RESEARCH CENTER
Bordeaux - Sud-Ouest

FIELD

Activity Report 2019

Section Partnerships and Cooperations

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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].

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).

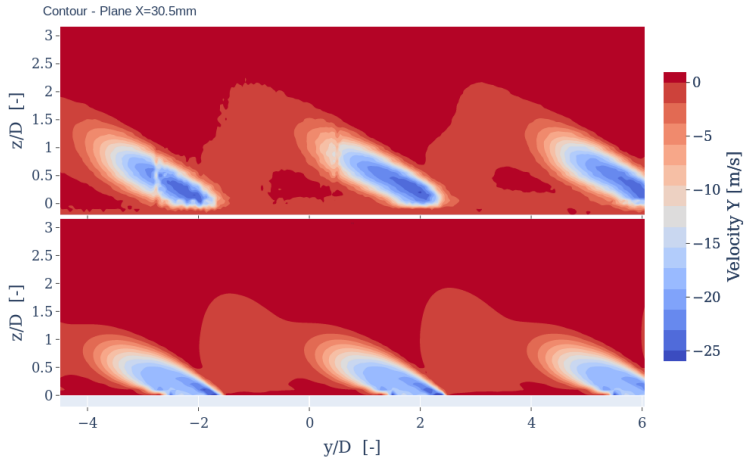

Figure 2. Simulation of the ONERA SOPRANO configuration: example of experimental (top) vs numerical (bottom) results concerning the mean velocity field.

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.

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

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.

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]

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, hominés, 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.

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.

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.

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)

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)

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.

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.

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/

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.

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

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.

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.