coordinator: Faiez Zannad (Inserm-CHU-UL)

Participants: Romain Serizel, Emmanuel Vincent

Abstract: The goal is to develop innovative technologies for health, and tools and strategies for personalized medicine. MULTISPEECH will collect data for distant-microphone voice commands.

9.1.3. Com-Medic ALOE

Company: Com-Medic (France)

Duration: Mar 2019 – August 2020

Participants: Denis Jouvet, Vincent Colotte, Slim Ouni, Louis Delebecque

Abstract: ALOE is a method of reading relying on a specific representation of sounds. Our involvement in the project is to develop tools to translate automatically and align text sentences into phone sequences as required by the ALOE system, and to provide audio and video tutoring examples.

9.2. National Initiatives

9.2.1. ANR ArtSpeech

Project acronym: ArtSpeech

Project title: Synthèse articulatoire phonétique

Duration: October 2015 - August 2020

Coordinator: Yves Laprie

Other partners: Gipsa-Lab (Grenoble), IADI (Nancy), LPP (Paris)

Participants: Ioannis Douros, Yves Laprie, Anastasiia Tsukanova

Abstract: The objective is to synthesize speech via the numerical simulation of the human speech production processes, i.e. the articulatory, aerodynamic and acoustic aspects. Articulatory data comes from MRI and EPGG acquisitions.

9.2.2. ANR JCJC KAMoulox

Project acronym: KAMoulox

Project title: Kernel additive modelling for the unmixing of large audio archives

Duration: January 2016 - September 2019

Coordinator: Antoine Liutkus (Inria Zenith)

Participants: Mathieu Fontaine

Abstract: The objective is to develop theoretical and applied tools to embed audio denoising and separation tools in web-based audio archives. The applicative scenario is to deal with the notorious audio archive "*Archives du CNRS — Musée de l'Homme*", gathering recordings dating back to the early 1900s.

9.2.3. PIA2 ISITE LUE

Project acronym: ISITE LUE

Project title: Lorraine Université d'Excellence

Duration: 2016 - 2020

Coordinator: Univ. Lorraine

Participants: Ioannis Douros, Yves Laprie

Abstract: LUE (Lorraine Université d'Excellence) was designed as an "engine" for the development of excellence, by stimulating an original dialogue between knowledge fields. Within challenge number 6: "Knowledge engineering" this project funds the PhD thesis of Ioannis Douros on articulatory modeling.

9.2.4. OLKI LUE

Project acronym: OLKI LUE

Project title: Open Language and Knowledge for Citizens, Lorraine Université d'Excellence

Coordinator: Christophe Cerisara (LORIA)

Participants: Tulika Bose, Dominique Fohr, Irène Illina

Abstract: The initiative aims at developing new algorithms that improve the automatic understanding of natural language documents, and a federated language resource distribution platform to enable and facilitate the sharing of open resources. This project funds the PhD thesis of Tulika Bose on the detection and classification of hate speech.

9.2.5. E-FRAN METAL

Project acronym: E-FRAN METAL

Project title: Modèles Et Traces au service de l'Apprentissage des Langues

Duration: October 2016 - September 2020

Coordinator: Anne Boyer (LORIA)

Other partners: Interpsy, LISEC, ESPE de Lorraine, D@NTE (Univ. Versailles Saint Quentin), Sailendra SAS, ITOP Education, Rectorat.

Participants: Theo Biasutto-Lervat, Anne Bonneau, Vincent Colotte, Dominique Fohr, Elodie Gauthier, Thomas Girod, Denis Jouvet, Odile Mella, Slim Ouni, Leon Rohrbacher

Abstract: METAL aims at improving the learning of languages (written and oral) through development of new tools and analysis of numeric traces associated with students' learning. MULTISPEECH is concerned by oral language learning aspects.

9.2.6. ANR VOCADOM

Project acronym: VOCADOM (http://vocadom.imag.fr/)

Project title: Robust voice command adapted to the user and to the context for ambient assisted living

Duration: January 2017 - December 2020

Coordinator: CNRS - LIG (Grenoble)

Other partners: Inria (Nancy), Univ. Lyon 2 - GREPS, THEORIS (Paris)

Participants: Dominique Fohr, Md Sahidullah, Sunit Sivasankaran, Emmanuel Vincent

Abstract: The goal is to design a robust voice control system for smart home applications. MULTISPEECH is responsible for wake-up word detection, overlapping speech separation, and speaker recognition.

9.2.7. ANR JCJC DiSCogs

Project acronym: DiSCogs

Project title: Distant speech communication with heterogeneous unconstrained microphone arrays

Duration: September 2018 – March 2022

Coordinator: Romain Serizel

Participants: Nicolas Furnon, Irène Illina, Romain Serizel, Emmanuel Vincent

Collaborators: Télécom ParisTech, 7sensing

Abstract: The objective is to solve fundamental sound processing issues in order to exploit the many devices equipped with microphones that populate our everyday life. The solution proposed is to apply deep learning approaches to recast the problem of synchronizing devices at the signal level as a multi-view learning problem.

9.2.8. ANR DEEP-PRIVACY

Project acronym: DEEP-PRIVACY

Project title: Distributed, Personalized, Privacy-Preserving Learning for Speech Processing

Duration: January 2019 - December 2022

Coordinator: Denis Jouvet

Other partners: LIUM (Le Mans), MAGNET (Inria Lille), LIA (Avignon)

Participants: Pierre Champion, Denis Jouvet, Emmanuel Vincent

Abstract: The objective is to elaborate a speech transformation that hides the speaker identity for an easier sharing of speech data for training speech recognition models; and to investigate speaker adaptation and distributed training.

9.2.9. ANR ROBOVOX

Project acronym: ROBOVOX

Project title: Robust Vocal Identification for Mobile Security Robots

Duration: Mar 2019 – Mar 2023

Coordinator: Laboratoire d'informatique d'Avignon (LIA)

Other partners: Inria (Nancy), A.I. Mergence

Participants: Antoine Deleforge, Sandipana Dowerah, Denis Jouvet, Romain Serizel

Abstract: The aim is to improve speaker recognition robustness for a security robot in real environment. Several aspects will be particularly considered such as ambiant noise, reverberation and short speech utterances.

9.2.10. ANR LEAUDS

Project acronym: LEAUDS

Project title: Learning to understand audio scenes

Duration: Apr 2019 - Sep 2022

Coordinator: Université de Rouen Normandie

Other partners: Inria (Nancy), Netatmo (Paris)

Participants: Mauricio Michel Olvera Zambrano, Romain Serizel, Emmanuel Vincent, and Christophe Cerisara (CNRS - LORIA)

Abstract: LEAUDS aims to make a leap towards developing machines that understand audio input through breakthroughs in the detection of thousands of audio events from little annotated data, the robustness to “out-of-the lab” conditions, and language-based description of audio scenes. MULTISPEECH is responsible for research on robustness and for bringing expertise on natural language generation.

9.2.11. Inria Project Lab HyAIAI

Project acronym: HyAIAI

Project title: Hybrid Approaches for Interpretable AI

Duration: Sep 2019 - Aug 2023

Coordinator: Inria LACODAM (Rennes)

Other partners: Inria TAU (Saclay), SEQUEL, MAGNET (Lille), MULTISPEECH, ORPAILLEUR (Nancy)

Participants: Irène Illina, Emmanuel Vincent, Georgios Zervakis

Abstract: HyAIAI is about the design of novel, interpretable artificial intelligence methods based on hybrid approaches that combine state of the art numeric models with explainable symbolic models.

9.2.12. ANR BENEPHIDIRE

Project acronym: BENEPHIDIRE

Project title: Stuttering: Neurology, Phonetics, Computer Science for Diagnosis and Rehabilitation

Duration: March 2019 - December 2023

Coordinator: Praxiling (Toulouse)

Other partners: LORIA (Nancy), INM (Toulouse), LiLPa (Strasbourg).

Participants: Yves Laprie, Slim Ouni, Shakeel Ahmad Sheikh

Abstract: This project brings together neurologists, speech-language pathologists, phoneticians, and computer scientists specializing in speech processing to investigate stuttering as a speech impairment and to develop techniques for diagnosis and rehabilitation.

9.2.13. ANR HAIKUS

Project acronym: HAIKUS

Project title: Artificial Intelligence applied to augmented acoustic Scenes

Duration: Dec 2019 - May 2023

Coordinator: Ircam (Paris)

Other partners: Inria (Nancy), IJLRA (Paris)

Participants: Antoine Deleforge, Emmanuel Vincent

Abstract: HAIKUS aims to achieve seamless integration of computer-generated immersive audio content into augmented reality (AR) systems. One of the main challenges is the rendering of virtual auditory objects in the presence of source movements, listener movements and/or changing acoustic conditions.

9.2.14. ANR Flash Open Science HARPOCRATES

Project acronym: HARPOCRATES

Project title: Open data, tools and challenges for speaker anonymization

Duration: Oct 2019 - Mar 2021

Coordinator: Eurecom (Nice)

Other partners: Inria (Nancy), LIA (Avignon)

Participants: Denis Jouvet, Md Sahidullah, Emmanuel Vincent

Abstract: HARPOCRATES will form a working group that will collect and share the first open datasets and tools in the field of speech privacy, and launch the first open challenge on speech privacy, specifically on the topic of voice de-identification.

9.2.15. ATT Dynalips & ATT Dynalips-2

Project acronym: DYNALIPS

Project title: Automatic Lip synchronization with speech

Duration: Jul 2018 - Dec 2019

Coordinator: Slim Ouni

Participants: Valerian Girard, Slim Ouni

Abstract: This is a technology transfer project of our research solution that aims to synchronize precisely and automatically the movement of the mouth of a 3D character with speech. We address 3D animation and video game industries.

9.2.16. InriaHub Carnot Technologies Vocales

Project title: InriaHub Carnot Technologies Vocales

Duration: Jan 2019 - Dec 2020

Coordinator: Denis Jouvet

Participants: Mathieu Hu, Denis Jouvet, Dominique Fohr, Vincent Colotte, Emmanuel Vincent, Romain Serizel

Abstract: This project aims to adjust and finalize the speech synthesis and recognition modules developed for research purposes in the team, so that they can be used in interactive mode.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. COMPRISE

Program: H2020 ICT-29-2018 (RIA)

Project acronym: COMPRISE

Project title: Cost-effective, Multilingual, Privacy-driven voice-enabled Services

Duration: Dec 2018- Nov 2021

Coordinator: Emmanuel Vincent

Other partners: Inria Magnet, Ascora GmbH, Netfective Technology SA, Rooter Analysis SL, Saarland University, Tilde SIA

Participants: Irène Illina, Denis Jouvet, Imran Sheikh, Brij Mohan Lal Srivastava, Mehmet Ali Tugtekin Turan, Emmanuel Vincent

Abstract: COMPRISE will define a fully private-by-design methodology and tools that will reduce the cost and increase the inclusiveness of voice interaction technologies.

9.3.1.2. AI4EU

Program: ICT-26-2018-2020

Project acronym: AI4EU

Project title: European Artificial Intelligence On-Demand Platform and Ecosystem

Duration: 2019–2021

Coordinator: THALES

Other partners: 80 partners from 22 countries

Participants: Seyed Ahmad Hosseini, Slim Ouni

Abstract: The aim of AI4EU is to develop a European Artificial Intelligence ecosystem, from knowledge and algorithms to tools and resources.

9.3.1.3. CPS4EU

Program: PSPC-ECSEL

Project acronym: CPS4EU

Project title: Cyber-physical systems for Europe

Duration: June 2019 – June 2022

Coordinator: CEA

Other partners: 42 partners from 6 countries

Participants: Antoine Deleforge, Romain Serizel

Abstract: CPS4EU aims to develop key enabling technologies, pre-integration and development expertise to support the industry and research players' interests and needs for emerging interdisciplinary cyber-physical systems (CPS) and securing a supply chain around CPS enabling technologies and products.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

9.3.2.1. AMIS

Program: CHIST-ERA

Project acronym: AMIS

Project title: Access Multilingual Information opinionS

Duration: Dec 2015- Nov 2019

Coordinator: Kamel Smaïli (LORIA)

Other partners: University of Avignon, University of Science and Technology Krakow, University of DEUSTO (Bilbao)

Participants: Dominique Fohr, Denis Jouvet, Odile Mella, Mohamed Amine Menacer

Abstract: The idea is to develop a multilingual system to help people understand broadcast news in a foreign language and compare them to corresponding news available in the user's mother tongue. MULTISPEECH contributions concern mainly the speech recognition in French, English and Arabic videos.

9.3.2.2. M-PHASIS

Program: ANR-DFG

Project acronym: M-PHASIS

Project title: Migration and Patterns of Hate Speech in Social Media - A Cross-cultural Perspective

Duration: March 2019 - Feb 2022

Coordinators: Angeliki Monnier (CREM) and Christian Schemer (Johannes Gutenberg university)

Partners: CREM (UL), LORIA (UL), JGUM (Johannes Gutenberg-Universität), SAAR (Saarland University)

Participants: Irène Illina, Dominique Fohr, Ashwin Geet D'sa

Abstract: Focusing on the social dimension of hate speech, M-PHASIS seeks to study the patterns of hate speech related to migrants, and to provide a better understanding of the prevalence and emergence of hate speech in user-generated content in France and Germany. MULTISPEECH contributions concern mainly the automatic detection of hate speech in social media.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- Alessio Brutti & Maurizio Omologo, Fondazione Bruno Kessler (Italy)
  speech enhancement and speaker recognition [60]
- Samuele Cornell & Stefano Squartini, Università Politecnica delle Marche (Italy)
  speech enhancement and speaker recognition [59], [60]
- Tomi Kinnunen, University of Eastern Finland (Finland)
  speaker recognition & spoofing countermeasures [35], [12], [51], [54], [46].
- Justin Salamon, Adobe Research (USA)
  Sound event detection [48], [61]
- Junichi Yamagishi, National Institute of Informatics (Japan)
  speaker recognition & spoofing countermeasures [51], [46].

9.5. International Research Visitors

9.5.1. Visits to International Teams

9.5.1.1. Research Stays Abroad

- 2019 Sixth Frederick Jelinek Memorial Summer Workshop (Jun.–Aug. 2019, M. Pariente, S. Sivasankaran)

ORPAILLEUR Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. ANR ELKER (2017–2020)

Participants: Nacira Abbas, Miguel Couceiro, Amedeo Napoli.

The objectives of the ELKER ANR Research Project (https://project.inria.fr/elker/) are to study, formalize, and implement the search for link keys in RDF data [2]. Link keys generalize database keys in two independent directions, as firstly they deal with RDF data and secondly they apply across two relation datasets. In this project, we study the discovery of link keys and reasoning with link keys, being based on the FCA formalism. The ELKER project relies on the competencies of the Orpailleur Team in FCA and pattern structure algorithms, and also in partition pattern structures which are related to the discovery of functional dependencies. This project involves the EPI Orpailleur at Inria Nancy Grand Est, the EPI MOEX at Inria Grenoble Rhône Alpes, and LIASD at Université Paris 8.

9.1.1.2. ANR PractiKPharma (2016–2020)

Participants: Miguel Couceiro, Adrien Coulet, Pierre Monnin, Amedeo Napoli, Yannick Toussaint.

PractiKPharma for "Practice-based evidences for actioning Knowledge in Pharmacogenomics" is an ANR research project (http://practikpharma.loria.fr/) about the validation of domain knowledge in pharmacogenomics. Pharmacogenomics is interested in understanding how genomic variations related to patients have an impact on drug responses. While most of the available knowledge in pharmacogenomics –state of the art knowledge– lies in the biomedical literature, with various levels of validation, an originality of PractiKPharma is to use Electronic Health Records (EHRs) to constitute cohorts of patients where to discover knowledge units. Indeed, these cohorts are mined for discovering potential pharmacogenomics patterns to be then validated w.r.t. literature knowledge for becoming actionable knowledge units. More precisely, firstly we have to discover pharmacogenomic patterns from the literature, and secondly we should confirm or moderate the interpretation and validation of these units by mining EHRs. Comparing knowledge patterns extracted from the literature with facts extracted from EHRs is a complex task depending on the EHR language –the literature is in English whereas EHRs are in French– and on knowledge level, as EHRs represent observations at the patient level whereas the literature is related to sets of patients. The PractiKPharma involves three other laboratories, namely LIRMM in Montpellier, SSPIM in St-Etienne, and CRC in Paris.

9.1.1.3. ANR AstroDeep (2019–2022)

Participants: Miguel Couceiro, Amedeo Napoli, Claire Theobald.

Astronomical surveys planned for the coming years will produce data that present analysis challenges not only because of their scale (hundreds of petabytes), but also by the complexity of the measurement challenges on very deep images (for instance subpercent-level measurement of colors or shapes on blended objects). New machine learning techniques appear very promising: once trained, they are very efficient and excel at extracting features from complex images. In the AstroDeep project, we aim at developing such machine learning techniques that can be applied directly on complex images without going through the traditional steps of astronomical image processing, that lose information at each stage. The developed techniques will help to leverage the observation capabilities of future surveys (LSST, Euclid, and WFIRST), and will allow a joint analysis of data.

The AstroDeep ANR Project involves three labs, namely APC Paris ("Astroparticules et Cosmologie Paris"), the Orpailleur Team at Inria Nancy Grand Est/LORIA, and "Département d'Astrophysique CEA Saclay".

9.1.2. Inria Project Labs, Exploratory Research Actions, and Technological Development Actions

Participants: Guilherme Alves Da Silva, Alexandre Bazin, Miguel Couceiro, Nyoman Juniarta, Tatiana Makhalova, Amedeo Napoli, Laureline Nevin, Abdelkader Ouali, Claire Theobald, Georgios Zervakis.

HyAiAI (IPL 2019-2022) Recent progress in Machine Learning (ML) and especially in Deep Learning has made ML present and prominent in a wide range of applications. However, current and efficient ML approaches rely on complex numerical models. Then, the decisions which are proposed may be accurate but cannot be easily explained to the layman, especially in some cases where complex and human-oriented decisions should be made, e.g. to get a loan or not, to obtain a chosen enrollment at university. The objectives of the HyAIAI IPL are to study the problem of making ML methods interpretable. For that, we will design hybrid ML approaches that combine state of the art numerical models (e.g. neural networks) with explainable symbolic models (e.g. pattern mining). More precisely, one goal is to integrate high level domain constraints into ML models, to provide model designers information on ill-performing parts of the model, and to give the layman/practitioner understandable explanations on the results of the ML model.

The HyAIAI IPL project involves seven Inria Teams, namely Lacodam in Rennes (project leader), Magnet and SequeL in Lille, Multispeech and Orpailleur in Nancy, and TAU in Saclay.

Ordem (ADT 2019-2020) One of the outputs of the former Hybride ANR project was the Orphamine system which aims at information retrieval and diagnosis aid in the domain of “rare diseases”. The Orphamine system is based on domain knowledge, and in particular on medical ontologies such as ORDO (“Orphanet Rare Diseases Ontology”) and HPO (“Human Phenotype Ontology”). In this way, the objective of the “Ordem” ADT is to update Orphamine, in making the system more accessible and more open. This requires many developments for developing the connections with domain knowledge, graph mining methods for retrieving relevant units in knowledge graphs, actual visualization tools, pattern mining, statistical decision tools for decision making (in particular log-linear models), and as well text mining tools for analyzing expert queries and medical literature about rare diseases. Such developments are and will be carried out until the end of next year, for making the system robust and publicly accessible through a web interface.

HyGraMi (PRE Inria 2018-2020) Finally, the so called “projet de recherche exploratoire” (PRE) HyGraMi for “Hybrid Graph Mining for the Design of New Antibacterials” is about the fight against resistance of bacteria to antibiotics. The objective of HyGraMi is to design a hybrid data mining system for discovering new antibacterial agents. This system should rely on a combination of numeric and symbolic classifiers, that will be guided by expert domain knowledge. The analysis and classification of the chemical structures is based on an interaction between symbolic methods e.g. graph mining techniques, and numerical supervised classifiers based on exact and approximate matching. This year we work on a method based on tree decomposition for performing feature selection and improving data lining of such complex molecular structures [49].

9.2. European Initiatives

9.2.1. The H2020 CrossCult Project (2016-2019)

Participants: Miguel Couceiro, Nyoman Juniarta, Amedeo Napoli.

The H2020 CrossCult [0] project aims at making “reflective history” a reality in the European cultural context, by enabling the re-interpretation of European (hi)stories through cross-border interconnections among cultural digital resources, citizen viewpoints and physical venues. The project has two main goals, (i) to lower cultural EU barriers and create unique cross-border perspectives, by connecting existing digital historical resources and by creating new ones through public participation, (ii) to create long-lasting experiences of social learning and entertainment that will provide a better understanding and re-interpretation of European history. To achieve

[0] http://www.crosscult.eu/

this, CrossCult aims at connecting and combining existing digital cultural assets, at increasing integration, interaction, and reflection about European past and present history. CrossCult was implemented w.r.t. four real-world pilots including cities, museums, and cultural sites. The role of the Orpailleur Team, in conjunction with the LORIA Kiwi Team, was to work on data mining –actually sequence mining– and recommendation, with a focus on the mining visitor trajectories in a museum or a touristic site, and on the definition of a visitor profile in connection with domain knowledge.

The CrossCult project involved many teams, namely Luxembourg Institute for Science and Technology and Centre Virtuel de la Connaissance sur l'Europe (Luxembourg, leaders of the project), University College London (England), University of Malta (Malta), University of Peloponnese and Technological Educational Institute of Athens (Greece), Università degli Studi di Padova (Italy), University of Vigo (Spain), National Gallery (London, England), and GVAM Guìas Interactivas (Spain), and the Kiwi Team from LORIA together with the Orpailleur team.

9.3. International Initiatives

9.3.1. Inria International Labs

Inria@SiliconValley

Associate Team involved in the International Lab:

9.3.1.1. Snowball

Title: Discovering knowledge on drug response variability by mining electronic health records

International Partner (Institution - Laboratory - Researcher):

University of Stanford (United States) - Department of Medicine, Stanford Center for Biomedical Informatics Research (BMIR) - Nigam Shah

Start year: 2017

See also: http://snowball.loria.fr/

Snowball (2017-2019) is an Inria Associate Team and the continuation of the preceding Associate Team called Snowflake (2014-2016). The objective of Snowball is to study drug response variability through the lens of Electronic Health Records (EHRs). This is motivated by the fact that many factors, genetic as well as environmental, contribute to different responses from people to the same drug. The mining of EHRs can bring substantial elements for understanding and explaining drug response variability.

Accordingly the objectives of Snowball are to identify in EHR repositories groups of patients which are responding differently to similar treatments, and then to characterize these groups and predict patient drug sensitivity. These objectives are complementary to those of the PractiKPharma ANR project. Moreover, Adrien Coulet finished in September 2019 a two-years sabbatical stay in the lab of Nigam Shah at Stanford University initiated in September 2017 (and partly granted by an “Inria délégation”).

9.3.2. Informal International Partners: Research Collaboration with HSE Moscow

Participants: Alexandre Bazin, Nacira Abbas, Guilherme Alves Da Silva, Miguel Couceiro, Nyoman Juniarta, Tatiana Makhalova, Amedeo Napoli, Justine Reynaud.

An ongoing collaboration involves the Orpailleur team and Sergei O. Kuznetsov at Higher School of Economics in Moscow (HSE). Amedeo Napoli visited HSE laboratory several times while Sergei O. Kuznetsov visits Inria Nancy Grand Est every year. The collaboration is materialized by the joint supervision of students (such as the thesis of Aleksey Buzmakov defended in 2015 and the ongoing thesis of Tatiana Makhalova), and the the organization of scientific events, as the workshop FCA4AI with seven editions between 2012 and 2019 (see http://www.fca4ai.hse.ru).

This year, we participated in the writing of common publications around the thesis work of Tatiana Makhalova and the organization of one main event, namely the seventh edition of the FCA4AI workshop in August 2019 at the IJCAI Conference which was held in Macao China.

PANAMA Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. Labex Comin Labs projects

CominLabs is a Laboratoire d'Excellence funded by the PIA (Programme Investissements d'Avenir) in the broad area of telecommunications.

- **HEMISFER (2014-2017) and HEMISFER-CLINICAL (2018-2019)**
  Participant: Rémi Gribonval.

  Acronym: HYBRID (Hybrid Eeg-MrI and Simultaneous neuro-feedback for brain Rehabilitation)

  http://hemisfer.cominlabs.u-bretagneloire.fr/

  Research axis: 3.1

  CominLabs partners : EMPENN, HYBRID and PANAMA Inria project-teams;

  External partners : EA 4712 team from University of Rennes I; ATHENA Inria project-team, Sophia-Antipolis;

  Coordinator: Christian Barillot, EMPENN Inria project-team

  Description: The goal of HEMISFER is to make full use of neurofeedback paradigm in the context of rehabilitation and psychiatric disorders. The major breakthrough will come from the use of a coupling model associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to "enhance" the neurofeedback protocol. We propose to combine advanced instrumental devices (Hybrid EEG and MRI platforms), with new man-machine interface paradigms (Brain computer interface and serious gaming) and new computational models (source separation, sparse representations and machine learning) to provide novel therapeutic and neuro-rehabilitation paradigms in some of the major neurological and psychiatric disorders of the developmental and the aging brain (stroke, attention-deficit disorder, language disorders, treatment-resistant mood disorders, ...).

  Contribution of PANAMA: PANAMA, in close cooperation with the EMPENN team, contributes to a coupling model between EEG and fMRI considered as a joint inverse problem addressed with sparse regularization. By combining both modalities, one expects to achieve a good reconstruction both in time and space. This new imaging technique will then be used for improving neurofeedback paradigms in the context of rehabilitation and psychiatric disorders, which is the final purpose of the HEMISFER project.

- **TEPN**
  Participant: Rémi Gribonval.

  Acronym: TEPN (Toward Energy Proportional Networks)

  http://tepn.cominlabs.u-bretagneloire.fr/

  Research axis: 3.1

  CominLabs partners : IRISA OCIF - Telecom Bretagne; IETR SCN; IETR SCEE; PANAMA Inria project-team

  Coordinator: Nicolas Montavont, IRISA OCIF - Telecom Bretagne

Description: As in almost all areas of engineering in the past several decades, the design of computer and network systems has been aimed at delivering maximal performance without regarding to the energy efficiency or the percentage of resource utilization. The only places where this tendency was questioned were battery-operated devices (such as laptops and smartphones) for which the users accept limited (but reasonable) performance in exchange for longer use periods. Even though the end users make such decisions on a daily basis by checking their own devices, they have no way of minimizing their energy footprint (or conversely, optimize the network resource usage) in the supporting infrastructure. Thus, the current way of dimensioning and operating the infrastructure supporting the user services, such as cellular networks and data centers, is to dimension for peak usage. The problem with this approach is that usage is rarely at its peak. The overprovisioned systems are also aimed at delivering maximal performance, with energy efficiency being considered as something desired, but non-essential. This project aims at making the network energy consumption proportional to the actual charge of this network (in terms of number of served users, or requested bandwidth). An energy proportional network can be designed by taking intelligent decisions (based on various constraints and metrics) into the network such as switching on and off network components in order to adapt the energy consumption to the user needs. This concept can be summarized under the general term of Green Cognitive Network Approach.

Contribution of PANAMA: PANAMA, in close cooperation with the SCEE team at IETR (thesis of Marwa Chafii, 2016), focuses on the design of new waveforms for multi carrier systems with reduced Peak to Average Power Ratio (PAPR).

- **FAWI** (2019-2020)
  Fourier Adaptive Waveform Implementation
  Participant: Rémi Gribonval.
  - This project is a follow-up to TEPN. Its main goal is to implement a prototype demonstrating concretely the feasibility of the new Fourier Adaptive Waveform modulation which has been patented [62].
  - Contribution of PANAMA: to provide initial training to the recruited engineer in charge of the implementation.
  - *Partners: PANAMA, IETR.*
  - Funding: 18 months of engineer, hosted by IETR.
- **SPARSE** (2019)
  Sparse representations in continuous dictionaries
  Participants: Rémi Gribonval, Clément Elvira, Clément Merdrignac.
  - This short exploratory action aims to explore the new paradigm of sparse representations in "continuous" dictionaries.
  - Contribution of PANAMA: to design algorithms for the sparse representation problem in continuous dictionaries with theoretical success guarantees.
  - *Partners: PANAMA, SIMSMART (Inria-Rennes), ENSTA Bretagne, IMT Atlantique.*
  - Funding: 5.6kEuros (internship + travel)

8.1.2. ANR INVATE project with IRT b-com, Rennes

Participants: Rémi Gribonval, Nancy Bertin, Mohammed Hafsati.

Thesis on 3D audio scene decomposition for interactive navigation

Duration: 3 years (2016-2019)

Research axis: 3.2.2

Partners: IRT b<>com; Inria-Rennes; IRISA

Funding: ANR INVATE project (PIA)

The objective of this thesis is to develop tools to analyze audio scenes in order to identify, locate, and extract the sources present in the scene to re-spatialize them according to the user head orientation and the movement of the user in the targeted virtual scene.

8.1.3. ANR OATMIL project

Participants: Rémi Gribonval, Antoine Chatalic, Nicolas Courty.

Duration: 4 years (2017-2021)

Acronym: OATMIL (Bringing Optimal Transport and Machine Learning Together)

http://people.irisa.fr/Nicolas.Courty/OATMIL/

Research Axis 3.1

Partners: Obelix team and PANAMA Inria project-team, IRISA; LITIS, Rouen; Lagrange Laboratory, Nice; Technicolor R&I France, Rennes.

Coordinator: Nicolas Courty (Obelix team)

Description: The OATMIL project will propose novel concepts, methodologies, and new tools for exploiting large data collections. This will result from a cross-fertilization of fundamental tools and ideas from optimal transport (OT) and machine learning (ML). The main objective of OATMIL is to develop new techniques for large-scale machine learning, encompassing adaptability, scalability, and robustness, by a cross-fertilization of ideas coming from OT and ML. This cross-fertilization leads to two complementary scientific challenges : bringing OT to ML and bringing ML to OT.

Contribution of PANAMA: PANAMA will explore the use of dimension-reduction with sketching strategies in the context compressive optimal transport.

Funding: ANR

8.1.4. Collaboration with 5th dimension – dynamic separation of localized sound sources

Participants: Nancy Bertin, Ewen Camberlein, Romain Lebarbenchon.

Duration: 1 year (2018-2019)

Research axis: 3.2

Partner: 5^{th} dimension (https://5dimo.com/)

Funding: LABEX AMIEX (https://www.agence-maths-entreprises.fr/a/)

After a first phase of this contract which involved porting in C++ a subset of our source localization library Multichannel BSS Locate (Oct.-Nov. 2018, in collaboration with InriaTech), a second phase was realized in 2019 with support from LABEX AMIES. We specified and recorded new data adapted to the partner's use case (microphones on glasses temples) and investigated the interplay between localization and separation, using the FASST library, on simulated and real data recorded with a prototype.

8.2. International Initiatives

8.2.1. Inria International Partners

8.2.1.1. Informal International Partners

Nancy Bertin is “external collaborator” of the MERLIN project (project between the Acoustics Research Institute of the Austrian Academy of Sciences and the Signal Processing Laboratory at Brno University of Technology.)

8.3. International Research Visitors

8.3.1. Visits of International Scientists

8.3.1.1. Internships

- Pavel Záviška and Ondřej Mokrý, visiting students from Brno University of Technology, in December 2018 (within the MERLIN collaboration).
- Andersen Man Shun Ang, visiting student from University of Mons, in February 2019.

PERCEPTION Project-Team

7. Partnerships and Cooperations

7.1. European Initiatives

7.1.1. Collaborations with Major European Organizations

Universitat Politècnica de Catalunya (UPC), Spain

Physical complex Interactions and Multi-person Pose Estimation (PIMPE) is three year project financed by IDEX. The scientific challenges of PIMPE are the followings: (i) Modeling multi-person interactions in full-body pose estimation, (ii) Estimating human poses in complex multi-person physical interactions, and (iii) Generating controlled and realistic multi-person complex pose images.

7.2. International Research Visitors

7.2.1. Research Stays Abroad

Xavier Alameda-Pineda spent three months at the University of Verona, Italy.

Yihong Xu (Ph.D. student) spent three months at the Technical University Munich, Germany.

PERVASIVE Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. LabEx Persyval, Project RHUM, Robots in Human Environments

Participants: Thierry Fraichard, Patrick Reignier.

Partners: GIPSA, Inria, LIG, LJK and TIMC.
Dates:*[Sep. 15-Dec. 19].*

The RHUM project from the LabEx Persyval (ANR-11-LABX-0025-01) brings together ten teams from different labs from the Grenoble academic scene: GIPSA, Inria, LIG, LJK and TIMC. Its goal is to tackle scientific problems related to active perception, navigation in human environments, learning and adaptation of robots behaviors for social interaction. PERVASIVE contributes to the navigation in human environments aspects.

8.1.2. ExpeSigno

Participants: Patrick Reignier, Amr Al-Zouhri Al-Yafi, Amine Awada.

Projet Région Pack Ambition Recherche EXPESIGNO : Expérimentation de la réactivité des ménages aux signaux des opérateurs de systèmes énergétiques
Other Partners : Laboratoire Gaël, Laboratoire G2ELAb, laboratoire G-Scop
Dates : 2018 - 2022

Buildings represent 66% of electricity consumption and they can act as nodes in a network of consumption, storage and energy production. In this case, it can be understood that buildings and their inhabitants will change from a passive consumer to an active consumer (the so called “pro-sumer”) who can respond quickly to price changes on the network and / or signals from operators, or even other pro-sumers offering energy production and storage solutions using solar panels or electric cars. To achieve this goal, energy systems must send consumers the right signal to induce appropriate local and global behavior. The introduction of equipment such as Smart Meters or interactive consumption management devices is decisive because they are considered as the solution to turn residential consumers into active users of their electricity or energy consumption. Nudges are an interesting way to induce lasting changes in consumer behavior. The idea of nudges is to set up environments of choice that help people make the choices that are best for them. During this project, we are going to deploy sensors within 4 volunteer families in order to study the impact of nudges on electricity consumption through a detailed analysis of the practices carried out. The objective is to establish the links between the sensor data and the activities declared by each household and to measure how nudges influence their activities.

8.1.3. ANR Project CEEGE: Chess Expertise from Eye Gaze and Emotion

Participants: Thomas Guntz, James Crowley, Dominique Vaufreydaz, Raffaella Balzarini.

Other Partners : Dept of NeuroCognition, CITEN, Bielefeld University
Dates : Jan 2016 to Dec 2019

The ANR CEEGE project is a multidisciplinary scientific research project conducted by the Inria PRIMA team in cooperation with the Dept of Cognitive Neuroscience at the University of Bielefeld. The primary impacts will be improved scientific understanding in the disciplines of Computer Science and Cognitive NeuroScience. The aim of this project is to experimentally evaluate and compare current theories for mental modelling for problem solving and attention, as well as to refine and evaluate techniques for observing the physiological reactions of humans to situation that inspire pleasure, displeasure, arousal, dominance and fear.

In this project, we have observed the visual attention, physiological responses and mental states of subject with different levels of expertise solving classic chess problems, and participating in chess matches. We observe chess players using eye-tracking, sustained and instantaneous face-expressions (micro-expressions), skin conductivity, blood flow (BVP), respiration, posture and other information extracted from audio-visual recordings and sensor readings of players. We use the recorded information to estimate the mental constructs with which the players understand the game situation. Information from visual attention as well as physiological reactions has been used to determine and model the degree to which a player understands the game situation in terms of abstract configurations of chess pieces. This provides a structured environment that use for experimental evaluation of current theories of mental modeling and emotional response during problem solving and social interaction.

The project have been organized in two phases. During the first phase, we will observed individual players of different levels of chess expertise solving known chess problems. We correlated scan-path from eye tracking and other information about visual attention to established configurations of pieces and known solutions to chess problems. We constructed a labeled corpus of chess play that can be used to evaluate competing techniques for estimating mental models and physiological responses. In a second phase, we have observed the attention and face expressions of pairs of players of different levels of chess ability solving problems followed by verbal self reports. We have used these recordings to evaluate the effectiveness of competing techniques for mental modeling and observation of emotions in terms of their abilities to predict the chess abilities of players, game outcomes and individual moves and player self reports.

8.1.4. CDP EcoSesa - Cross Disciplinary Project of the ComUE UGA

Participants: Patrick Reignier, James Crowley, Raffaella Balzarini, Amr Al-Zouhri Al-Yafi.

Funding : UGA Idex Cross disciplinary project
Dates : Jan 2017 to Dec 2020

Cities and their energy systems are undergoing profound transformations. Electric Power networks are being transformed from centralized, high capacity, generating plants, dimensioned to meet peak loads to decentralized, local, production based on intermittent renewable sources. This transformation is made possible by integration of information and energy technologies, new energy materials and components, and the rapid spread of pervasive computing. The result is a change in the socio-economics of energy distribution, and a change in the role of users from passive consumers to active participants in a dynamically fluctuating energy market. Many cities worldwide have initiated research projects and experiments to accelerate the spread of clean technologies. However, these initiatives generally focus on a specific issue that depends on the priorities and preferences of the local decision makers and stakeholders. At the same time, academic research has generally been confined to specialized silos in energy materials and management systems, in Social Sciences as well as in Information and Communication Technologies (ICT), resulting in piecemeal knowledge.

The vision of Eco-SESA is to address the problems resulting from the transition to clean decentralized energy production based on renewable sources with a holistic integrated humansystem approach. The project will address the development of Safe, Efficient, Sustainable and Accessible energy systems, from the individual end-user to dynamic communities of stakeholders at the district and grid levels.

Pervasive is involved in two research front of the project :

- Interactive systems to involve occupants of buildings
- Emerging behaviors from individual to communities

8.1.5. ANR VALET

Participant: Dominique Vaufreydaz.

Partners: Inria (Pervasive and Chroma teams for Inria Rhône-Alpes, RITS in Paris), Ircyyn (Nantes), AKKA (Paris)
Dates: 2016-2018

The ANR VALET project investigates two aspects of car sharing. In the first one, a novel approach for solving vehicle redistribution problem is proposed by managing an autonomous platoons guided by professional drivers. The second aspect concerns autonomous parking of shared cars when they arrived at their destination parking lot. In this project, our researches address the prediction of pedestrians' behaviors during urban fleet movements and during parking phases. The PhD student (Pavan Vashista) recruited in this project focus on integrating models of human behaviors to evaluate the risk that surrounding pedestrians encounter the trajectory of the VALET vehicles. His PhD thesis started in February 2016 is co-supervised by Anne Spalanzani (Chroma team) and Dominique Vaufreydaz.

8.1.6. ANR HIANIC

Participant: Dominique Vaufreydaz.

Partners: ARMEN and PACCE teams from LS2N laboratory (Nantes), Inria (Pervasive and Chroma teams for Inria Rhône-Alpes, RITS in Paris), MAGMA from LIG laboratory (Grenoble).
Dates: 2018-2021

The HIANIC project proposes to endow autonomous vehicles with smart behaviors (cooperation, negotiation, socially acceptable movements) to address problems that arise when autonomous cars are mixed with pedestrians in urban shared environment. It aims at developing new technologies in term of autonomous navigation in dense and human populated traffic. In order to contribute to urban safety and intelligent mobility, the HIANIC project also explores the complex problem of sociable interactions between pedestrians and cars while sharing the same urban environment.

In this project, Dominique Vaufreydaz works jointly with the Chroma team on perceiving pedestrians and their behaviors around autonomous cars and on interaction between autonomous vehicles and pedestrians.

8.1.7. LabEx Persyval - Project MicroBayes: Probabilistic Machines for Low-level Sensor Interpretation

Participants: Emmanuel Mazer, Raphael Frisch.

Partners: Laurent Girin (GIPSA Lab), Didier Piau (L'Institut Fourier)
Dates: Nov 2016 to Nov 2019

The project MicroBayes builds on results of the recently completed EC FET Open project BAMBI to explore a new technique for Blind source separation and acoustic signal location using a new form of Bayesian Computer. The techniques have recently been demonstrated using a software simulation. Current plans are to implement and demonstrate the Bayesian computer using an FPGA. By the end of the project we expect to produce a hardware implementation suitable for use in low-cost low-power applications.

8.1.8. Competitivity Clusters

James Crowley is on the scientific committee for the Minalogic Competitivity Cluster. Minalogic is the global innovation cluster for digital technologies serving France's Auvergne-Rhône-Alpes region. The Scientific Committee advises the pole of strategy, advises local industry in proposal preparation, reviews FUI project proposals, and makes recommendations about labelling and support of project proposals.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. AI4EU - A European AI On-Demand Platform and Ecosystem

Call: H2020 ICT-26-2018-2020
Coordinateur: Thales Systems
Partners: 79 European institutions
Dates: Jan 2019 through Dec 2021

AI4EU will build a comprehensive European AI-on-demand Platform that provides innovators in all areas of society with access to expertise, knowledge, algorithms and tools for developing, deploying and funding innovations based on Artificial Intelligence.

The aim is to empower actors across a broad spectrum of commercial, industrial and societal sectors in Europe with tools for innovation through AI Technologies. By bringing together a whole ecosystem of researchers, innovators, SMEs, large corporations, students and many others, around a single access point to AI resources, we will lower the barriers to education, research and innovation. Moreover, the AI4EU Platform will embrace on European values, respect European laws and support a human-centric approach providing a competitive advantage for European players.

8.2.1.2. H2020 FET Human AI

Call: H2020 FETFLAG-01-2018
Coordinateur: DFKI
Partners: 49 European institutions
Dates:1 March 2019 to 31 May 2020.

Humane AI has been funded to create a European network of centers of excellence for Artificial Intelligence technologies that synergistically work with humans, seamlessly fit in with our complex social settings and dynamically adapt to changes in our environment. The project seeks to develop world-leading insights and AI technologies, from fundamental algorithms, through methods specific to concrete applied AI domains such as Computer Vision, Robotics, IoT, Language Technologies and multi Agent Systems all the way up to disruptive AI applications and broadly usable platforms. Core innovations include (1) tools for enhancing human cognitive capabilities, channeling human creativity, inventiveness and intuition and empowering humans to make important decisions in a more informed way, (2) AI systems that can intelligently interact with and within complex social settings and seamlessly adapt to changing, open-ended environments, (3) explainable, transparent, validated and thus trustworthy AI systems that will help us more effectively deal with the complexity of a networked globalized world and (4) ways to embed values, ethics, privacy and security as core design considerations in all AI systems and applications.

To ensure broad and lasting socio-economic impact in areas which are important to Europe and its citizens on top of the basic research we will implemented dedicated impact-oriented work packages in domains such as Society and Policy, Industry 4.0, Sustainability and Energy, Finance, Science and Education, Health and Mobility/Automotive. To realize the Humane AI vision the consortium has lined up key European players and brought the relevant community on board to mobilize the critical mass needed for success. Many of the partners have strong interdisciplinary research track records, and several PIs on this project hold ERC grants, documenting scientific excellence. With their capability, networks and experience, we have a solid plan to bring the remaining players into the flagship activity during the preparatory action phase.

8.3. International Research Visitors

8.3.1. Visits of International Scientists

8.3.1.1. Sethserey Sam, Vice-Président NIPTICT, Phnom Penh

Position: Vice-Président en charge de la recherche et des relations internationales du NIPTICT, Phnom Penh, Cambodge (et son assistante)
Date: Du 14 au 17 Avril 2019

8.3.1.2. Dr. Dao Trung Kien

Position: Directeur adjoint de l'Institut MICA, HUST, Hanoi, Vietnam
Date: novembre et décembre 2019
Travail sur la thématique de la localisation indoor de personnes grâce aux technologies sans fil et à la fusion intelligente de données hétérogènes.

PETRUS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR PerSoCloud (Jan 2017 - Dec 2020)

Partners: Orange Labs (coordinator), PETRUS (Inria-UVSQ), Cozy Cloud, U. of Versailles.

The objective of PerSoCloud is to design, implement and validate a full-fledged Privacy-by-Design Personal Cloud Sharing Platform. One of the major difficulties linked to the concept of personal cloud lies in organizing and enforcing the security of the data sharing while the data is no longer under the control of a central server. We identify three dimensions to this problem. Devices-sharing: assuming that the primary copy of user U1's personal data is hosted in a secure place, how to share and synchronize it with U1's multiple (mobile) devices without compromising security? Peers-sharing: how user U1 could exchange a subset of his-her data with an identified user U2 while providing to U1 tangible guarantees about the usage made by U2 of this data? Community-sharing: how user U1 could exchange a subset of his-her data with a large community of users and contribute to personal big data analytics while providing to U1 tangible guarantees about the preservation of his-her anonymity? In addition to tackling these three scientific and technical issues, a legal analysis will guarantee compliance of this platform with the security and privacy French and UE regulation, which firmly promotes the Privacy by Design principle, including the current reforms of personal data regulation.

8.1.2. GDP-ERE, DATA-IA project (Sept. 2018 - Jan. 2022)

Partners: DANTE (U. of Versailles), PETRUS (Inria-UVSQ).

The role of individuals and the control of their data is a central issue in the new European regulation (GDPR) enforced on 25th May 2018. Data portability is a new right provided under those regulations. It allows citizens to retrieve their personal data from the companies and governmental agencies that collected them, in an interoperable digital format. The goals are to enable the individual to get out of a captive ecosystem, and to favor the development of innovative personal data services beyond the existing monopolistic positions. The consequence of this new right is the design and deployment of technical platforms, commonly known as Personal Cloud. But personal cloud architectures are very diverse, ranging from cloud based solutions where millions of personal cloud are managed centrally, to self-hosting solutions. These diversity is not neutral both in terms of security and from the point of view of the chain of liabilities. The GDP-ERE project tends to study those issues in an interdisciplinary approach by the involvement of jurists and computers scientists. The two main objectives are (i) to analyze the effects of the personal cloud architectures on legal liabilities, enlightened by the analysis of the rules provided under the GDPR and (ii) to propose legal and technological evolutions to highlight the share of liability between each relevant party and create adapted tools to endorse those liabilities. http://dataia.eu/actualites/linstitut-dataia-vous-presente-le-projet-gdp-ere-rgpd-et-cloud-personnel-de-lempowerment

8.1.3. Postdoc DIM RFSI, Ile-de-France Region (2019 - 2020)

Partners: Inria (PETRUS).

This project is a continuation of Julien Loudet's Phd thesis. Julien finalized a CIFRE thesis defended in October 2019. This thesis is the result of a solid collaboration (another CIFRE thesis was defended in 2018) between the PETRUS team and the startup Cozy Cloud, which is also working on the personal cloud issue. The project finances 8 months of postdoc for Julien. The objective is to enforce the collaboration with Cozy Cloud by allowing the postdoc (i) to submit an extended journal paper on his last results (DISPERS protocol), (ii) to realize a detailed specification of the distributed protocols developed during his PhD for their implementation in the Cozy Cloud platform and (iii) to collaborate with a future PhD candidate of a new thesis in collaboration with Cozy Cloud exploring decentralized automatic learning techniques in the personal cloud context.

POTIOC Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

HOBIT:

Funding: Program STEP - (Soutien à la Transformation et l'Expérimentation Pédagogiques)

Duration: 2019-2020

Local coordinator: Martin Hachet

Partners: Université de Bordeaux

The objective is to transform traditional practices for the teaching of optics in more innovative approaches based on augmented reality and tangible interaction. To this end, we continue improving and testing our HOBIT platform.

Echelles Celestes:

Funding: Idex - Université de Bordeaux - Art and Sciences program

Duration: 2019-2020

Local coordinator: Martin Hachet

Partners: Université de Bordeaux

We explore interactive artistic installations based on the combination of physical and virtual elements.

Erlen:

Funding: Université de Bordeaux - Hacketafac program

Duration: 2018-2019

Local coordinator: Pierre-Antoine Cinquin

We won a grant from Université de Bordeaux to explore awareness of power consumption by way of tangible and ambient interfaces.

Neuroperf:

Funding: Labex BRAIN / Université de Bordeaux

Duration: 2017-2019

Coordinator: Jean-Arthur Micoulaud Franchi

Local coordinator: Fabien Lotte

A project aimed at exploring EEG-based neurofeedback for improving daytime alertness.

9.2. National Initiatives

eTAC: Tangible and Augmented Interfaces for Collaborative Learning:

Funding: EFRAN

Duration: 2017-2021

Coordinator: Université de Lorraine

Local coordinator: Martin Hachet

Partners: Université de Lorraine, Inria, ESPE, Canopé, OpenEdge,

the e-TAC project proposes to investigate the potential of technologies ”beyond the mouse” in order to promote collaborative learning in a school context. In particular, we will explore augmented reality and tangible interfaces, which supports active learning and favors social interaction.

website: http://e-tac.univ-lorraine.fr/index

ANR Project EMBER:

Duration: 2020-2023

Partners: Inria/AVIZ, Sorbonne Université

Coordinator: Pierre Dragicevic (Inria Saclay)

Local coordinator: Martin Hachet

The goal of the project will be to study how embedding data into the physical world can help people get insights into their own data. While the vast majority of data analysis and visualization takes place on desktop computers located far from the objects or locations the data refers to, in situated and embedded data visualizations, the data is directly visualized near the physical space, object, or person it refers to.

website: https://ember.inria.fr

ANR Project REBEL:

Duration: 2016-2019

Partners: Potioc, Handicap Activity Cognition Health lab (Univ. Bordeaux)

Coordinator: Fabien Lotte

Brain-Computer Interfaces (BCI) are communication systems that enable their users to send commands to computers through brain activity only. While BCI are very promising for assistive technologies or human-computer interaction (HCI), they are barely used outside laboratories, due to a poor reliability. Designing a BCI requires 1) its user to learn to produce distinct brain activity patterns and 2) the machine to recognize these patterns using signal processing. Most research efforts focused on signal processing. However, BCI user training is as essential but is only scarcely studied and based on heuristics that do not satisfy human learning principles. Thus, currently poor BCI reliability is probably due to suboptimal user training. Thus, we propose to create a new generation of BCI that apply human learning principles in their design to ensure the users can learn high quality control skills, hence making BCI reliable. This could change HCI as BCI have promised but failed to do so far.

website: https://team.inria.fr/potioc/collaborative-projects/rebel/

Inria Project Lab AVATAR:

Duration: 2018-2022

Partners: Inria project-teams: GraphDeco, Hybrid, Loki, MimeTIC, Morpheo

Coordinator: Ludovic Hoyet (Inria Rennes)

Local coordinator: Martin Hachet

This project aims at designing avatars (i.e., the user’s representation in virtual environments) that are better embodied, more interactive and more social, through improving all the pipeline related to avatars, from acquisition and simulation, to designing novel interaction paradigms and multi-sensory feedback.

website: https://avatar.inria.fr

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

BrainConquest:

Program: ERC Starting Grant

Project title: BrainConquest - Boosting Brain-Computer Communication with High Quality User Training

Duration: 2017-2022

Coordinator: Fabien Lotte

Abstract: Brain-Computer Interfaces (BCIs) are communication systems that enable users to send commands to computers through brain signals only, by measuring and processing these signals. Making computer control possible without any physical activity, BCIs have promised to revolutionize many application areas, notably assistive technologies, e.g., for wheelchair control, and man-machine interaction. Despite this promising potential, BCIs are still barely used outside laboratories, due to their current poor reliability. For instance, BCIs only using two imagined hand movements as mental commands decode, on average, less than 80% of these commands correctly, while 10 to 30% of users cannot control a BCI at all. A BCI should be considered a co-adaptive communication system: its users learn to encode commands in their brain signals (with mental imagery) that the machine learns to decode using signal processing. Most research efforts so far have been dedicated to decoding the commands. However, BCI control is a skill that users have to learn too. Unfortunately how BCI users learn to encode the commands is essential but is barely studied, i.e., fundamental knowledge about how users learn BCI control is lacking. Moreover standard training approaches are only based on heuristics, without satisfying human learning principles. Thus, poor BCI reliability is probably largely due to highly suboptimal user training. In order to obtain a truly reliable BCI we need to completely redefine user training approaches. To do so, I propose to study and statistically model how users learn to encode BCI commands. Then, based on human learning principles and this model, I propose to create a new generation of BCIs which ensure that users learn how to successfully encode commands with high signal-to-noise ratio in their brain signals, hence making BCIs dramatically more reliable. Such a reliable BCI could positively change man-machine interaction as BCIs have promised but failed to do so far.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

VISTE:

Program: Erasmus + Key Action 2: Cooperation for Innovation and Exchange of Good Practices

Project title: VISTE: Empowering spatial thinking of students with visual impairment

Duration: 01/09/2016 - 31/08/2019

Coordinator: Professor Marinos Kavouras (Vice-Rector, National Technical University of Athens and VISTE Project Leader)

Partners: National Technical University of Athens, Inria, Intrasoft International S.A., Casa Corpului Didactic Cluj, Eidiko Dimotiko Sxolio Tiflon Kallitheas, Liceul Special pentru Deficienti de Vedere Cluj-Napoca. External collaborators : IRSA, RealityTech

Abstract: Six partners from four European countries are working together to develop strategies, educational components and an ICT toolkit towards effective spatial thinking of students with VI, facilitating inclusion. The competence of spatial thinking, usage and interpretation of maps or other spatial tools is not self-evident for all; it is a dexterity which must be cultivated. For students experiencing disabilities, such as visual impairment (VI), spatial thinking proves to be an imperative skill for perceiving the world far beyond their immediate experience. Learning functional ways to utilize spatial experiences as an entirety and realize the relationships between objects in space and themselves is vital. Maps and other spatial representations are a splendid source of information for portraying space and environment. By using tactile maps and innovative ICT technologies, children may deploy their spatial notion more effectively compared to proximate orientation experiences in accordance with verbal directions. Providing thus a concrete set of such tools would empower specific spatial thinking skills not only of those with VI but of all students. VISTE aims at empowering the spatial thinking skills of students with VI. This will be accomplished by providing an innovative methodological framework and a semantic and technical infrastructure for developing appropriate inclusive educational modules to foster spatial thinking. The project's main target groups are primary/secondary education students, as well as teachers, teachers' trainers, and staff involved in their education.

9.4. International Initiatives

9.4.1. Inria International Labs

9.4.1.1. Informal International Partners

- Univ. Ulster UK (Pr. Damien Coyle) on RSVP-BCI
- NTNU, Norway (Pr. Marta Molinas, Dr. Alejandro Torres Garcia) on colour-based BCI
- EPFL, Switzerland (Dr Ricardo Chavarriaga) on Negative Results for BCI

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Dr. Alejandro Torres Garcia, postdoc from NTNU, Norway, August 2019
- Ahmed Azab, PhD student, Univ. Sheffield, UK, August 2019
- Pr. Stephanie Enriquez-Geppert, University of Groningen, the Netherlands, April 2019
- Pr. Stephan Debener, Univ. Oldenburg, Germany, May 2019
- Pr. Jordi Solé-Casal, Univ. Vic, Spain and Pr. Feng Duan, Univ. Nankai, China, December 2019

9.5.1.1. Internships

- Sayu Yamamoto, Tokyo Univ. of Agriculture and Technology, Japan - from September 2019 to March 2020

9.5.2. Visits to International Teams

9.5.2.1. Research Stays Abroad

- Fabien Lotte was a visiting associate Professor at the Tokyo University of Agriculture and Technology (TUAT), Japan, for 2 weeks in February and for the whole month on November 2019. He worked on BCI and EEG signal processing in the lab of Pr. Toshihisa Tanaka.
- Jelena Mladenovic was a scientific visitor at the Serbian Academy of Science and Arts, Institute of Mathematics, with Dragan Urosevic, from 20th of February to 25th of March 2019.

RAINBOW Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. SAD WH-DRONE

Participants: Marco Aggravi, Claudio Pacchierotti.

no CNRS Rennes 181089, duration: 24 months.

This project funded by the Brittany council started in January 2019. It supports in part Marco Aggravi's research on using wearable interfaces for flying swarms of drones.

8.1.2. Allocation d'installation scientifique

Participant: Claudio Pacchierotti.

no CNRS Rennes 17C0487, duration: 36 months.

This grant from "Rennes Métropole" has been obtained in July 2017 and supports the activities related to the teleoperation of drones (quadrotor UAVs) using wearable haptics interfaces.

8.1.3. IRT Jules Verne Happy

Participant: François Chaumette.

no Inria Rennes 13521, duration: 36 months.

This project started in June 2018. It is managed by IRT Jules Verne in Nantes and achieved in cooperation with LS2N and Airbus. Its goal is to develop local sensor-based control methods for the assembly of large parts of aircrafts.

8.1.4. Prisme

Participants: Solenne Fortun, François Pasteau, Marie Babel.

no Insa Rennes 2017-0004, duration: 36 months.

This project started in January 2017 and is supported by Brittany region/BPI. This project aims at designing a fall prevention strategy based on the sensing collaboration of a smart wheelchair and a smart medical bed. Fall detection and automatic positioning of the wheelchair next to the bed issues are addressed (see Section 6.2.14).

8.1.5. Silver Connect

Participant: Marie Babel.

no Insa Rennes 2018-0076, duration: 34 months.

This project started in November 2018 and is supported by Brittany region/BPI as well as FEDER. This project aims at designing a fall detection framework by means of vision-based algorithms coupled with deep learning solutions.

8.1.6. Cartam

Participants: Noura Neji, Fabien Spindler, François Chaumette.

no Inria 13954 and 14041, duration: 36 months.

This project started in January 2019 and is supported by Brittany region and FEDER. It is managed by Triskalia with Unilet, Copeeks, Neotec Vision, Rainbow group, and our start-up Dilepix. It aims at designing a vision system able to detect adventices in a field. We are in charge of tracking the adventices once they are detected and of building a mosaic of the field for locating them.

8.2. National Initiatives

8.2.1. ANR PLaTINUM

Participant: Vincent Drevelle.

no Inria Sophia 10204, duration: 42 months.

This project started in November 2015. It involves a consortium managed by Litis in Rouen with IGN Matis (Paris), Le2i (Le Creusot) and Inria (Chorale group in Sophia-Antipolis and Rainbow). The project is focused on robust long-term mapping of urban environments. Map building consists in the acquisition of a textured 3-D model of urban environment, and automatic semantic labelling of the environment features (roads, buildings, cars, etc.). From this model, an optimal representation is generated and made available in the cloud, in the form of a network of RGB-D-L spheres storing photometry, geometry (depth) and object labels. Mobile agents are able to determine their position and navigate in the sphere graph using dense matching. Agents upload significant environment changes to the sphere server in cloud, for map update purposes.

8.2.2. ANR Sesame

Participant: François Chaumette.

no Inria 13722, duration: 48 months.

This project started in January 2019. It involves a consortium managed by LS2N (Nantes) with LIP6 (Paris) and Rainbow group. It aims at analysing singularity and stability issues in visual servoing.

8.2.3. Equipex Robotex

Participants: Fabien Spindler, François Chaumette.

no Inria Rennes 6388, duration: 9 years.

Rainbow is one of the 15 French academic partners involved in the Equipex Robotex network that started in February 2011. It is devoted to get and manage significant equipment in the main robotics labs in France. In the scope of this project, we have obtained the humanoid robot Romeo in 2015.

8.3. European Initiatives

FP7 & H2020 Projects

8.3.1. FP7 Space RemoveDEBRIS

Participants: Eric Marchand, François Chaumette.

Instrument: Specific Targeted Research Project

Duration: October 2013 - March 2019

Coordinator: University of Surrey (United Kingdom)

Partners: Surrey Satellite Technology (United Kingdom), Airbus (Toulouse, France and Bremen, Germany), Isis (Delft, The Netherlands), CSEM (Neuchâtel, Switzerland), Stellenbosch University (South Africa).

Inria contact: François Chaumette

Abstract: A huge amount of debris have progressively been generated since the beginning of the space era. Most of the objects launched into space are still orbiting the Earth and today these objects and their by-products represent a threat both in space and on Earth. In Space, debris lead to collisions and therefore to damages to operational satellites. For both issues, a credible solution has emerged over the recent years: actively removing heavy debris objects by capturing them and then either disposing them by destructive re-entry in Earth atmosphere or disposing them in graveyard orbits. The RemoveDEBRIS project aimed to demonstrate key technologies for ADR in three main domains by performing in-orbit demonstrations representative of an ADR mission. The specific key technologies that have been demonstrated as part of this project are: (i) Capture technologies such as nets and harpoons (ii) De-orbiting technologies such as electric propulsion and drag augmentation (iii) Proximity Rendezvous operations technologies based on vision-based navigation. The technology demonstrations has been carried in orbit using a micro satellite test-bed, a world's first. The micro satellite has carried the ADR payloads together with two deployable nanosatellites (CubeSats). Through a series of operations, the nanosatellites have been ejected, re-captured, inspected and de-orbited, thereby demonstrating the ADR key technologies [16], [8], [7]. Our goal in this long project was to develop and validate model-based tracking algorithms on images acquired during the actual space debris removal mission [47].

8.3.2. H2020 ICT Comanoid

Participants: Fabien Spindler, François Chaumette.

Title: Multi-contact Collaborative Humanoids in Aircraft Manufacturing

Programme: H2020

Duration: January 2015 - February 2019

Coordinator: CNRS (Lirmm)

Partners: Airbus Group (France), DLR (Germany), Università Degli Studi di Roma La Sapienza (Italy), CNRS (I3S)

Inria contact: François Chaumette

Abstract: Comanoid investigated the deployment of robotic solutions in well-identified Airbus airliner assembly operations that are laborious or tedious for human workers and for which access is impossible for wheeled or rail-ported robotic platforms. As a solution to these constraints a humanoid robot was proposed to achieve the described tasks in real-use cases provided by Airbus Group. At a first glance, a humanoid robotic solution appears extremely risky, since the operations to be conducted are in highly constrained aircraft cavities with non-uniform (cargo) structures. Furthermore, these tight spaces are to be shared with human workers. Recent developments, however, in multi-contact planning and control suggested that this is a much more plausible solution than current alternatives such as a manipulator mounted on multi-legged base. Indeed, if humanoid robots can efficiently exploit their surroundings in order to support themselves during motion and manipulation, they can ensure balance and stability, move in non-gaited (acyclic) ways through narrow passages, and also increase operational forces by creating closed-kinematic chains. Bipedal robots are well suited to narrow environments specifically because they are able to perform manipulation using only small support areas. Moreover, the stability benefits of multi-legged robots that have larger support areas are largely lost when the manipulator must be brought close, or even beyond, the support borders. COMANOID aimed at assessing clearly how far the state-of-the-art stands from such novel technologies. In particular the project focused on implementing a real-world humanoid robotics solution using the best of research and innovation. The main challenge was to integrate current scientific and technological advances including multi-contact planning and control; advanced visual-haptic servoing; perception and localization; human-robot safety, and the operational efficiency of cobotics solutions in airliner manufacturing [21].

8.3.3. H2020 ICT CrowdBot

Participants: Javad Amirian, Fabien Grzeskowiak, Solenne Fortun, Marie Babel, Julien Pettré, Fabien Spindler.

Title: Robot navigation in dense crowds

Programme: H2020

Duration: Jan 2018 - Jun 2021

Coordinator: Inria

Partners: UCL (UK), SoftBank Robotics (France), Univ. Aachen (Germany), EPFL (Switzerland), ETHZ (Switzerland), Locomotec (Germany)

Inria contact: Julien Pettré

Abstract: CROWDBOT will enable mobile robots to navigate autonomously and assist humans in crowded areas. Today's robots are programmed to stop when a human, or any obstacle is too close, to avoid coming into contact while moving. This prevents robots from entering densely frequented areas and performing effectively in these high dynamic environments. CROWDBOT aims to fill in the gap in knowledge on close interactions between robots and humans during navigation tasks. The project considers three realistic scenarios: 1) a semi-autonomous wheelchair that must adapt its trajectory to unexpected movements of people in its vicinity to ensure neither its user nor the pedestrians around it are injured; 2) the commercially available Pepper robot that must navigate in a dense crowd while actively approaching people to assist them; 3) the under development robot cuyBot will adapt to compact crowd, being touched and pushed by people. These scenarios generate numerous ethical and safety concerns which this project addresses through a dedicated Ethical and Safety Advisory Board that will design guidelines for robots engaging in interaction in crowded environments. CROWDBOT gathers the required expertise to develop new robot capabilities to allow robots to move in a safe and socially acceptable manner. This requires achieving step changes in a) sensing abilities to estimate the crowd motion around the robot, b) cognitive abilities for the robot to predict the short term evolution of the crowd state and c) navigation abilities to perform safe motion at close range from people. Through demonstrators and open software components, CROWDBOT will show that safe navigation tasks can be achieved within crowds and will facilitate incorporating its results into mobile robots, with significant scientific and industrial impact. By extending the robot operation field toward crowded environments, we enable possibilities for new applications, such as robot-assisted crowd traffic management.

8.3.4. H2020 ICT PRESENT

Participants: Adèle Colas, Alberto Jovane, Claudio Pacchierotti, Julien Pettré.

Title: Photoreal REaltime Sentient ENTity

Programme: H2020

Duration: Sep 2019 - Aug 2022

Coordinator: Univ Pompeu Fabra (Spain)

Partners: The Framestore Ltd (UK), Cubic Motion Ltd (UK), InfoCert Spa (Italy), Brainstorm Multimedia S.L. (ES), Creative Workers - Creatieve Werkers VZW (Belgium), Universitaet Augsburg (Germany), Inria (France)

Inria contact: Julien Pettré

Abstract: PRESENT is a three-year Research and Innovation project to create virtual digital companions—embodied agents—that look entirely naturalistic, demonstrate emotional sensitivity, can establish meaningful dialogue, add sense to the experience, and act as trustworthy guardians and guides in the interfaces for AR, VR and more traditional forms of media.

There is no higher quality interaction than the human experience when we use all our senses together with language and cognition to understand our surroundings and—above all—to interact with other people. We interact with today's Ïntelligent Personal Assistantsprimarily by voice; communication is episodic, based on a request-response model. The user does not see the assistant, which does not take advantage of visual and emotional clues or evolve over time. However, advances in the real-time creation of photorealistic computer generated characters, coupled with emotion recognition and behaviour, and natural language technologies, allow us to envisage virtual agents that are realistic in both looks and behaviour; that can interact with users through vision, sound, touch and movement as they navigate rich and complex environments; converse in a natural manner; respond to moods and emotional states; and evolve in response to user behaviour.

PRESENT will create and demonstrate a set of practical tools, a pipeline and APIs for creating realistic embodied agents and incorporating them in interfaces for a wide range of applications in entertainment, media and advertising.

8.3.5. H2020 FET-OPEN H-Reality

Participants: Claudio Pacchierotti, Paolo Robuffo Giordano, François Chaumette.

Title: Mixed Haptic Feedback for Mid-Air Interactions in Virtual and Augmented Realities

Programme: H2020

Duration: October 2018 - September 2021

Coordinator: Univ. Birmingham (UK)

Partners: Univ. Birmingham (UK, coordinator), CNRS (France), TU Delft (NL), Ultrahaptics (UK) and Actronika SAS (France)

CNRS contact: Claudio Pacchierotti

Abstract: Digital content today remains focused on visual and auditory stimulation. Even in the realm of VR and AR, sight and sound remain paramount. In contrast, methods for delivering haptic (sense of touch) feedback in commercial media are significantly less advanced than graphical and auditory feedback. Yet without a sense of touch, experiences ultimately feel hollow, virtual realities feel false, and Human-Computer Interfaces become unintuitive. Our vision is to be the first to imbue virtual objects with a physical presence, providing a revolutionary, untethered, virtual-haptic reality: H-Reality. The ambition of H-Reality will be achieved by integrating the commercial pioneers of ultrasonic "non-contact" haptics, state-of-the-art vibrotactile actuators, novel mathematical and tribological modelling of the skin and mechanics of touch, and experts in the psychophysical rendering of sensation. The result will be a sensory experience where digital 3D shapes and textures are made manifest in real space via modulated, focused, ultrasound, ready for the untethered hand to feel, where next-generation wearable haptic rings provide directional vibrotactile stimulation, informing users of an object's dynamics, and where computational renderings of specific materials can be distinguished via their surface properties. The implications of this technology will be far-reaching. The computer touch-screen will be brought into the third dimension so that swipe gestures will be augmented with instinctive rotational gestures, allowing intuitive manipulation of 3D data sets and strolling about the desktop as a virtual landscape of icons, apps and files. H-Reality will transform online interactions; dangerous machinery will be operated virtually from the safety of the home, and surgeons will hone their skills on thin air. Rainbow is involved in H-Reality in cooperation with Anatole Lécuyer and Maud Marchal from the Hybrid group.

Collaborations in European Programs, Except FP7 & H2020

8.3.6. Interreg Adapt

Participants: Nicolas Le Borgne, Marie Babel.

Programme: Interreg VA France (Channel) England

Project acronym: Adapt

Project title: Assistive Devices for empowering disAbled People through robotic Technologies

Duration: Jan 2017 - Jun 2021

Coordinator: ESIGELEC/IRSEEM Rouen

Other partners: INSA Rennes - IRISA, LGCGM, IETR (France), Université de Picardie Jules Verne - MIS (France), Pôle Saint Hélier (France), CHU Rouen (France), Réseau Breizh PC (France), Pôle TES (France), University College of London - Aspire CREATE (UK), University of Kent (UK), East Kent Hospitals Univ NHS Found. Trust (UK), Health and Europe Centre (UK), Plymouth Hospitals NHS Trust (UK), Canterbury Christ Church University (UK), Kent Surrey Sussex Academic Health Science Network (UK), Cornwall Mobility Center (UK).

Abstract: This project aims to develop innovative assistive technologies in order to support the autonomy and to enhance the mobility of power wheelchair users with severe physical/cognitive disabilities. In particular, the objective is to design and evaluate a power wheelchair simulator as well as to design a multi-layer driving assistance system.

Collaborations with Major European Organizations

8.3.7. ANR Opmops

Participants: Florian Berton, Julen Bruneau, Julien Pettré.

Programme: ANR

Project acronym: Opmops

Project title: Organized Pedestrian Movement in Public Spaces: Preparation and Crisis Management of Urban Parades and Demonstration Marches with High Conflict Potential

Duration: June 2017 - June 2020

Coordinator: Université de Haute Alsace (for France), Technische Universität Kaiserslautern (for Germany)

Other partners: Gendarmerie Nationale, Hochschule München, ONHYS S.A.S, Polizei Rheinland-Pfalz, Universität Koblenz-Landau, VdS GmbH

Abstract: This project is about parades of highly controversial groups or of political demonstration marches that are considered as a major threat to urban security. Due to the movement of the urban parades and demonstration marches (in the following abbreviated by UPM) through large parts of cities and the resulting space and time dynamics, it is particularly difficult for forces of civil security (abbreviated in the following by FCS) to guarantee safety at these types of urban events without endangering one of the most important indicators of a free society. In this proposal, partners representing the FCS (police and industry) will cooperate with researchers from academic institutions to develop a decision support tool which can help them both in the preparation phase and crisis management situations of UPMs. Specific technical issues which the French-German consortium will have to tackle include the following: Optimization methods to plan UPM routes, transportation to and from the UPM, location and personnel planning of FCS, control of UPMs using stationary and moving cameras, and simulation methods, including their visualization, with specific emphasis on social behavior.

8.3.8. iProcess

Participants: Agniva Sengupta, François Chaumette, Alexandre Krupa, Eric Marchand, Fabien Spindler.

Project acronym: i-Process

Project title: Innovative and Flexible Food Processing Technology in Norway

Duration: January 2016 - December 2019

Coordinator: Sintef Ocean (Norway)

Other partners: Nofima, Univ. of Stavanger, NMBU, NTNU (Norway), DTU (Denmark), KU Leuven (Belgium), and about 10 Norwegian companies.

Abstract: This project was granted by the Norwegian Government. Its main objective was to develop novel concepts and methods for flexible and sustainable food processing in Norway. In the scope of this project, the Rainbow group was involved for visual tracking and visual servoing of generic and potentially deformable objects (see Section 6.1.1 and Section 6.1.2). This year, we published [52], [53] in the scope of this project.

8.3.9. GentleMAN

Participants: Alexandre Krupa, Eric Marchand, François Chaumette, Fabien Spindler.

Project acronym: GentleMAN

Project title: Gentle and Advanced Robotic Manipulation of 3D Compliant Objects

Duration: August 2019 - December 2023

Coordinator: Sintef Ocean (Norway)

Other partners: NTNU (Norway), NMBU (Norway), MIT (USA) and QUT (Australia).

Abstract: This project is funded by the Norwegian Government. Its main objective is to develop a novel learning framework that uses visual, force and tactile sensing to develop new multi-modal learning models, interfaced with underlying robot control, for enabling robots to learn new and advanced skills for the manipulation of 3D compliant objects. In the scope of this project, the Rainbow group is involved in the elaboration of new approaches for visual tracking of deformable objects, active vision and visual servoing for deforming soft objects into desired shapes.

8.4. International Initiatives

8.4.1. Inria Associate Teams Not Involved in an Inria International Labs

8.4.1.1. ISI4NAVE

Title: Innovative Sensors and adapted Interfaces for assistive NAVigation and pathology Evaluation

International Partner (Institution - Laboratory - Researcher):

University College London (United Kingdom) - Aspire CREATe - Tom Carlson

Start year: 2019

See also: https://team.inria.fr/isi4nave/

Using a wheelchair allows people with disability to compensate a loss of mobility. However only 5 to 15% of the 70 million people worldwide who require a wheelchair have access to this type of technical aid. In particular, visual, visuo-spatial and/or cognitive impairments can alter the ability of an individual to independently operate a wheelchair safely.

This project focuses then on two main complementary objectives:

1. to compensate both sensorimotor disabilities and cognitive impairments by designing adapted interfaces,
2. to enhance the driving experience and to bring a new tool for rehabilitation purposes by defining efficient physical Human-Robot Interaction.

In order to ensure a widespread use of robotic systems, innovative interfaces, enabling relevant feedback (medically validated), constitute a major challenge. Trajectory corrections, obtained thanks to an assistance module, will have to be perceived by the user by means of sensitive (visual, tactile…) feedback that will have to be easily adapted to the pathology. Conversely, user interaction with the robotic system can be interpreted to control the wheelchair. Designing such systems require a multidisciplinary study, including medical data collection and analysis.

In our preliminary works, we demonstrated the relevance of share control frameworks. The scope of this new ISI4NAVE Associate Team is then to provide advanced and innovative solutions for controlling wheelchair as well as providing appropriate and relevant feedback to users.

8.4.2. Participation in Other International Programs

8.4.2.1. ACRV

François Chaumette is one of the five external experts of the Australian Center for Robotic Vision (see http://roboticvision.org). This center groups QUT in Brisbane, ANU in Canberra, Monash University and Adelaide University. In the scope of this project, Alexander Oliva received a grant to participate to the 2019 Robotic Vision Summer School in Kioloa (New South Wales) and spent a 1-week visit at QUT in March 2019.

RITS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

8.1.1.1. VALET

Title: Redistribution automatique d'une flotte de véhicules en partage et valet de parking

Instrument: ANR

Duration: January 2016 - September 2019

Coordinator: Fawzi Nashashibi

Partners: Inria, Ecole Centrale de Nantes (IRCCyN), AKKA Technologies

Inria contact: Fawzi Nashashibi

Abstract: The VALET project proposes a novel approach for solving car-sharing vehicles redistribution problem using vehicle platoons guided by professional drivers. An optimal routing algorithm is in charge of defining platoons drivers' routes to the parking areas where the followers are parked in a complete automated mode. The main idea of VALET is to retrieve vehicles parked randomly on the urban parking network by users. These parking spaces may be in electric charging stations, parking for car sharing vehicles or in regular parking places. Once the vehicles are collected and guided in a platooning mode, the objective is then to guide them to their allocated parking area or to their respective parking lots. Then each vehicle is assigned a parking place into which it has to park in an automated mode.

8.1.1.2. Hianic

Title: navigation autonome dans les foules inspirée par les humains (Human Inspired Autonomous Navigation In Crowds)

Instrument: ANR

Duration: January 2018 - December 2020

Coordinator: Anne Spalanzani (Inria Rhône-Alpes, Chroma research team)

Partners: Inria Rhône-Alpes, Inria Paris, LIG Laboratoire d'Informatique de Grenoble, LS2N - ECN Laboratoire des Sciences du Numérique de Nantes

Inria contact: Fawzi Nashashibi

Abstract: The HIANIC project will try to address some problems that will arise when these cars are mixed with pedestrians. The HIANIC project will develop new technologies in term of autonomous navigation in dense and human populated traffic. It will explore the complex problem of navigating autonomously in shared-space environments, where pedestrians and cars share the same environment.

Such a system will contribute both to urban safety and intelligent mobility in "shared spaces". Negotiation will help to avoid frozen situations increasing the vehicle's reactivity and optimizing the navigable space. Negotiation, Human-Aware Navigation and Communication will contribute to a better public acceptance of such autonomous systems and facilitate their penetration in the transportation landscape.

8.1.2. FUI

8.1.2.1. PAC V2X

Title: Perception augmentée par coopération véhicule avec l'infrastructure routière

Instrument: FUI

Duration: September 2016 - May 2020

Coordinator: SIGNATURE Group (SVMS)

Partners: DigiMobee, LOGIROAD, MABEN PRODUCTS, SANEF, SVMS, VICI, Inria, VEDECOM

Inria contact: Raoul de Charette

Abstract: The objective of the project is to integrate two technologies currently being deployed in order to significantly increase the time for an automated vehicle to evolve autonomously on European road networks. It is the integration of technologies for the detection of fixed and mobile objects such as radars, lidars, cameras ... etc. And local telecommunication technologies for the development of ad hoc local networks as used in cooperative systems.

8.1.3. Competitivity Clusters

RITS team is a very active partner in the competitivity clusters, especially MOV'EO and System@tic. We are involved in several technical committees like the DAS SUR of MOV'EO for example.
RITS is also the main Inria contributor in the VEDECOM institute (IEED).

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. AUTOCITS

Title: AUTOCITS Regulation Study for Interoperability in the Adoption of Autonomous Driving in European Urban Nodes

Program: CEF- TRANSPORT Atlantic corridor

Duration: November 2016 - March 2019

Coordinator: Indra Sistemas S.A. (Spain)

Partners: Indra Sistemas S.A. (Spain); Universidad Politécnica de Madrid (UPM), Spain; Dirección General de Tráfico (DGT), Spain; Inria (France); Instituto Pedro Nunes (IPN), Portugal; Autoridade Nacional de Segurança Rodoviária (ANSR), Portugal; Universidade de Coimbra (UC), Portugal.

Inria contact: Fawzi Nashashibi, Mohammad Abualhoul

Abstract: The aim of the Study is to contribute to the deployment of C-ITS in Europe by enhancing interoperability for autonomous vehicles as well as to boost the role of C-ITS as catalyst for the implementation of autonomous driving. Pilots will be implemented in 3 major Core Urban nodes (Paris, Madrid, Lisbon) located along the Core network Atlantic Corridor in 3 different Member States. The Action consists of Analysis and design, Pilots deployment and assessment, Dissemination and communication as well as Project Management and Coordination.

8.2.2. Collaborations with Major European Organizations

RITS is member of the **euRobotics AISBL** (Association Internationale Sans But Lucratif) and the Leader of "People transport" Topic. This makes from Inria one of the rare French robotics representatives at the European level. See also: http://www.eu-robotics.net/

RITS is a full partner of **VRA – Vehicle and Road Automation**, a support action funded by the European Union to create a collaboration network of experts and stakeholders working on deployment of automated vehicles and its related infrastructure. VRA project is considered as the cooperation interface between EC funded projects, international relations and national activities on the topic of vehicle and road automation. It is financed by the European Commission DG CONNECT and coordinated by ERTICO – ITS Europe. See also: http://vra-net.eu/

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

RITS has signed 3 MoU with the following international laboratories:

- Vehicle Dynamics and Control Laboratory, Seoul National University (SNU), S. Korea: international cooperation agreement for Graduate-Level Academic and Research Collaboration
- MICA Lab, Hanoi University of Science and Technology, Vietnam: cooperation agreement for research collaboration and PhD students co-supervision
- Integrated Industrial Design Lab (INDEL) of the Department of Product and Systems Design Engineering, University of the Aegean, Greece: international cooperation agreement for Graduate-Level Academic and Research Collaboration

8.3.2. Participation in Other International Programs

Samuel de Champlain Québec-France collaboration program: "Vision par ordinateur en conditions difficiles", cooperation between Raoul de Charette and Jean-François Lalonde from Laval University.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Plamen Petrov from Technical University of Sofia, from July to September 2019.

8.4.1.1. Internships

- Pranav Agarwal, from August 2019.
- Fares Bessam, Master student, April-September 2019.
- Manuel Gonzalez and Leonardo Ward, from Simon Bolivar University, Venezuela, from September 2019.
- Manohar KV, May-July 2019.

8.4.2. Visits to International Teams

8.4.2.1. Research Stays Abroad

Maximilian Jaritz was at UC San Diego, visiting SU Lab directed by Hao Su, from October 1st 2018 to February 15th 2019.

SEMAGRAMME Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

CPER LCHN

Langues, Connaissances et Humanités Numériques (Languages, Knowledge and Digital Humanities)

Duration: 2015 - 2020 Coordinator: Bruno Guillaume

Other partners: Université de Lorraine, Région Grand-Est, France

Participants: Maxime Amblard, Karën Fort, Bruno Guillaume

Abstract: This initiative is an interdisciplinary project which involves several laboratories in the Université de Lorraine. It aims to strengthen the University de Lorraine University in the areas of management and access to digital content. A huge part of the project concerns researches on language. The initiative combines national and regional funding which mainly supports equipment purchase. It proposes to set up scientific experimentation platforms to strengthen cooperation between Lorraine's partners thus enabling Lorraine to acquire significant visibility through national platforms for the dissemination of resources. Most of the online tools built in the team (https://zombiludik.org, http://match.grew.fr for instance) are available through virtual machines funded by the CPER.

8.2. National Initiatives

ODiM

Outils informatisés d'aide au Diagnostic des Maladies mentales

2019 - 2022

Coordinator: Maxime Amblard

Participants: Maxime Amblard, Vincent-Thomas Barrouillet, Samuel Buchel, Amandine Lecomte, Chuyuan Li, Michel Musiol

Abstract:

ODiM is an interdisciplinary project, at the interface of psychiatry-psychopathology, linguistics, formal semantics and digital sciences. It aims to replace the paradigm of Language and Thought Disorders (LTD) as used in the Mental Health sector with a semantic-formal and cognitive model of Discourse Disorders (DD). These disorders are translated into pathognomonic signs, making them complementary diagnostic tools as well as screening for vulnerable people before the psychosis's trigger. The project has three main components.

The work is based on real data from interviews with patients with schizophrenia. A data collection phase in partner hospitals and with a control group, consisting of interviews and neuro-cognitive tests, is therefore necessary.

The data collection will allow the development of the theoretical model, both in psycholinguistic and semantic formalization for the identification of diagnostic signs. The success of such a project requires the extension of the analysis methodology in order to increase the model's ability to identify sequences with symptomatic discontinuities.

If the general objective of the project is to propose a methodological framework for defining and understanding diagnostic clues associated with psychosis, we also wish to equip these approaches by developing software to automatically identify these clues, both in terms of discourse and language behaviour.

8.3. European Initiatives

8.3.1. Collaborations in European Programs, Except FP7 & H2020

EnetCollect

European Network for Combining Language Learning with Crowdsourcing Techniques

2015- 2025

Coordinator: Lionel Nicolas and Verena Lyding (Chair & Grant Holder)

Participants: Karën Fort, Bruno Guillaume

Abstract:

Karën Fort and Bruno Guillaume participate in the EnetCollect [0] COST action. EnetCollect aims at performing the groundwork to set into motion a Research and Innovation trend combining the well-established domain of Language Learning with recent and successful crowdsourcing approaches.

- Karën Fort co-organized with Rodrigo Agerri (Univ. of the Basque Country) the first Hackathon (named Crowdfest) in January in Brussels,
- Karën Fort and Bruno Guillaume participated in the 3rd Annual Action meeting in Lisbon in March,
- Karën Fort participated to a Workgroup meeting in Malta in November.

Karën Fort pariticipates in the COST action NexusLinguarum [0]. The main aim of this action is to promote synergies across Europe between linguists, computer scientists, terminologists, and other stakeholders in industry and society, in order to investigate and extend the area of linguistic data science.

8.4. International Initiatives

8.4.1. Participation in other International Programs

Common work and a common workshop was held in Gothenburg with the Centre for Linguistic Theory and Studies in Probability (CLASP, University of Gothenburg, Sweden), especially with Robin Cooper, Ellen Breitholtz and Chris Howes on the topic of dialogical reasoning in patients with schizophrenia and formal approaches to (in)coherence and dynamics in dialogue. The visit was supported by the French Institute in Sweden (*Programme Galan*).

[0] https://enetcollect.eurac.edu/
[0] https://www.cost.eu/actions/CA18209

SIROCCO Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. CominLabs InterCom project

Participants: Aline Roumy, Thomas Maugey.

- Title : Interactive Communication (INTERCOM): Massive random access to subsets of compressed correlated data .
- Research axis : 7.4.1
- Partners : Inria-Rennes (Sirocco team and i4S team); LabSTICC, IMT Atlantique, Signal & Communications Department; External partners: L2S, CentraleSupelec, Univ. Paris Sud; EPFL, Signal Processing Laboratory (LTS4).
- Funding : Labex CominLabs.
- Period : Oct. 2016 - Dec. 2020.

This project aims to develop novel compression techniques allowing massive random access to large databases. Indeed, we consider a database that is so large that, to be stored on a single server, the data have to be compressed efficiently, meaning that the redundancy/correlation between the data have to be exploited. The dataset is then stored on a server and made available to users that may want to access only a subset of the data. Such a request for a subset of the data is indeed random, since the choice of the subset is user-dependent. Finally, massive requests are made, meaning that, upon request, the server can only perform low complexity operations (such as bit extraction but no decompression/compression). Algorithms for two emerging applications of this problem are being developed: Free-viewpoint Television (FTV) and massive requests to a database collecting data from a large-scale sensor network (such as Smart Cities).

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. ERC-CLIM

Participants: Pierre Allain, Pierre David, Elian Dib, Simon Evain, Christian Galea, Christine Guillemot, Laurent Guillo, Fatma Hawary, Xiaoran Jiang, Maja Krivokuca, Ehsan Miandji, Hoai Nam Nguyen, Mira Rizkallah, Alexander Sagel, Jinglei Shi.

- Title : Computational Light field Imaging.
- Research axis : 7.1.1 , 7.1.2 , 7.1.4 , 7.2.1 , 7.2.3 , 7.2.4 , 7.2.2 , 7.3.1 , 7.3.2 , 7.3.3 , 7.3.4
- Partners : Inria-Rennes
- Funding : European Research Council (ERC) advanced grant
- Period : Sept. 2016 - Aug. 2021.

All imaging systems, when capturing a view, record different combinations of light rays emitted by the environment. In a conventional camera, each sensor element sums all the light rays emitted by one point over the lens aperture. Light field cameras instead measure the light along each ray reaching the camera sensors and not only the sum of rays striking each point in the image. In one single exposure, they capture the geometric distribution of light passing through the lens. This process can be seen as sampling the plenoptic function that describes the intensity of the light rays interacting with the scene and received by an observer at every point in space, along any direction of gaze, for all times and every wavelength.

The recorded flow of rays (the light field) is in the form of high-dimensional data (4D or 5D for static and dynamic light fields). The 4D/5D light field yields a very rich description of the scene enabling advanced creation of novel images from a single capture, e.g. for computational photography by simulating a capture with a different focus and a different depth of field, by simulating lenses with different apertures, by creating images with different artistic intents. It also enables advanced scene analysis with depth and scene flow estimation and 3D modeling. The goal of the ERC-CLIM project is to develop algorithms for the entire static and video light fields processing chain. The planned research includes the development of:

- novel low-rank or graph-based models for dimensionality reduction and compression
- deep learning methods for scene analysis (e.g. scene depth and scene flow estimation)
- learning methods for solving a range of inverse problems: denoising, super-resolution, axial super-resolution, view synthesis.

9.3. International Initiatives

9.3.1. Inria International Labs

EPFL-Inria: Associate Team involved in the International Lab: Graph-based Omnidirectional video Processing (GOP)

- Participant: Thomas Maugey
- International Partner (Institution - Laboratory - Researcher): Ecole Polytechnique Fédérale de Lausanne (Switzerland) - LTS4 - Pascal Frossard
- period: 2017-2019

Due to new camera types, the format of the video data has become more complex than simple 2D images or videos as it was the case a few years ago. In particular, the omnidirectional cameras provide pixels on a whole sphere around a center point and enable a vision in 360°. In addition to the fact that the data size explodes with such cameras, the inherent structure of the acquired signal fundamentally differs from the 2D images, which makes the traditional video codec obsolete. In parallel of that, an important effort of research has been led recently, especially at EPFL, to develop new processing tools for signals lying on irregular structures (graphs). It enables in particular to build efficient coding tools for new types of signals. During this project, we study how graphs can be built for defining a suitable structure on one or several 360 videos and then used for compression.

9.3.2. Inria International Partners

9.3.2.1. Informal International Partners

We have international collaborations with:

- Reuben Farrugia, Prof. at the University of Malta, with whom we continue collaborating on light field super-resolution.The collaboration started during the sabbatical year (Sept. 2015-Aug. 2016) he spent within the team.
- Ehsan Miandji and Prof. Jonas Unger from Linkoping Univ. with whom we collaborate on compressive sampling of light fields.
- Mikael Le Pendu and Prof. Aljosa Smolic from Trinity College Dublin on HDR light field recovery from multiple exposures.
- Pascal Frossard, Prof. at EPFL, in the context of the Comin Lab/Intercom project and in the context of the EPFL-Inria associated team.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

9.4.1.1. Internships

- Zhaolin Xiao, Prof. Xian University, Dec. 2018-Nov. 2019.

Stars Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

See CoBTek, Nice Hospital, FRIS

8.2. National Initiatives

See Vedecom

8.2.1. ANR

8.2.1.1. ENVISION

Program: ANR JCJC

Project acronym: ENVISION

Project title: Computer Vision for Automated Holistic Analysis of Humans

Duration: October 2017-September 2020.

Coordinator: Antitza Dantcheva (STARS)

Abstract: The main objective of ENVISION is to develop the computer vision and theoretical foundations of efficient biometric systems that analyze appearance and dynamics of both face and body, towards recognition of identity, gender, age, as well as mental and social states of humans in the presence of operational randomness and data uncertainty. Such dynamics - which will include facial expressions, visual focus of attention, hand and body movement, and others, constitute a new class of tools that have the potential to allow for successful holistic analysis of humans, beneficial in two key settings: (a) biometric identification in the presence of difficult operational settings that cause traditional traits to fail, (b) early detection of frailty symptoms for health care.

8.2.2. FUI

8.2.2.1. Visionum

Program: FUI

Project acronym: Visionum

Project title: Visonium.

Duration: January 2015- December 2018.

Coordinator: Groupe Genious

Other partners: Inria (Stars), StreetLab, Fondation Ophtalmologique Rothschild, Fondation Hospitalière Sainte-Marie.

Abstract: This French project from Industry Minister aims at designing a platform to re-educate at home people with visual impairment.

8.2.2.2. StoreConnect

Program: FUI

Project acronym: StoreConect.

Project title: StoreConnect.

Duration: September 2016 - June 2019.

Coordinator: Ubudu (Paris).

Other partners: Inria (Stars), STIME (groupe Les Mousquetaires Paris), Smile (Paris), Thevolys (Dijon).

Abstract: StoreConnect is a FUI project started in 2016 and ended in 2019. The goal is to improve the shopping experience for customers inside supermarkets by adding new sensors such as cameras, beacons and RFID. By gathering data from all the sensors and combining them, it is possible to improve the way to communicate between shops and customers in a personalized way. StoreConnect acts as a middleware platform between the sensors and the shops to process the data and extract interesting knowledge organized via ontologies.

8.2.2.3. ReMinAry

Program: FUI

Project acronym: ReMinAry.

Project title: ReMinAry.

Duration: September 2016 - June 2020.

Coordinator: GENIOUS Systèmes,

Other partners: Inria (Stars), MENSIA technologies, Institut du Cerveau et de la Moelle épinière, la Pitié-Salpêtrière hospital.

Abstract: This project is based on the use of motor imagery (MI), a cognitive process consisting of the mental representation of an action without concomitant movement production. This technique consists in imagining a movement without realizing it, which entails an activation of the brain circuits identical to those activated during the real movement. By starting rehabilitation before the end of immobilization, a patient operated on after a trauma will gain rehabilitation time and function after immobilization is over. The project therefore consists in designing therapeutic video games to encourage the patient to re-educate in a playful, autonomous and active way in a phase where the patient is usually passive. The objective will be to measure the usability and the efficiency of the re-educative approach, through clinical trials centered on two pathologies with immobilization: post-traumatic (surgery of the shoulder) and neurodegenerative (amyotrophic lateral sclerosis).

8.3. European Initiatives

8.3.1. Collaborations in European Programs, Except FP7 & H2020

See EIT Health.

8.4. International Initiatives

8.4.1. Inria International Labs

- $EASafEE$: Associated team (2018-2020) Safe and Easy Environment for Alzheimer disease and related disorders. Inria Stars, National Taipei University of Technology Taiwan and CoBTeK team. The objective of SafEE is to develop an automated home support system, using information and communication technologies (ICT), to support the loss of autonomy and to improve the quality of life of the elderly population.
- $FER4HM$: Inria International Lab (2017-2020) Facial Expression Recognition for Health Monitoring. Coordinator: François Brémond, Antitza Dantcheva. Other partners: Chinese Academy of Sciences (CAS) (China). FER4HM aims to investigate computer vision methods for facial expression recognition in patients with Alzheimer's disease. Most importantly though, the project seeks to be part of a paradigm shift in current health care, efficiently and cost-effectively finding objective measures to (a) assess different therapy treatments, as well to (b) enable automated human-computer interaction in remote scale health care-frameworks.

8.4.1.1. Other IIL projects

- RESPECT

  Program: ANR PRCI (French-German, ANR-DFG)

  Project acronym: RESPECT

  Project title: Reliable, secure and privacy preserving multi-biometric person authentication

  Duration: April 2019-March 2023.

  Coordinator: Antitza Dantcheva (STARS)

  Abstract: In spite of the numerous advantages of biometric recognition systems over traditional authentication systems based on PINs or passwords, these systems are vulnerable to external attacks and can leak data. Presentations attacks (PAs) – impostors who manipulate biometric samples to masquerade as other people – pose serious threats to security. Privacy concerns involve the use of personal and sensitive biometric information, as classified by the GDPR, for purposes other than those intended. Multi-biometric systems, explored extensively as a means of improving recognition reliability, also offer potential to improve PA detection (PAD) generalisation. Multi-biometric systems offer natural protection against spoofing since an impostor is less likely to succeed in fooling multiple systems simultaneously. For the same reason, previously unseen PAs are less likely to fool multi-biometric systems protected by PAD. RESPECT, a Franco-German collaborative project, explores the potential of using multi-biometrics as a means to defend against diverse PAs and improve generalisation while still preserving privacy. Central to this idea is the use of (i) biometric characteristics that can be captured easily and reliably using ubiquitous smart devices and, (ii) biometric characteristics which facilitate computationally manageable privacy preserving, homomorphic encryption.

  The research focuses on characteristics readily captured with consumer-grade microphones and video cameras, specifically face, iris and voice. Further advances beyond the current state of the art involve the consideration of dynamic characteristics, namely utterance verification and lip dynamics. The core research objective is to determine which combination of biometrics characteristics gives the best biometric authentication reliability and PAD generalisation while remaining compatible with computationally efficient privacy preserving BTP schemes.

- $VIdeoSeizureAnalysis$: Inserm-Inria PhD grant (October 2018- September 2021). Partners: Prof F Bartolomei Inserm UMR 1106 La Timone Hospital Marseille and M Thonnat DR Inria Stars Sophia Antipolis. The objective of the PhD thesis entitled Quantified video analysis of seizure semiology in epilepsy is to provide new automated and objective analysis and interpretation of recorded videos of patients during epilepsy seizures.

8.4.2. Inria Associate Teams Not Involved in an Inria International Labs

8.4.2.1. SafEE (Safe & Easy Environment)

Title: SafEE (Safe Easy Environment) investigates technologies for the evaluation, stimulation and intervention for Alzheimer patients. The SafEE project aims at improving the safety, autonomy and quality of life of older people at risk or suffering from Alzheimer.

International Partner (Institution - Laboratory - Researcher):

  National Taipei University of Technology Taipei (Taiwan) - Dept. of Electrical Engineering - Chao-Cheng Wu

Start year: 2018

See also: https://project.inria.fr/safee2/

SafEE (Safe Easy Environment) investigates technologies for the evaluation, stimulation and intervention for Alzheimer patients. The SafEE project aims at improving the safety, autonomy and quality of life of older people at risk or suffering from Alzheimer's disease and related disorders. More specifically the SafEE project : 1) focuses on specific clinical targets in three domains: behavior, motricity and cognition 2) merges assessment and non pharmacological help/intervention and 3) proposes easy ICT device solutions for the end users. In this project, experimental studies will be conducted both in France (at Hospital and Nursery Home) and in Taiwan.

8.4.2.2. Declared Inria International Partners

See Taiwan, China

8.4.3. Participation in Other International Programs

8.4.3.1. International Initiatives

FER4HM

Title: Facial expression recognition with application in health monitoring

International Partner (Institution - Laboratory - Researcher):

Institute of Computing Technology (ICT) of the Chinese Academy of Sciences (CAS) - Prof. Hu HAN

Duration: 2017 - 2019

Start year: 2017

See also: https://project.inria.fr/fer4hm/

The proposed research aims to provide computer vision methods for facial expression recognition in patients with Alzheimer's disease. Most importantly though, the work seeks to be part of a paradigm shift in current healthcare, in efficiently and cost effectively finding objective measures to (a) assess different therapy treatments, as well as to (b) enable automated human-computer interaction in remote large-scale healthcare- frameworks. Recognizing expressions in severely demented Alzheimer's disease (AD) patients is essential, since such patients have lost a substantial amount of their cognitive capacity, and some even their verbal communication ability (e.g., aphasia). This leaves patients dependent on clinical staff to assess their verbal and non-verbal language, in order to communicate important messages, as of discomfort associated to potential complications of the AD. Such assessment classically requires the patients' presence in a clinic, and time consuming examination involving medical personnel. Thus, expression monitoring is costly and logistically inconvenient for patients and clinical staff, which hinders among others large-scale monitoring. Approaches need to cater to the challenging settings of current medical recordings, which include continuous pose variations, occlusions, camera-movements, camera-artifacts, as well as changing illumination. Additionally and importantly, the (elderly) patients exhibit generally less profound facial activities and expressions in a range of intensities and predominantly occurring in combinations (e.g., talking and smiling). Both, Inria-STARS and CAS-ICT have already initiated research activities related to the here proposed topic. While both sides have studied facial expression recognition, CAS-ICT has explored additionally the use of heart rate monitoring sensed from a webcam in this context.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Wael Abd-Almageed from the Information Sciences Institute of the University of Southern California (USC) Viterbi School of Engineering visited in January 2019.
- Timur Luguev from the Intelligent Systems Group of Fraunhofer Institute for Integrated Circuits, Germany visited STARS in March 2019.
- Alan Aboudib from College de France visited STARS in July 2019.

- Julien Pettre from Inria Rennes (Team Rainbow) visited STARS in July 2019.
- Radu Horaud from Inria Grenoble (Team Perception) visited STARS in September 2019.
- Marcos Zuniga from Universidad Tecnica Federico Santa Maria, Chile visited STARS in 2019.
- Chao-Cheng Hu from the National Taipei University of Technology, Taiwan visited STARS in October 2019.

8.5.2. Internships

Several students from India, China, South Korea

THOTH Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. MIAI chair - Towards more data efficiency in machine learning

Participants: Julien Mairal, Karteek Alahari, Jakob Verbeek.

Julien Mairal holds a chair of the 3IA MIAI institute. The goal is to improve the data efficiency of machine learning algorithms.

9.1.2. MIAI chair - Towards self-supervised visual learning

Participant: Cordelia Schmid.

Cordelia Schmid holds a chair of the 3IA MIAI institute. The goal is to develop new self-supervised learning methods for computer vision.

9.1.3. MIAI chair - Multiscale, multimodal and multitemporal remote sensing

Participant: Jocelyn Chanussot.

Jocelyn Chanussot holds a chair of the 3IA MIAI institute.

9.1.4. DeCore (Deep Convolutional and Recurrent networks for image, speech, and text)

Participants: Jakob Verbeek, Maha Elbayad.

DeCore is a project-team funded by the Persyval Lab for 3.5 years (september 2016 - February 2020), coordinated by Jakob Verbeek. It unites experts from Grenoble's applied-math and computer science labs LJK, GIPSA-LAB and LIG in the areas of computer vision, machine learning, speech, natural language processing, and information retrieval. The purpose of DeCore is to stimulate collaborative interdisciplinary research on deep learning in the Grenoble area, which is likely to underpin future advances in machine perception (vision, speech, text) over the next decade. It provides funding for two full PhD students. Maha Elbayad is one of them, supervised by Jakob Verbeek and Laurant Besacier (LIG, UGA).

9.1.5. PEPS AMIES AuMalis POLLEN

Participant: Karteek Alahari.

This is a collaborative project with POLLEN, a startup in the Grenoble area, which develops POLLEN Metrology, a software editor specialized in signal processing, hybrid metrology and machine learning for the automatic processing of heterogeneous data. This funding supports a postdoc to accelerate the introduction of artificial intelligence, and in particular computer vision, techniques, into the manufacture of new generation of microprocessors. Karteek Alahari and Valerie Perrier (LJK, UGA) jointly supervise a postdoc as part of this collaboration. This collaboration ended in 2019.

9.2. National Initiatives

9.2.1. ANR Project Macaron

Participants: Julien Mairal, Zaid Harchaoui [Univ. Washington], Laurent Jacob [CNRS, LBBE Laboratory], Michael Blum [CNRS, TIMC Laboratory], Joseph Salmon [Telecom ParisTech], Mikita Dvornik, Daan Wynen.

The project MACARON is an endeavor to develop new mathematical and algorithmic tools for making machine learning more scalable. Our ultimate goal is to use data for solving scientific problems and automatically converting data into scientific knowledge by using machine learning techniques. Therefore, our project has two different axes, a methodological one, and an applied one driven by explicit problems. The methodological axis addresses the limitations of current machine learning for simultaneously dealing with large-scale data and huge models. The second axis addresses open scientific problems in bioinformatics, computer vision, image processing, and neuroscience, where a massive amount of data is currently produced, and where huge-dimensional models yield similar computational problems.

This is a 4 years and half project, funded by ANR under the program “Jeunes chercheurs, jeunes chercheuses”, which started in October 2014 and ended in March 2019. The principal investigator is Julien Mairal.

9.2.2. ANR Project DeepInFrance

Participants: Jakob Verbeek, Adria Ruiz Ovejero.

DeepInFrance (Machine learning with deep neural networks) project also aims at bringing together complementary machine learning, computer vision and machine listening research groups working on deep learning with GPUs in order to provide the community with the knowledge, the visibility and the tools that brings France among the key players in deep learning. The long-term vision of Deep in France is to open new frontiers and foster research towards algorithms capable of discovering sense in data in an automatic manner, a stepping stone before the more ambitious far-end goal of machine reasoning. The project partners are: INSA Rouen, Univ. Caen, Inria, UPMC, Aix-Marseille Univ., Univ. Nice Sophia Antipolis.

9.2.3. ANR Project AVENUE

Participant: Karteek Alahari.

This ANR project (started in October 2018) aims to address the perception gap between human and artificial visual systems through a visual memory network for human-like interpretation of scenes. To this end, we address three scientific challenges. The first is to learn a network representation of image, video and text data collections, to leverage their inherent diverse cues. The second is to depart from supervised learning paradigms, without compromising on the performance. The third one is to perform inference with the learnt network, e.g., to estimate physical and functional properties of objects, or give cautionary advice for navigating a scene. The principal investigator is Karteek Alahari, and the project involves participants from CentraleSupelec and Ecole des Ponts in Paris.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

9.3.1.1. ERC Advanced grant Allegro

Participants: Cordelia Schmid, Konstantin Shmelkov, Vladyslav Sydorov, Daan Wynen, Nikita Dvornik, Xavier Martin.

The ERC advanced grant ALLEGRO started in April 2013 and will end in April 2019. The aim of ALLEGRO is to automatically learn from large quantities of data with weak labels. A massive and ever growing amount of digital image and video content is available today. It often comes with additional information, such as text, audio or other meta-data, that forms a rather sparse and noisy, yet rich and diverse source of annotation, ideally suited to emerging weakly supervised and active machine learning technology. The ALLEGRO project will take visual recognition to the next level by using this largely untapped source of data to automatically learn visual models. We will develop approaches capable of autonomously exploring evolving data collections, selecting the relevant information, and determining the visual models most appropriate for different object, scene, and activity categories. An emphasis will be put on learning visual models from video, a particularly rich source of information, and on the representation of human activities, one of today’s most challenging problems in computer vision.

9.3.1.2. ERC Starting grant Solaris

Participants: Julien Mairal, Ghislain Durif, Andrei Kulunchakov, Alberto Bietti, Dexiong Chen, Gregoire Mialon.

The project SOLARIS started in March 2017 for a duration of five years. The goal of the project is to set up methodological and theoretical foundations of deep learning models, in the context of large-scale data processing. The main applications of the tools developed in this project are for processing visual data, such as videos, but also structured data produced in experimental sciences, such as biological sequences.

The main paradigm used in the project is that of kernel methods and consist of building functional spaces where deep learning models live. By doing so, we want to derive theoretical properties of deep learning models that may explain their success, and also obtain new tools with better stability properties. Another work package of the project is focused on large-scale optimization, which is a key to obtain fast learning algorithms.

9.4. International Initiatives

9.4.1. Inria International Labs

Inria@EastCoast

Associate Team involved in the International Lab:

9.4.1.1. GAYA

Title: Semantic and Geometric Models for Video Interpretation

International Partner (Institution - Laboratory - Researcher):

Carnegie Mellon University (United States) - Machine Learning Department - Katerina Fragkiadaki

Start year: 2019

See also: https://team.inria.fr/gaya/

We propose to renew the associate team GAYA, with the primary goal of interpreting videos in terms of recognizing actions, understanding the human-human and human-object interactions. In the first three years, the team has started addressing the problem of learning an efficient and robust video representation to attack this challenge. GAYA will now focus on building semantic models, wherein we learn incremental, joint audio-visual models, with limited supervision, and also geometric models, where we study the geometric properties of object shapes to better recognize them. The team consists of researchers from two Inria project-teams (Thoth and WILLOW), a US university (Carnegie Mellon University [CMU]) as the main partner team, and another US university (UC Berkeley) as a secondary partner. It will allow the partners to effectively combine their respective strengths in areas such as inference and machine learning approaches for vision tasks, joint audio-visual models, large-scale learning, geometric reasoning. The main expected outcomes of this collaboration are: new machine learning algorithms for handling minimally annotated multi-modal data, large-scale public datasets for benchmarking, theoretical analysis of objects shapes and contours. This associate team originally started in 2016, and was extended in 2019 for another 3 years.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

- **MPI Tübingen:** Cordelia Schmid collaborates with Michael Black, a research director at MPI, starting in 2013. End of 2015 she was award a Humbolt research award funding a long-term research project with colleagues at MPI. In 2019, the project resulted in the development of an approach for object interaction [20].

9.4.3. Participation in Other International Programs

- **Indo-French project EVEREST** with IIIT Hyderabad, India, funded by CEFIPRA (Centre Franco-Indien pour la Promotion de la Recherche Avancee). The aim of this project between Cordelia Schmid, Karteek Alahari and C. V. Jawahar (IIIT Hyderabad) is to enable the use of rich, complex models that are required to address the challenges of high-level computer vision. The work plan for the project will follow three directions. First, we will develop a learning framework that can handle weak annotations. Second, we will build formulations to solve the non-convex optimization problem resulting from the learning framework. Third, we will develop efficient and accurate energy minimization algorithms, in order to make the optimization computationally feasible.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

9.5.1.1. Internships

- Pia Bideau (PhD Student, Univ. Massachusetts Amherst) was an intern in the team until Jan 2019.
- Avijit Dasgupta (PhD Student, IIIT Hyderabad, India) was an intern in the team from Feb to May 2019.
- Gunnar Sigurdsson (PhD student, CMU) was an intern in the team from Jan to Mar 2019.

TITANE Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

9.1.1.1. PISCO: Perceptual Levels of Detail for Interactive and Immersive Remote Visualization of Complex 3D Scenes

Participants: Pierre Alliez [contact], Flora Quilichini, Florent Lafarge.

The way of consuming and visualizing this 3D content is evolving from standard screens to Virtual and Mixed Reality (VR/MR). Our objective is to devise novel algorithms and tools allowing interactive visualization, in these constrained contexts (Virtual and Mixed reality, with local/remote 3D content), with a high quality of user experience. Partners: Inria, LIRIS INSA Lyon Institut National des Sciences Appiquées (coordinator), Laboratoire d'Informatique en Images et Systèmes d'Information LS2N Nantes University. Total budget 550 KE, 121 KE for TITANE. The PhD thesis of Flora Quilichini is funded by this project which started in January 2018, for a total duration of 4 years.

9.1.1.2. LOCA-3D: Localization Orientation and 3D CArtography

Participants: Fernando Ireta Munoz, Florent Lafarge, Pierre Alliez [contact].

This project is part of the ANR Challenge MALIN LOCA-3D (Localization, orientation and 3D cartography). The challenge is to develop and experiment accurate location solutions for emergency intervention officers and security forces. These solutions must be efficient inside buildings and in conditions where satellite positioning systems do not work satisfactorily. Our solution is based on an advanced inertial system, where part of the inertial sensor drift is compensated by a vision system. Partners: SME INNODURA TB (coordinator), IBISC laboratory (Evry university) and Inria. Total budget: 700 KE, 157 KE for TITANE. The engineer position of Fernando Ireta Munoz is funded by this project which started in January 2018, for a total duration of 4 years.

9.1.1.3. EPITOME: efficient representation to structure large-scale satellite images

Participants: Nicolas Girard, Yuliya Tarabalka [PI].

The goal of this young researcher project is to devise an efficient multi-scale vectorial representation, which would structure the content of large-scale satellite images. More specifically, we seek for a novel effective representation for large-scale satellite images, that would be generic, i.e., applicable for images worldwide and for a wide range of applications, and structure-preserving, i.e. best representing the meaningful objects in the image scene. To address this challenge, we plan to bridge the gap between advanced machine learning and geometric modeling tools to devise a multi-resolution vector-based representation, together with the methods for its effective generation and manipulation. Total budget: 225 KE for TITANE. The PhD thesis of Nicolas Girard is funded by this project which started in October 2017, for a total duration of 4 years.

9.1.1.4. Faults_R_GEMS: Properties of FAULTS, a key to Realistic Generic Earthquake Modeling and hazard Simulation

Participants: Lionel Matteo, Yuliya Tarabalka [contact].

The goal of the project is to study the properties of seismic faults, using advanced math tools including learning approaches. The project is in collaboration with Geoazur lab (coordinator), Arizona State University, CALTECH, Ecole Centrale Paris, ENS Paris, ETH Zurich, Geosciences Montpellier, IFSTTAR, IPGP Paris, IRSN Fontenay-aux-Roses, LJAD Nice, UNAVCO Colorado and Pisa University. The PhD thesis of Lionel Matteo is funded by this project which started in October 2017, for a total duration of 4 years.

9.1.1.5. BIOM: Building Indoor and Outdoor Modeling

Participants: Muxingzi Li, Pierre Alliez, Florent Lafarge [contact].

The BIOM project aims at automatic, simultaneous indoor and outdoor modelling of buildings from images and dense point clouds. We want to achieve a complete, geometrically accurate, semantically annotated but nonetheless lean 3D CAD representation of buildings and objects they contain in the form of a Building Information Models (BIM) that will help manage buildings in all their life cycle (renovation, simulation, deconstruction). The project is in collaboration with IGN (coordinator), Ecole des Ponts Paristech, CSTB and INSA-ICube. Total budget: 723 KE, 150 KE for TITANE. The PhD thesis of Muxingzi Li is funded by this project which started in February 2018, for a total duration of 4 years.

9.2. International Initiatives

9.2.1. Inria International Partners

9.2.1.1. Declared Inria International Partners

We collaborated with David Bommes from Bern University (Switzerland), Gianmarco Cherchi and Riccardo Scateni from University of Cagliary (Sardinia), and Elmar Schoemer from Johannes Gutenberg Universität Mainz.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Michael Hemmer, research engineer at Google X, visited us in June.
- Jorg Peters, Professor at University of Florida, visited us in June.

9.3.2. Visits to International Teams

- Pierre Alliez visited the Google X team for one week in April.
- Florent Lafarge visited the Institute of Computer Graphics and Vision at TU Graz in March.

TYREX Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

BioQurate

Title: Querying and Curating Hierarchies of Biological Graphs

Funding: Fédération Informatique de Lyon (FIL)

Duration: 2018-2020

Coordinator: Angela Bonifati

Others partners: LIP/LIRIS. The project involves a bio-computing team and a database team on a common research problem

Abstract: This project aims at leveraging graph rewriting techniques of ReGraph and graph data management techniques in order to provide a persistent, robust and scalable substrate for the construction and manipulation of hierarchies of biological graphs. Moreover, we wish to investigate whether the involved graphs need further expressive graph constraints for enforcing consistency and performing data cleansing.

7.2. National Initiatives

7.2.1. ANR

CLEAR

Title: Compilation of intermediate Languages into Efficient big dAta Runtimes

Call: Appel à projets générique 2016 défi 'Société de l'information et de la communication' – JCJC

Duration: January 2017 – September 2021

Coordinator: Pierre Genevès

See also: http://tyrex.inria.fr/clear

Abstract: This project addresses one fundamental challenge of our time: the construction of effective programming models and compilation techniques for the correct and efficient exploitation of big and linked data. We study high-level specifications of pipelines of data transformations and extraction for producing valuable knowledge from rich and heterogeneous data. We investigate how to synthesize code which is correct and optimized for execution on distributed infrastructures.

DataCert

Title: Coq deep specification of security aware data integration

Call: Appel à projets Sciences et technologies pour la confiance et la sécurité numérique

Duration: January 2016 – January 2020

Participant: Angela Bonifati

Others partners: Université Paris Sud/Laboratoire de Recherche en Informatique, Université de Lille/Centre de Recherche en Informatique, Signal et Automatique de Lille, Université de Lyon/Laboratoire d'InfoRmatique en Image et Systèmes d'information.

See also: http://datacert.lri.fr/

Abstract: This project's aim is to develop a comprehensive framework handling the fundamental problems underlying security-aware data integration and sharing, resulting in a paradigm shift in the design and implementation of security-aware data integration systems. To fill the gap between both worlds, we strongly rely on deep specifications and proven-correct software, develop formal models yielding highly reliable technology while controlling the disclosure of private or confidential information.

QualiHealth

Title: Enhancing the Quality of Health Data

Call: Appel à projets Projets de Recherche Collaborative – Entreprise (PRCE)

Duration: 2018-2022

Coordinator: Angela Bonifati

Others partners: LIMOS, Université Clermont Auvergne. LIS, Université d'Aix-Marseille. HEGP, INSERM, Paris. Inst. Cochin, INSERM, Paris. Gnubila, Argonay. The University of British Columbia, Vancouver (Canada)

Abstract: This research project is geared towards a system capable of capturing and formalizing the knowledge of data quality from domain experts, enriching the available data with this knowledge and thus exploiting this knowledge in the subsequent quality-aware medical research studies. We expect a quality-certified collection of medical and biological datasets, on which quality-certified analytical queries can be formulated. We envision the conception and implementation of a quality-aware query engine with query enrichment and answering capabilities.

To reach this ambitious objectives, the following concrete scientific goals must be fulfilled : (1) An innovative research approach, that starts from concrete datasets and expert practices and knowledge to reach formal models and theoretical solutions, will be employed to elicit innovative quality dimensions and to identify, formalize, verify and finally construct quality indicators able to capture the variety and complexity of medical data; those indicators have to be composed, normalized and aggregated when queries involve data with different granularities (e.g., accuracy indications on pieces of information at the patient level have to be composed when one queries cohort) and of different quality dimensions (e.g., mixing incomplete and inaccurate data); and (2) In turn, those complex aggregated indicators have to be used to provide new quality-driven query answering, refinement, enrichment and data analytics techniques. A key novelty of this project is the handling of data which are not rectified on the original database but sanitized in a query-driven fashion: queries will be modified, rewritten and extended to integrate quality parameters in a flexible and automatic way.

VALDA Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

The ISORE project from the Île-de-France region (6k€ grant, DIM RFSI), which started in 2019, was completed in 2020.

Leonid Libkin received funding from FSMP through his *Chaire d'Excellence*, in the fall of 2019.

Pierre Senellart is a recipient of a Chair of the PaRis Artificial Intelligence Research InstitutE, PRAIRIE, sarting in the fall of 2019.

9.2. National Initiatives

9.2.1. ANR

Valda has been part of four ANR projects in 2019:

HEADWORK (2016–2021; 38 k€ for Valda, budget managed by Inria), together with IRISA (Druid, coordinator), Inria Lille (Links & Spirals), and Inria Rennes (Sumo), and two application partners: MNHN (Cesco) and FouleFactory. The topic is workflows for crowdsourcing. See http://headwork.gforge.inria.fr/.

BioQOP (2017–2020; 66 k€ for Valda, budget managed by ENS), with Idemia (coordinator) and GREYC, on the optimization of queries for privacy-aware biometric data management. See http://bioqop.di.ens.fr/.

CQFD (2018–2022; 19 k€ for Valda, budget managed by Inria), with Inria Sophia (GraphIK, coordinator), LaBRI, LIG, Inria Saclay (Cedar), IRISA, Inria Lille (Spirals), and Télécom ParisTech, on complex ontological queries over federated and heterogeneous data. See http://www.lirmm.fr/cqfd/.

QUID (2018–2022; 49 k€ for Valda, budget managed by Inria), LIGM (coordinator), IRIF, and LaBRI, on incomplete and inconsistent data. See https://quid.labri.fr/home.html.

Camille Bourgaux is participating in the AI Chair of Meghyn Bienvenu on *INTENDED (Intelligent handling of imperfect data)* to start in 2020.

9.3. European Initiatives

9.3.1. Collaborations in European Programs, Except FP7 & H2020

A bilateral French–German ANR project, entitled *EQUUS – Efficient Query answering Under UpdateS* was accepted in 2019. It will start in 2020. It involves CNRS (CRIL, CRIStAL, IMJ), Télécom Paris, HU Berlin, and Bayreuth University, in addition to Inria Valda.

9.4. International Initiatives

9.4.1. Informal International Partners

Valda has strong collaborations with the following international groups:

Univ. Edinburgh, United Kingdom: Paolo Guagliardo, Andreas Pieris

Univ. Oxford, United Kingdom: Michael Benedikt, Dan Olteanu, and Georg Gottlob

TU Dresden, Germany: Markus Krötzsch and Sebastian Rudolph

Dortmund University, Germany: Thomas Schwentick

Free Univ. Bozen-Bolzano, Italy: Ana Ozaki

Warsaw University, Poland: Mikołaj Bojańczyk and Szymon Toruńczyk

Tel Aviv University, Israel: Daniel Deutch and Tova Milo

Drexel University, USA: Julia Stoyanovich

Univ. California San Diego, USA: Victor Vianu

Pontifical Catholic University of Chile: Marcelo Arenas, Pablo Barceló

National University of Singapore: Stéphane Bressan

9.5. International Research Visitors

9.5.1. Visits of International Scientists

Victor Vianu, Professor at UC San Diego and former holder of an Inria international chair, spent 6 months within Valda, as a University Paris-Diderot and ENS invited professor.

Thomas Schwentick, Professor at TU Dortmund, spend 1 month within Valda in May–June.

WILLOW Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. PRAIRIE

Participants: Ivan Laptev, Jean-Paul Laumond, Jean Ponce, Josef Sivic.

The Prairie Institute (PaRis AI Research InstitutE) is one of the four French Institutes for Interdisciplinary Artificial Intelligence Research (3IA), which were created as part of the national French initiative on AI announced by President Emmanuel Macron on May 29, 2018. It brings together five academic partners (CNRS, Inria, Institut Pasteur, PSL University, and University of Paris) as well as 17 industrial partners, large corporations which are major players in AI at the French, European and international levels, as well as 45 Chair holders, including four of the members of WILLOW (Laumond, Laptev, Ponce, Sivic). Ponce is the scientific director of PRAIRIE.

9.1.2. DGA - RAPID project DRAAF

Participant: Ivan Laptev.

DGA DRAAF is a two-year collaborative effort with University of Caen (F. Jurie) and the industrial partner EVITECH (P. Bernas) focused on modelling and recognition of violent behaviour in surveillance videos. The project aims to develop image recognition models and algorithms to automatically detect weapons, gestures and actions using recent advances in computer vision and deep learning to provide an affordable real-time solution reducing effects of threats in public places.

9.2. European Initiatives

9.2.1. IMPACT: Intelligent machine perception

Participants: Josef Sivic, Jean Ponce, Ivan Laptev.

IMPACT is a 5-year collaborative project with Czech Technical University, Center for Robotics, Informatics and Cybernetics (CIIRC) (2017-2022). The IMPACT project focuses on fundamental and applied research in computer vision, machine learning and robotics to develop machines that learn to perceive, reason, navigate and interact with complex dynamic environments. For example, people easily learn how to change a flat tire of a car or perform resuscitation by observing other people doing the same task. This involves advanced visual intelligence abilities such as interpreting sequences of human actions that manipulate objects to achieve a specific task. Currently, however, there is no artificial system with a similar level of cognitive visual competence. Breakthrough progress in intelligent machine perception will have profound implications on our everyday lives as well as science and commerce, with smart assistive robots that automatically learn new skills from the Internet, safer cars that autonomously navigate in difficult changing conditions, or intelligent glasses that help people navigate never seen before environments.

9.3. International Initiatives

9.3.1. Associate team GAYA

Participants: Jean Ponce, Matthew Trager.

GAYA is a joint research team bringing together two Inria project-teams (Thoth, Grenoble and WILLOW, Paris) and Carnegie Mellon University, USA. It focuses on two research themes: (i) semantic structured interpretation of videos, and (ii) studying the geometric properties of object shapes to enhance state-of-the-art object recognition approaches.

Interpreting videos semantically in a general setting, involving various types of video content like home video clips, news broadcasts, feature films, which contain a lot of clutter, non-rigid motion, many “actors” performing actions, person-object and person-person interactions, varying viewpoints, is challenging. This task is being examined increasingly over the past decade, with the availability of large video resources, e.g., YouTube. Despite this progress, an effective video representation for recognizing actions is still missing. To address this critical challenge, we propose a joint optimization framework, wherein we learn the video representation and also develop models for action recognition. Specifically, we aim to exploit the spatio-temporal relations among pixels in a video through graphical models and novel deep learning feature representations.

The second research theme explores geometric aspects of computer vision, in particular how to model three-dimensional objects from their two-dimensional projections, and how the appearance of these objects evolves with changes in viewpoint. Beyond its theoretical interest, this work is critical for developing object recognition algorithms that take into account the three-dimensional nature of the visual world and go beyond the template-matching approaches dominant today. Duality is an important concept in this area, and we are investigating its application to the construction of visual hulls as well as the characterization of the topology of image contours using the Gauss map. Existing results are essentially limited to the Euclidean setting, and we are investigating their generalization to the general projective case.

Partners: CMU (Deva Ramanan, Martial Hebert, Abhinav Gupta, Gunnar Sigurdsson), Inria Thoth (Cordelia Schmid, Karteek Alahari, Pavel Tokmakov).

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Pierre-Yves Masse (post-doc, Czech Technical University) spent 50% of his time at Sierra (F. Bach) and Willow teams as a visiting post-doc within the framework of collaboration with the Intelligent Machine Perception project lead by J. Sivic at the Czech Technical University in Prague.
- Vladimir Petrik spent October - Janurary 2020 in Willow as a visiting post-doc within the framework of collaboration with the Intelligent Machine Perception project.
- Mircea Cimpoi spent three weeks in March 2019 in Willow as a visiting post-doc within the framework of collaboration with the Intelligent Machine Perception project.

9.4.1.1. Internships

- Anna Kukleva (Master student, University of Bonn) spent six months in the Willow team working on her Master project under supervision of M. Tapaswi and I. Laptev.

9.4.2. Visits to International Teams

9.4.2.1. Explorer programme

- J.Ponce, multiple visits to CMU’s Robotics Institute within the framework of the Gaia associated team

WIMMICS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- Nhan Le Thanh is responsible of project Idex Jedi MIRE, Université Côte d'Azur (2017-2020)
- IADB UCA Project *Integration and Learning on Biomedical Data*[0], is a project funded by UCA JEDI Labex (Université Côte d'Azur). The goal of the project is to leverage medical prognosis and decision making in the clinical domain with big data analysis techniques, Natural Language Processing and Machine Learning. The partners are: I3S, Wimmics, CHU Nice, BCL (Bases, Corpus, Language) Laboratory.

9.2. National Initiatives

9.2.1. PIA GDN ANSWER

Participants: Fabien Gandon, Hai Huang, Vorakit Vorakitphan, Serena Villata, Elena Cabrio.

ANSWER stands for Advanced aNd Secured Web Experience and seaRch [0]. It is a GDN project (Grands Défis du Numérique) from the PIA program (Programme d'Investissements d'Avenir) on Big Data. The project is between four Inria research teams and the Qwant company.

The aim of the ANSWER project is to develop the new version of the Qwant [0] search engine by introducing radical innovations in terms of search criteria as well as indexed content and users' privacy.

The purpose is to strengthen everyone's confidence in the search engine and increase the effectiveness of Web search. Building trust in the search engine is based on innovations in (1) Security: computer security, privacy; (2) Completeness: completeness and heterogeneity of (re)sources; and (3) Neutrality: analysis, extraction, indexing, and classification of data.

Increasing the effectiveness of Web-based research relies on innovations related to (1) Relevance: variety and value of content taken into account, measurement of emotions carried by query results; (2) Interaction with the user: adaptation of the interfaces to the types of research; and (3) Performance: perceived relevance of results and response time.

The proposed innovations include:

- Design and develop models and tools for the detection of emotions in query results:
  - Ontology, thesaurus, linguistic resources
  - Metrics, indicators, classification of emotions
- Design and develop new crawling algorithms:
  - Dynamic crawling strategies
  - Crawlers and indexes for linked open data
- Ensure respect for privacy:
  - Detection of Internet tracking
  - Preventive display of tracing techniques
  - Certified security of automatic adaptation of ads to keywords entered by the user

[0] *Intégration et Apprentissage sur les Données Biomédicales*
[0] https://project.inria.fr/answer/
[0] http://www.qwant.com

9.2.2. DGA CONFIRMA

Participants: Elena Cabrio, Serena Villata.

The theme of this new project with DGA is counter argumentation against fake news. Its duration is 2018-2020.

9.2.3. Ministry of Culture: MonaLIA 2.0

Participants: Anna Bobasheva, François Raygagne, Fabien Gandon, Frédéric Precioso.

The objective of the MonaLIA 2 project is to exploit the crossover of the automatic learning methods particularly applied to image analysis and knowledge-based representation and reasoning, in particular for the semantic indexing of annotated works and images in JocondeLab. The goal is to identify automated or semi-automatable tasks to improve the annotation. This project follows the preliminary project MonaLIA 1 which established the state of the art in order to evaluate the potential and the combination of learning (notably deep learning) and the semantization of annotations on the case of JocondeLab. In the project MonaLIA 2 we now want to go beyond the preliminary study and to design and build a prototype and the methods assisting the creation, the improvement and the maintenance of the metadata of the image database in order to assist the actors of the cultural world in their daily tasks. The preliminary study identified several possible coupling points between deep learning from non-necessarily structured data and reasoning from structured data. This project proposes to select the most promising of them to carry out a proof of concept combining these methods by focusing on the assistance to the annotation and curation tasks of the metadata of a real base to improve the contents, the course and exploitation thereafter.

9.2.4. ANR WASABI

Participants: Michel Buffa, Elena Cabrio, Catherine Faron Zucker.

The ANR project WASABI started in January 2017 with IRCAM, Deezer, Radio France and the SME Parisson, consists in building a 2 million songs knowledge base of commercial popular music (rock, pop, etc.) Its originality is the joint use of audio-based music information extraction algorithms, song lyrics analysis algorithms (natural language processing), and the use of the Semantic Web. Web Audio technologies will then explore these bases of musical knowledge by providing innovative applications for composers, musicologists, music schools and sound engineers, music broadcasters and journalists. This project is in its mid-execution and gave birth to many publications in international conferences as well as some mainstream coverage (i.e for "la fête de la Science"). Michel Buffa, national coordinator of this project, presented the project to "Journées Sciences et Musique" in October 2019 in Rennes, and animated a Master Class during the Sophia Summit 2019 event in November 2019. Participation in the ANR OpenMiage project aimed at offering online Bachelor and Master degrees.

Industrial transfer of some of the results of the WASABI project (partnership with AmpedStudio.com/Amp Track company) for integration of our software into theirs), SATT PACA.

Web site: http://wasabihome.i3s.unice.fr

9.2.5. ANR SIDES 3.0

Participants: Catherine Faron Zucker, Olivier Corby, Fabien Gandon, Alain Giboin, Andrea Tettamanzi.

Partners: Université Grenoble Alpes, Inria, Ecole Normale Supérieure de Lyon, Viseo, Theia.

SIDES 3.0 is an ANR project (2017-2020) which started in fall 2017. It is led by Université Grenoble Alpes (UGA) and its general objective is to introduce semantics within the existing SIDES educational platform [0] for medicine students, in order to provide them with added value educational services.

Web site: https://www.uness.fr/anr/projets/dune/sides3.0

9.2.6. ANR D2KAB

Participants: Olivier Corby, Catherine Faron Zucker, Franck Michel.

[0] http://side-sante.org/

Partners: LIRMM, INRA, IRD, ACTA

D2KAB is an ANR project which started in June 2019, led by the LIRMM laboratory (UMR 5506). Its general objective is to to create a framework to turn agronomy and biodiversity data into knowledge - semantically described, interoperable, actionable, open– and investigate scientific methods and tools to exploit this knowledge for applications in science and agriculture.

Web site: http://www.d2kab.org

9.2.7. Smart Enseigno

Participant: Catherine Faron Zucker.

Partner: Educlever, Ludotic, Cabrilog, IFE

As a follow-up of the EduMICS project, the Smart Enseigno project started in September 2019, led by Educlever. It is funded by the Ministry of National Education (MEN), within the Programme des Investissements d'Avenir (PIA2), action Partenariat d'innovation Intelligence artificielle(PI-IA) [00]. This project aims at developing resources and intelligent services within the Educlever platform for secondary school mathematics education.

9.2.8. DBpedia.fr

Participants: Elmahdi Korfed, Fabien Gandon.

The DBpedia.fr project proposes the creation of a French chapter of the DBpedia database. This project was the first project of the Semanticpedia convention signed by the Ministry of Culture, the Wikimedia foundation and Inria.

Web site: http://dbpedia.fr

9.2.9. Convention between Inria and the Ministry of Culture

Participant: Fabien Gandon.

We supervise the research convention with the Ministry of Culture to foster research and development at the crossroad of culture and digital sciences. This convention signed between Inria and the Ministry of Culture provides a framework to support projects at the cross-road of the cultural domain and the digital sciences.

9.2.10. Qwant-Inria Joint Laboratory

Participant: Fabien Gandon.

We supervise the Qwant-Inria Joint Laboratory where joint teams are created and funded to contribute to the search engine research and development. The motto of the joint lab is Smart Search and Privacy with five research directions:

- Crawling, Indexing, Searching
- Execution platform, privacy by design, security, ethics
- Maps and navigation
- Augmented interaction, connected objects, chatbots, personnal assistants
- Education technologies (EdTech)

We released the final, but confidential, report of the Qwant-Culture short-term project. This project aimed at identifying possibilities of exploiting the Qwant search engine to improve the search for information in the digital cultural resources of the French Ministry of Culture. Some possibilities have been selected to be the subject of research actions in the context a long-term project.

9.2.11. GDRI Zoomathia

Participants: Catherine Faron Zucker, Franck Michel, Andrea Tettamanzi.

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[0] https://eduscol.education.fr/pid29713/appels-a-projets-numeriques-des-investissements-d-avenir.html

[0] https://primabord.eduscol.education.fr/P2IA

Wimmics is a partner of the International Research Group (GDRI) Zoomathia funded by two CNRS institutes: INEE and INSHS. This group aims at studying transmission of zoological knowledge from Antiquity to Middle-Age through material resources (bio residues, artefacts), iconography and texts.

As a continuation of the work initiated with the *Muséum National d'Histoire Naturelle* (MNHN) during the last three years, the TAXREF-LD linked data dataset, that we produced jointly with the MNHN, now appears in the Linked Open Data cloud [0] and is published on AgroPortal [0]. Relatedly, we have reflected on modelling principles for biodiversity Linked Data [63].

Web site: http://www.cepam.cnrs.fr/zoomathia/

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

- AI4EU : In January 2019, the AI4EU consortium was established to build the first European Artificial Intelligence On-Demand Platform and Ecosystem with the support of the European Commission under the H2020 programme. We participate to the design of an ontology of AI resources. We have set up a prototype of Web server with a SPARQL endpoint to demonstrate the ontology and RDF metadata. Web site: https://www.ai4eu.eu

9.3.2. Collaborations in European Programs, Except FP7 & H2020

MIREL Project

Program: RISE

Project acronym: MIREL

Project title: MIning and REasoning with Legal texts

Duration: January 2016 - December 2019

Coordinator: University of Luxembourg

Other partners: 16 members from 11 countries [0].

Abstract: project that defines a formal framework and develops tools for MIning and REasoning with Legal texts, with the aim of translating these legal texts into formal representations that can be used for querying norms, checking compliance, and supporting decision .

CREEP EIT Project

Program: KIC EIT Digital 2018

Project acronym: CREEP

Project title: Cyberbulling Effects Prevention

Duration: January 2018 - December 2019

Coordinator: Fondazione Bruno Kessler

Other partners: University of Trento, Fondazione Bruno Kessler, ExpertSystem, NeuroNation

Abstract: CREEP (Cyberbulling Effects Prevention) aims at identifying and preventing the possible negative impacts of cyberbullying on young people. It seeks to realize advanced technologies for the early detection of cyberbullying phenomena through the monitoring of social media and the communication of preventive advices and personalized recommendations tailored to teenagers' needs through a virtual coaching system (chatbot).

[0] http://lod-cloud.net/
[0] http://agroportal.lirmm.fr/ontologies/TAXREF-LD/
[0] http://www.mirelproject.eu/members.html

9.4. International Research Visitors

- Laura Alonso Alemany, Professor, Cordoba University, Argentina
- Luigi Asprino, PhD, Research Assistant, Institute of Cognitive Sciences and Technologies, Roma, Italy
- Cristian Cardelino, PhD student, Cordoba University, Argentina
- Alberto Ceselli, Professor, University of Milano, Italy
- Andrei Ciortea, Postdoctoral researcher, University St. Gallen, Switzerland
- Johanna Frau, PhD student, Cordoba University, Argentina
- Marco Guerini, Researcher, Fondazione Bruno Kessler, Trento, Italy
- Phan Hieu Ho, PhD student, Danang Polytech, Vietnam
- Dario Malchiodi, Associate Professor, University of Milano, Italy
- Enrico Mensa, PhD Student, University of Torino, Italy
- Than Tuan Nguyen, Ph. D. student, Université Hanoi, Vietnam
- Debora Nozza, PhD student, University of Milano, Italy
- Johan Pauwels, Research Assistant, Queen Mary University of London
- Mark Sandler, Professor, Queen Mary University of London
- Milagro Teruel, PhD student, Cordoba University, Argentina

9.4.1. Visits to International Teams

9.4.1.1. Research Stays Abroad

- Fabien Gandon visited Stanford, USA from July to August 2019. In the context of the project MIREL he worked on the problem of SHACL-based validation of ontologies.

ZENITH Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Institut de Convergence Agriculture numérique #DigitAg, (2017-2023), 275Keuro.

Participants: Alexis Joly, Florent Masseglia, Esther Pacitti, Christophe Pradal, Patrick Valduriez.

#DigitAg brings together in a partnership of seventeen actors (public research and teaching organizations, transfer actors and companies) with the objective of accelerating and supporting the development of agriculture companies in France and in southern countries based on new tools, services and uses. Based in Montpellier with an office in Toulouse and Rennes and led by Irstea, #DigitAg's ambition is to become a world reference for digital agriculture. In this project, Zenith is involved in the analysis of big data from agronomy, in particular, plant phenotyping and biodiversity data sharing.

9.1.2. ANR WeedElec (2018-2021), 106 Keuro.

Participants: Julien Champ, Hervé Goëau, Alexis Joly.

The WeedElec project offers an alternative to global chemical weed control. It combines an aerial means of weed detection by drone coupled to an ECOROBOTIX delta arm robot equipped with a high voltage electrical weeding tool. WeedElec's objective is to remove the major related scientific obstacles, in particular the weed detection/identification, using hyperspectral and colour imaging, and associated chemometric and deep learning techniques.

9.1.3. Others

9.1.3.1. Pl@ntNet InriaSOFT consortium, 80 Keuro / year

Participants: Alexis Joly, Jean-Christophe Lombardo, Julien Champ, Hervé Goëau.

This contract between four research organisms (Inria, INRA, IRD and CIRAD) aims at sustaining the Pl@ntNet platform in the long term. It has been signed in November 2019 in the context of the InriaSOFT national program of Inria. Each partner subscribes a subscription of 20K euros per year to cover engineering costs for maintenance and technological developments. In return, each partner has one vote in the steering committee and the technical committee. He can also use the platform in his own projects and benefit from a certain number of service days within the platform. The consortium is not fixed and is not intended to be extended to other members in the coming years.

9.1.3.2. Ministry of Culture, 130 Keuro

Participants: Alexis Joly, Jean-Christophe Lombardo.

Two contracts have been signed with the ministry of culture to adapt, extend and transfer the content-based image retrieval engine of Pl@ntNet ("Snoop") toward two major actors of the French cultural domain: the French National Library (BNF) and the French National institute of audio-visual (INA).

9.1.3.3. INRA/Inria PhD program, 100 Keuro

Participant: Alexis Joly.

This contract between INRA and Inria allows funding a 3-years PhD student (Christophe Botella). The addressed challenge is the large-scale analysis of Pl@ntNet data with the objective to model species distribution (a big data approach to species distribution modeling). The PhD student is supervised by Alexis Joly with François Munoz (ecologist, IRD) and Pascal Monestiez (statistician, INRA).

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. CloudDBAppliance

Participants: Reza Akbarinia, Boyan Kolev, Florent Masseglia, Esther Pacitti, Patrick Valduriez.

Project title: CloudDBAppliance
Instrument: H2020
Duration: 2016 - 2019
Total funding: 5 Meuros (Zenith: 500Keuros)
Coordinator: Bull/Atos, France
Partners: Inria Zenith, U. Madrid, INESC and the companies LeanXcale, QuartetFS, Nordea, BTO, H3G, IKEA, CloudBiz, and Singular Logic.
Inria contact: Florent Masseglia, Patrick Valduriez

The project aims at producing a European Cloud Database Appliance for providing a Database as a Service able to match the predictable performance, robustness and trustworthiness of on premise architectures such as those based on mainframes. In this project, Zenith is in charge of designing and implementing the components for analytics and parallel query processing.

9.2.1.2. Cos4Cloud

Participants: Alexis Joly, Jean-Christophe Lombardo, Antoine Affouard.

Project title: Cos4Cloud
Instrument: H2020
Duration: 2019 - 2022
Total funding: 5 Meuros (Zenith: 400Keuros)
Coordinator: CSIC (Spain)
Partners: The Open University, CREAF, Bineo, EarthWatch, SLU, NKUA, CERT, Bineo, ECSA.
Inria contact: Alexis Joly

Cos4Cloud will integrate citizen science in the European Open Science Cloud (EOSC) through the co-design of innovative services to solve challenges faced by citizen observatories, while bringing Citizen Science (CS) projects as a service for the scientific community and the society and providing new data sources. In this project, Zenith is in charge of developing innovative web services related to automated species identification, location-based species prediction and training data aggregation services.

9.3. International Initiatives

The team has two PhD students funded by an Algerian initiative ("Bourses d'excellence Algériennes "):

- Khadidja Meguelati, since 2016, "Massively Distributed Time Series Clustering via Dirichlet Mixture Models"
- Lamia Djebour, since 2019, "Parallel Time Series Indexing and Retrieval with GPU architectures"

9.3.1. Inria International Labs

In the context of LIRIMA, P. Valduriez gave a one week course in big data at IMSP, Bénin, in march, and an online seminar on Blockchain on 13 dec at Inria Rennes.

9.3.2. Inria Associate Teams Not Involved in an Inria International Labs

9.3.2.1. SciDISC

Title: Scientific data analysis using Data-Intensive Scalable Computing

International Partner (Institution - Laboratory - Researcher):

Universidade Federal do Rio de Janeiro (Brazil) - Computer Laboratory - Marta Mattoso

Start year: 2017

See also: https://team.inria.fr/zenith/scidisc/

Data-intensive science requires the integration of two fairly different paradigms: high-performance computing (HPC) and data-intensive scalable computing (DISC). Spurred by the growing need to analyze big scientific data, the convergence between HPC and DISC has been a recent topic of interest [[Coutinho 2014, Valduriez 2015]. This project will address the grand challenge of scientific data analysis using DISC (SciDISC), by developing architectures and methods to combine simulation and data analysis. The expected results of the project are: new data analysis methods for SciDISC systems; the integration of these methods as software libraries in popular DISC systems, such as Apache Spark; and extensive validation on real scientific applications, by working with our scientific partners such as INRA and IRD in France and Petrobras and the National Research Institute (INCT) on e-medicine (MACC) in Brazil.

9.3.3. Inria International Partners

9.3.3.1. Informal International Partners

We have regular scientific relationships with research laboratories in

- North America: Univ. of Waterloo (Tamer Özsu), UCSB Santa Barbara (Divy Agrawal and Amr El Abbadi), Northwestern Univ. (Chicago), university of Florida (Pamela Soltis, Cheryl Porter, Gil Nelson), Harvard (Charles Davis), UCSB (Susan Mazer).
- Asia: National Univ. of Singapore (Beng Chin Ooi, Stéphane Bressan), Wonkwang University, Korea (Kwangjin Park), Kyoto University (Japan), Tokyo University (Hiroyoshi Iwata)
- Europe: Univ. of Madrid (Ricardo Jiménez-Periz), UPC Barcelona (Josep Lluis Larriba Pey), HES-SO (Henning Müller), University of Catania (Concetto Spampinatto), Cork School of Music (Ireland), RWTH (Aachen, Germany), Chemnitz technical university (Stefan Kahl), Berlin Museum für Naturkunde (Mario Lasseck), Stefanos Vrochidis (Greece, ITI), UK center for hydrology and ecology (Tom August)
- Africa: Univ. of Tunis (Sadok Ben-Yahia), IMSP, Bénin (Jules Deliga)
- Australia: Australian National University (Peter Christen)
- Central America: Technologico de Costa-Rica (Erick Mata, former director of the US initiative Encyclopedia of Life)

9.3.4. Participation in Other International Programs

9.3.4.1. Inria International Chairs

Dennis Shasha (NYU)

Title: Data Science in a Dynamic World

International Partner: New York University (NYU), USA

Duration: 2015 - 2019

Start year: 2015

Many fundamental problems in natural science from astronomy to microbiology require data from heterogeneous sources, hence giving rise to a new “data science”. The basic workflow is to collect that data, form some kind of similarity metric between objects based on each data source, and then weight those different similarity metrics for some data analysis task. The goal is to gain actionable insight such as the cause of some symptoms, the function of some protein, or the likely source of some epidemic. Most often this is conceived of as "do-it-once" exercise. However, as data acquisition techniques improve, data may evolve continuously. When that happens the question is whether new revised insights can be obtained in a close to real time manner. Whether this is possible depends on the qualities of the new data, the weighting of the data sources, and the machine learning algorithms used. This project addresses data science in a dynamic world, aiming to find fast and minimalist methods to update insights as new data appears. This will result in new data management algorithms that will be implemented in tools and validated in the context of real data, in particular biology data.

9.3.5. Visits of International Scientists

- Renan Souza (COPPE/UFRJ and IBM,Brazil): “Providing Online Data Analytical Support for Humans in the Loop of Computational Science and Engineering Applications” on Jan 15.
- Youcef Djenouri (Norwegian University of Science and Technology, Trondheim): “Urban traffic outlier detection” on Feb 14.
- Dennis Shasha (NYU) “Bounce Blockchain: a secure, energy-efficient permission less blockchain” on May 27.
- Alvaro Coutinho (COPPE/UFRJ, Brazil): “Some Reflections on Predictive Science in Geophysical Applications” on Nov 20.
- Marta Mattoso (COPPE/UFRJ, Brazil): “Adding Provenance Data to Experiments: From Computational Science to Deep Learning” on Nov 20.
- Eduardo Ogasawara, (CEFET-RJ, Brazil): “Event Detection in Time Series” on Nov 20.
- Heraldo Borges (CEFET-RJ, Brazil): “Discovering Patterns in Restricted Space-Time Datasets” on Nov 20.