RESEARCH CENTER

FIELD
Applied Mathematics, Computation and Simulation

Activity Report 2018

Section Partnerships and Cooperations

Edition: 2019-03-07

ACUMES Project-Team

8. Partnerships and Cooperations

8.1. European Initiatives

8.1.1. FK32

Title: Multi-agent Fokker-Planck Nash games

Programm: Bayerisch-Französische Hochschulzentrum / Centre de Coopération Univ. Franco-Bavarois (BFHZ-CCUFB)

Duration: January - December 2018

PIs: A. Borzi (Univ. Wuerzburg) and A. Habbal

The purpose of this project is the formulation and application of a new mathematical framework for modeling avoidance and/or meeting in multi-agents' motion in the framework of differential games with stochastic processes and related Fokker-Planck equations.

8.1.2. FP7 & H2020 Projects

8.1.2.1. TramOpt

Title: A Traffic Management Optimization platform for enhanced road network efficiency

Programm: H2020

Duration: Mai 2017 - Octobre 2018

Coordinator: Inria

Inria contact: Paola Goatin

Building on the advances of the ERC TRAM3 project, the TRAMOPT PoC project aims are twofold:

- developing a robust prototype to allow real-life testing and deployment of a novel traffic control Decision Support System (DSS) based on a software platform for road traffic management including variable speed limits, ramp-metering and re-routing policies. This DSS is intended for public and private traffic managers to increase freeway network performances (e.g. congestion and pollution reduction);
- assessing the exploitation perspectives through a dedicated market study evaluating the added value of TRAMOPT over existing solutions and identifying the best business approach to foster uptake and commercialization of our technology.

8.2. International Initiatives

8.2.1. NAMReD

Program: Program Hubert Curien PHC Utique (Tunisia)

Project acronym: NAMReD

Project title: Novel Algorithms and Models for Data Reconstruction

Duration: January 2018 - December 2020

Coordinator: A. Habbal and M. Kallel (Univ. Tunis al Manar)

Abstract: The project goal is the design of new and efficient algorithms tailored for data reconstruction involving ill-posed problems. We rely on an original use of game theory and p-Kirchhoff methods. We apply these approaches for missing data recovery and image restoration.

8.2.2. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

8.2.2.1. NOLOCO

Title: Efficient numerical schemes for non-local transport phenomena

International Partner (Institution - Laboratory - Researcher):

Universidad del Bio-Bio (Chile) - Department of Mathematics - Luis Miguel Villada Osorio

Start year: 2018

See also: https://team.inria.fr/acumes/assoc-team/noloco/

This project tackles theoretical and numerical issues arising in the mathematical study of conservation laws with non-local flux functions. These equations include in a variety of applications, ranging from traffic flows to industrial processes and biology, and are intended to model macroscopically the action of non-local interactions occurring at the microscopic level.

The team, bi-located in France and Chile, has complementary skills covering the analysis, numerical approximation and optimization of non-linear hyperbolic systems of conservation laws, and their application to the modeling of vehicular and pedestrian traffic flows, sedimentation and other industrial problems.

Based on the members' expertise and on the preliminary results obtained by the team, the project will focus on the following aspects: - The development of efficient, high-order finite volume numerical schemes for the computation of approximate solutions of non-local equations. - The sensitivity analysis of the solutions on model parameters or initial conditions

The impact of the project is therefore twofold: while addressing major mathematical advances in the theory and numerical approximation of highly non-standard problems, it puts the basis for innovative tools to handle modern applications in engineering sciences.

8.2.3. Inria International Partners

8.2.3.1. ORESTE

Title: Optimal REroute Strategies for Traffic managEment

International Partner (Institution - Laboratory - Researcher):

University of California Berkeley (United States) - Electrical Engineering and Computer Science (EECS) (EECS) - Alexandre M. Bayen

Duration: 2018 - 2022

Start year: 2018

See also: https://team.inria.fr/acumes/assoc-team/oreste

The rapidly changing transportation ecosystem opens new challenges in traffic modeling and optimization approaches. We will focus in particular on the two following aspects:

Route choice apps impact. The vast use of personal route choice systems through phone applications or other devices is modifying the traditional flow of networks, requiring new models for accounting of the guidance impact. Indeed, routing apps have changed traffic patterns in the US and Europe, leading to new congestion patterns where previously no traffic was observed. Over the last decade, GPS enabled smart phones and connected personal navigation devices have disrupted the mobility landscape. Initially, the availability of traffic information led to better guidance of a small portion of motorists in the system. But as the majority of the driving public started to use apps, the systematic broadcasting of "selfish" best routes led to the worsening of traffic in numerous places, ultimately leading to the first lawsuit against one specific company in particular (Waze) accused to be the cause of these problems. This is just the beginning of an evolution, which, if not controlled and regulated, will progressively asphyxiate urban landscapes (already nearly hundreds of occurrences of this phenomenon are noticed by the popular media, which indicates the presence of probably

thousands of such issues in the US alone). Traffic managers are typically not equipped to fix these problems, and typically do not fund this research, as in order to be able to regulate and fix the problem, fundamental science needs to be advanced, modeling and game theory in particular, so remediation can happen (for which the traffic managers are equipped). In this project, we will mainly focus on the development and study of new macroscopic dynamical models to describe the aforementioned phenomena, and we will explore control strategies to mitigate their impact.

Autonomous vehicles. Besides, the foreseen deployment of connected and autonomous vehicles (CAVs) opens new perspectives both in traffic modeling and control. Indeed, CAVs are expected to modify the classical macroscopic traffic dynamics due to their peculiar motion laws, which are more uniform than human drivers' and follow different rules. Besides, due to their extended information on neighboring traffic conditions, the resulting dynamics would have a non-local character, justifying the use of rapidly developing non-local models. In any case, the different behavior of autonomous vehicles requires the design of new multi-class models capable of accounting for different vehicle classes characteristics and mutual interactions. Moreover, CAVs could be used as endogenous variable speed limiters, thus providing new action points to control traffic flow. Preliminary results show that the presence of few controlled vehicles can positively affect traffic conditions. In this setting, the interaction of AVs with the surrounding traffic can be described by strongly coupled PDE-ODE systems, which have been largely studied by the ACUMES team. Yet, the study of CAVs impact in realistic situations requires further research, in particular towards model validation, for which the Berkeley team will provide the necessary data.

8.2.3.2. Informal International Partners

University of Brescia, Information Engineering (R.M. Colombo: http://rinaldo.unibs.it/)

University of Mannheim, Scientific Computing Research Group (SCICOM) (S. Göttlich: http://lpwima.math.uni-mannheim.de/de/team/prof-dr-simone-goettlich/)

University of Rutgers - Camden, Department of Mathematical Science (B. Piccoli: https://piccoli.camden.rutgers.edu/)

University of Texas Arlington (S. Roy, https://mentis.uta.edu/explore/profile/souvik-roy)

Technical University of Kaiserslautern - Department of mathematics (B. Simeon https://www.mathematik.uni-kl.de/en/das/people/head/simeon/)

8.3. International Research Visitors

8.3.1. Visits of International Scientists

- M.D. Rosini (January 2018, Lublin University): co-direction of N. Dymski's PhD thesis.
- R.M. Colombo (July 2018, Brescia University): well-posedness of Initial Boundary Value Problems.
- L.M. Villada (September 2018, University of Bio-Bio): finite volume schemes for non-local systems of conservation laws.

8.3.2. Visits to International Teams

8.3.2.1. Research Stays Abroad

- N. Laurent-Brouty visited UC Berkeley (A. Bayen) for 1 month in April-May 2018.
- E. Rossi visited Mannheim University (S. Göttlich) for 1.5 months in September-October 2018.

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. Enrique Gutierrez Alvarez (post-doctoral) joined the team in October 2018 to work on this project.

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 [47] 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. No scientific activity has been devoted around those codes during 2018, but a 2-day Yales2 training session held in Rouen was attended by Pascal Bruel. Some technical activity was also devoted to install Yales2 at Evora University (Portugal) in the framework of the on-going informal scientific cooperation with Dr. P. Correia.

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: Rémi Manceau, Pascal Bruel, [A one-year Post-doc starting in January 2019].

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. This year, we attended the two ITR meetings in Stuttgart (Germany) and Bordes (France) and recruited a post-doc bound to start by mid-january 2019.

9.4. International Initiatives

9.4.1. Inria International Partners

9.4.1.1. Informal International Partners

- Institute of Mathematics, Almaty, Kazakhstan:

  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 (1 journal paper submitted in 2018). The low-Mach preconditioning of an in-house ENO based compressible flow solver was also further investigated. [PB] (one 13-day stay in Almaty).
- Collaboration with P. Correia (University of Evora, Portugal) related to the development of enhanced boundary conditions for the simulations of Mach zero flows with the artificial compressibility method and low Mach flows with a pressure-based approach. [PB] (two 5-day stays in Evora).
- Collaboration with S. Lardeau (Siemens Industry Software Computational Dynamics, Nuremberg, Germany) on the EB-RSM model and hybrid RANS/LES model for industrial applications. [RM]

9.4.2. Participation in International Programs

Participants: Pascal Bruel, Jonathan Jung, Rémi Manceau, Vincent Perrier.

- ECOS-Sud A17A07 project with UNC (Cordoba, Argentina): this is the first year of this project devoted to the simulations of the wind around aerial fuel tank. Jonathan Jung and Pascal Bruel spent several weeks at UNC in the framework of this project.

9.5. International Research Visitors

- Dr. Juan Pablo Saldia (University of Cordoba, Argentina) spent one month in the team in the framework of the A17A07 Ecos-Sud project.

CARDAMOM Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. CRA - Region Nouvelle Aquitaine EVE

Title : Virtual prototyping of EVE engines

Type : Co-funded from Region Aquitaine and Inria

Duration : 36 months

Starting : January 2017

Coordinator : P.M. Congedo

Abstract : The main objective of this thesis is the construction of a numerical platform, for permitting an efficient virtual prototyping of the EVE expander. This will provide EXOES with a numerical tool, that is much more predictive with respect to the tools currently available and used in EXOES, by respecting an optimal trade-off in terms of complexity/cost needed during an industrial design process.i Two research axes will be mainly developed. First, the objective is to perform some high-predictive numerical simulation for reducing the amount of experiments, thanks to a specific development of RANS tools (Reynolds Averaged Navier-Stokes equations) for the fluids of interest for EXOES. These tools would rely on complex thermodynamic models and a turbulence model that should be modified. The second axis is focused on the integration of the solvers of different fidelity in a multi-fidelity platform for performing optimization under uncertainties. The idea is to evaluate the system perfor- mances by using massively the low-fidelity models, and by correcting these estimations via only few calculations with the high-fidelity code.

9.1.2. CRA - Region Nouvelle Aquitaine SANSON

Title : CRA/15-CARDAMOM THESE SANSON-10199

Type : Co-funded from Region Aquitaine and Inria

Duration :

Starting :

Coordinator :

Abstract :

9.1.3. CRA - Region Aquitaine ETRURIA

Title : EvaluaTion des Risques de submersion côtière et Urbaine par Remaillage et déformatIon Adaptative de maillage (ETRURIA)

Type : Co-funded from Region Aquitaine and Inria

Duration : 36 months

Starting : November 2018

Coordinator : M. Ricchiuto

Abstract : the objective of this project is to develop improved tools for the simulation of coastal floods by combining mesh adaptation techniques based on remeshing and deformation, representations of the coastal structures allowing to mix exact meshing and embedded representations, and high order schemes. The tools developed will be used to study inundation of French coasts, and in particular coasts of the Nouvelle Aquitaine Region, in collaboration with BRGM, and the Rivages ProTech Center of SUEZ.

9.2. National Initiatives

9.2.1. ANR VISCAP

Title:

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. The crack network resulting from local damage opens a path to fibre degradation by corrosion and ultimately to failure of the composite, e.g. under static fatigue in high-temperature oxidative conditions. But 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. Numerical modelling is an essential tool for such an aim, and very few mathematical models exist for these materials; fulfilling the needs requires a strong academic-level effort before considering industrial valorisation. Therefore, 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.

9.2.2. 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

subsectionFUI ICARUS

Title: Intensive Calculation for AeRo and automotive engines Unsteady Simulations.

Type: FUI

Duration: January 2017 - December 2019

Coordinator: Turbomeca, Safran group

9.2.3. 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.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: FET-Future & emerging technologies

Project acronym: ExaQUte

Project title: EXAscale Quantification of Uncertainties for Technology and Science Simulation

Duration: 2018-2021

Coordinator: Riccardo Rossi (CIMNE, Barcelona)

Other partners: EPFL (Switzerland), UPC (Spain), TUM (Germany), VSB (Czech Republic), str.ucture GmbH (Germany)

The ExaQUte project aims at constructing a framework to enable Uncertainty Quantification (UQ) and Optimization Under Uncertainties (OUU) in complex engineering problems using computational simulations on Exascale systems. The stochastic problem of quantifying uncertainties will be tackled by using a Multi Level MonteCarlo (MLMC) approach that allows a high number of stochastic variables. New theoretical developments will be carried out to enable its combination with adaptive mesh refinement, considering both, octree-based and anisotropic mesh adaptation. Gradient-based optimization techniques will be extended to consider uncertainties by developing methods to compute stochastic sensitivities, This requires new theoretical and computational developments.

With a proper definition of risk measures and constraints, these methods allow high-performance robust designs, also maximizing the solution reliability. 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 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 exists. This will include the quantification of uncertainties in the response of civil engineering structures to the wind action, and the shape optimization taking into account uncertainties related to wind loading, structural shape and material behavior. All developments in ExaQUte will be open-source and will follow a modular approach, thus maximizing future impact.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: Ocean ERANET

Project acronym: MIDWEST

Project title: Multi-fidelity decision making tools for wave energy systems

Duration: October 2015- October 2018

Coordinator: Mario Ricchiuto

Other partners: Chalmers University (Sweden), IST Lisbon (Portugal), DTU Compute (Denmark)

MIDWEST is a project starting in 2016 (kick-off in December 2015) and funded by the EU-OceaneraNET program by the French ADEME, by the Swedish SWEA, and by the Portuguese FCT, aiming at proposing new tools for the wave energy industry. Wave energy converters (WECs) design currently relies on low-fidelity linear hydrodynamic models. While these models disregard fundamental nonlinear and viscous effects â which might lead provide sub-optimal designs â 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.

9.4. International Initiatives

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

9.4.1.1. HAMster

Title: High order Adaptive moving MeSh finiTE elements in immeRsed computational mechanics

International Partner (Institution - Laboratory - Researcher):

Duke (United States) - Civil & Environmental Engineering and Mechanical Engineering & Material Science - Guglielmo Scovazzi

Inria Bordeaux Sud-Ouest (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 Â fronts (e.g. shock waves) present in the flow. The two teams involved in the project have developed over the years complementary strategies, Â one focusing more on an Eulerian description aiming at capturing fronts on adaptive unstructured grids, Â the other Â 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 Â enormous flexibility when considering complex cases, Â 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.

9.4.2. Inria International Partners

9.4.2.1. Informal International Partners

- We entertain since many years a collaboration with Ecole de Technologie SupÃ©rieure de MontrÃ©al (Quebec), and in particular with Prof. Francois Morency, on the modelling of wing icing
- Collaboration with Universitá La Sapienza i (Prof. Renato Paciorri) and Universitá della Basilicata (Prof. Aldo Bonfiglioli) on the development of shock fitting techniques. We have regular exchanges of mutual visits and of students (this year Mirco Ciallella)
- We collaborate with Politecnico di Milano (Prof. Alberto Guardone) on the development of adaptive mesh techniques for time dependent problems. Within this collaboration Luca Cirrottola has spend part of his PhD in CARDAMOM
- We work with DTU Compute in Denmark (Prof. Allan-Peter Engsig Karup) and with and RISE in Sweden (Dr. Claes Eskilsson) on the simulation of free surface flows with floating structures. The PhD of U. Bosi is partially (and informally) co-supervised by Prof. Engsig-Karup and Dr. Eskilsson
- We work with Alireza Mazaheri (NASA LaRC, Virginia) on high order adaptive discretizations for compressible flows. Marco Lorini visited the NASA center in March/April

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- L. Nouveau
- G. Scovazzi, Professor at Duke University (Durham, NC), has visited Mario Ricchiuto in January and in June 2018 to work on high order embedded methods
- Aron Roland, CEO of BGS IT&E (Information Technology & Engineering) has visited Mario Ricchiuto in February 2018 to work on the simulation of flash floods
- Nicolas Perinet, Postdoctoral fellow at University of Chile has visited Mario Ricchiuto to work on the benchmarking of the SLOWS CODE. From Jul 2018 until Sep 2018
- Tatsuya Watanabe, Professor at Kyoto Sangyo University has visited Mathieu Collin to work on Born-Infeld theory in March 2018.
- Francois Morency, Professeur at Ecole de Technologie Supérieure de Montréal has visited Héloïse Beaugendre to work on aircraft icing, roughness modeling and performance degradation, on Jul 2018 and from Sep to Dec 2018

9.5.1.1. Internships

- Agnes Chan (Inria, M. Sc. Student). From Jun 2018 until Sep 2018.
- Beatrice Battisti (Inria, M. Sc. Student). From Apr 2018 until Sep 2018.
- Elie Solai (Inria, M. Sc. Student). From Mar 2018 until Aug 2018.
- Mirco Ciallella (Inria, M. Sc. Student). From Nov 2018.

DEFI Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. EVE

- Title : Virtual prototyping of EVE engines
- Type : Co-funded from Region Aquitaine and Inria
- Duration : 36 months
- Starting : October 2018
- Coordinator : P.M. Congedo
- Abstract : The main objective of this thesis is the construction of a numerical platform, for permitting an efficient virtual prototyping of the EVE expander. This will provide EXOES with a numerical tool, that is much more predictive with respect to the tools currently available and used in EXOES, by respecting an optimal trade-off in terms of complexity/cost needed during an industrial design process.i Two research axes will be mainly developed. First, the objective is to perform some high-predictive numerical simulation for reducing the amount of experiments, thanks to a specific development of RANS tools (Reynolds Averaged Navier-Stokes equations) for the fluids of interest for EXOES. These tools would rely on complex thermodynamic models and a turbulence model that should be modified. The second axis is focused on the integration of the solvers of different fidelity in a multi-fidelity platform for performing optimization under uncertainties. The idea is to evaluate the system performances by using massively the low-fidelity models, and by correcting these estimations via only few calculations with the high-fidelity code.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. UTOPIAE

Program: H2020 MSCA-ITN
Project acronym: UTOPIAE
Project title: Handling the unknown at the edge of tomorrow
Duration: January 2017- December 2020
Coordinator: M. Vasile (Strathclyde University)
Other partners: see http://utopiae.eu/ for additional details
UTOPIAE is a European research and training network looking at cutting edge methods bridging optimisation and uncertainty quantification applied to aerospace systems. The network will run from 2017 to 2021, and is funded by the European Commission through the Marie Skłodowska-Curie Actions of H2020. The network is made up of 15 partners across 6 European countries, including the UK, and one international partner in the USA, collecting mathematicians, engineers and computer scientists from academia, industry, public and private sectors.
Mission statement : To train, by research and by example, 15 Early Stage Researchers in the field of uncertainty quantification and optimisation to become leading independent researchers and entrepreneurs that will increase the innovation capacity of the EU. To equip the researchers with the skills they will need for successful careers in academia and industry. To develop fundamental mathematical methods and algorithms to bridge the gap between Uncertainty Quantification and Optimisation and between Probability Theory and Imprecise Probability Theory for Uncertainty Quantification to efficiently solve high-dimensional, expensive and complex engineering problems.

9.3. International Initiatives

9.3.1. Inria International Labs

P.M. Congedo is the Inria Coordinator of the CWI-Inria Inria International Lab.

IIL CWI-Inria

Associate Team involved in the International Lab:

9.3.1.1. COMMUNES

Title: Computational Methods for Uncertainties in Fluids and Energy Systems

International Partner (Institution - Laboratory - Researcher):

CWI (Netherlands) - Scientific Computing Group - Daan Crommelin

Start year: 2017

See also: https://project.inria.fr/inriacwi/projects/communes/

This project aims to develop numerical methods capable to take into account efficiently unsteady experimental data, synthetic data coming from numerical simulation and the global amount of uncertainty associated to measurements, and physical-model parameters. We aim to propose novel algorithms combining data-inferred stochastic modeling, uncertainty propagation through computer codes and data assimilation techniques. The applications of interest are both related to the exploitation of renewable energy sources: wind farms and solar Organic Rankine Cycles (ORCs).

9.3.1.2. Informal International Partners

University of Zurich : R. Abgrall. Collaboration on high order adaptive methods for CFD and uncertainty quantification.

Politecnico di Milano, Aerospace Department (Italy) : Pr. A. Guardone. Collaboration on ALE for complex flows (compressible flows with complex equations of state).

von Karman Institute for Fluid Dynamics (Belgium). With Pr. T. Magin we work on Uncertainty Quantification problems for the identification of inflow condition of hypersonic nozzle flows.

Rutgers University. Collaboration with Pr. F. Cakoni on transmission eigenvalues.

University of Delaware. Collaboration with Pr. D. Colton on inverse scattering theory

Ecole Nationale des Ingénieurs de Tunis. Collaboration with Pr. M. Moakher on Diffusion MRI

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Fioralba Cakoni, one month, July 15-August 14, 2018

ECUADOR Project-Team

8. Partnerships and Cooperations

8.1. International Initiatives

8.1.1. Inria International Labs

Ecuador participates in the Joint Laboratory for Exascale Computing (JLESC) together with colleagues at Argonne National Laboratory.

ELAN Team

7. Partnerships and Cooperations

7.1. European Initiatives

7.1.1. FP7 & H2020 Projects

7.1.1.1. GEM

Title: from GEometry to Motion, inverse modeling of complex mechanical structures

Programm: H2020

Type: ERC

Duration: September 2015 - August 2021

Coordinator: Inria

Inria contact: Florence BERTAILS-DESCOUBES

With the considerable advance of automatic image-based capture in Computer Vision and Computer Graphics these latest years, it becomes now affordable to acquire quickly and precisely the full 3D geometry of many mechanical objects featuring intricate shapes. Yet, while more and more geometrical data get collected and shared among the communities, there is currently very little study about how to infer the underlying mechanical properties of the captured objects merely from their geometrical configurations. The GEM challenge consists in developing a non-invasive method for inferring the mechanical properties of complex objects from a minimal set of geometrical poses, in order to predict their dynamics. In contrast to classical inverse reconstruction methods, my proposal is built upon the claim that 1/ the mere geometrical shape of physical objects reveals a lot about their underlying mechanical properties and 2/ this property can be fully leveraged for a wide range of objects featuring rich geometrical configurations, such as slender structures subject to frictional contact (e.g., folded cloth or twined filaments). To achieve this goal, we shall develop an original inverse modeling strategy based upon a/ the design of reduced and high-order discrete models for slender mechanical structures including rods, plates and shells, b/ a compact and well-posed mathematical formulation of our nonsmooth inverse problems, both in the static and dynamic cases, c/ the design of robust and efficient numerical tools for solving such complex problems, and d/ a thorough experimental validation of our methods relying on the most recent capturing tools. In addition to significant advances in fast image-based measurement of diverse mechanical materials stemming from physics, biology, or manufacturing, this research is expected in the long run to ease considerably the design of physically realistic virtual worlds, as well as to boost the creation of dynamic human doubles.

7.2. International Initiatives

7.2.1. Inria International Partners

7.2.1.1. Declared Inria International Partners

- Long-term partnership with Rahul Narain (University of Minnesota, USA, and IIT Delhi, INDIA) and Rahul Narain's PhD student Jie Li (University of Minnesota, USA).
- Long-term partnership with Alexandre-Derouet-Jourdan (OLM Digital, JAPAN).

GAMMA3 Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

7.1.1.1. ANR IMPACTS 2018-2021

Ideal Mesh generation for modern solvers and comPuting ArchiteCTureS.

- Coordinateur : Adrien Loseille
- The rapid improvement of computer hardware and physical simulation capabilities has revolutionized science and engineering, placing computational simulation on an equal footing with theoretical analysis and physical experimentation. This rapidly increasing reliance on the predictive capabilities has created the need for rigorous control of numerical errors which strongly impact these predictions. A rigorous control of the numerical error can be only achieved through mesh adaptivity. In this context, the role of mesh adaptation is prominent, as the quality of the mesh, its refinement, and its alignment with the physics are major contributions to these numerical errors. The IMPACTS project aims at pushing the envelope in mesh adaptation in the context of large size, very high fidelity simulations by proposing a new adaptive mesh generation framework. This framework will be based on new theoretical developments on Riemannian metric-field and on innovative algorithmic developments coupling a unique cavity-operator with an advancing-point techniques in order to produce high quality hybrid, curved and adapted meshes.

7.2. International Initiatives

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

7.2.1.1. AM2NS

Title: Advanced Meshing Methods for Numerical Simulations

International Partner (Institution - Laboratory - Researcher):

Mississippi State University (United States) - Center for Advanced Vehicular Systems - Computational Fluid Dynamics Dept. (CAVS-CFD) - Marcum David

Start year: 2017

See also: http://pages.saclay.inria.fr/frederic.alauzet/AssociateTeam_AM2NS/AT_am2ns.html

The purpose of the AM2NS Associate Team is to mutualize the knowledge of all teams in order to develop the next generation of meshing methods and their parallelization to address the new challenges in numerical simulations for industrial problems. The Associate Team is composed of four partners: Inria, Mississippi State University, The Boeing Company and Massachusetts Institute of Technology.

7.2.1.2. MODIS

Title: High-order discrete geometric modeling

International Partner (Institution - Laboratory - Researcher):

Polytechnique Montréal (Canada) - Computer Science - Franọis Guibault

Start year: 2017

See also: http://pages.saclay.inria.fr/patrick.laug/MODIS/MODIS.html

In the area of geometric modeling, major challenges are linked to the efficient visualization of CAD surfaces and to the generation of meshes adapted to numerical simulation. In this context, the conception of a discrete geometric model provides a simple and universal representation model, without the need for CAD. A first study has been carried out for the conception of a model of order 1 (one) defined by a 'triangulation' composed of quadrilaterals and triangles. The advantage of this model of order 1 lies in its geometric simplicity. However, in the case of complex surfaces, it may require a very large number of elements, and besides it is not sufficiently rich to give certain essential characteristics like geometric curvatures. The main goal of this project is to extend this discrete model of order 1 to higher orders.

MATHERIALS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

The project-team is involved in several ANR projects:

- S. Boyaval is the PI of the ANR JCJC project SEDIFLO (2016-2020) to investigate new numerical models of solid transport in rivers.
- V. Ehrlacher is a member of the ANR project ADAPT (2018-2022), PI: D. Lombardi, Inria REO team-project. This project is concerned with the parallelization of tensor methods for high-dimensional problems.
- F. Legoll is a member of the ANR project CINE-PARA (2015-2019), PI: Y. Maday, Sorbonne Université. This project is concerned with parallel-in-time algorithms.
- G. Stoltz is the PI of the ANR project COSMOS (2014-2019) which focuses on the development of efficient numerical techniques to simulate high-dimensional systems in molecular dynamics and computational statistics. It includes research teams from Institut Mines-Telecom, Inria Rennes and IBPC Paris.

Members of the project-team are participating in the following GdR:

- AMORE (Advanced Model Order REduction),
- CORREL (correlated methods in electronic structure computations),
- DYNQUA (time evolution of quantum systems, with applications to transport problems, nonequilibrium systems, etc.),
- EGRIN (gravity flows),
- MANU (MAthematics for NUclear applications),
- MASCOT-NUM (stochastic methods for the analysis of numerical codes),
- MEPHY (multiphase flows)
- REST (theoretical spectroscopy),
- CHOCOLAS (experimental and numerical study of shock waves).

The project-team is involved in two Labex: the Labex Bezout (started in 2011) and the Labex MMCD (started in 2012).

8.2. European Initiatives

The ERC consolidator Grant MSMATH (ERC Grant Agreement number 614492, PI T. Lelièvre) is running (it started in June 2014).

8.3. International Initiatives

T. Lelièvre, G. Stoltz and F. Legoll participate in the Laboratoire International Associé (LIA) CNRS / University of Illinois at Urbana-Champaign on complex biological systems and their simulation by high performance computers. This LIA involves French research teams from Université de Nancy, Institut de Biologie Structurale (Grenoble) and Institut de Biologie Physico-Chimique (Paris). The LIA has been renewed for 4 years, starting January 1st, 2018.

MEMPHIS Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Leading team of the regional project "Investigation and Modeling of Suspensions with the LOMA and LOF labs in Bordeaux.

8.2. National Initiatives

We are part of the GDR AMORE on ROMs.

MEPHYSTO-POST Team

5. Partnerships and Cooperations

5.1. National Initiatives

5.1.1. ANR

A. de Laire is a member of the ANR ODA project.

Title: Dispersive and random waves.

ANR reference : ANR-18-CE40-0020-01.

Coordinator: Nikolay Tzvetkov, Université de Cergy-Pontoise.

A. Hardy is a member of the ANR BoB project.

Title: Inférence bayésienne à ressources limitées - données massives et modèles coûteux.

Programme ANR: (DS0705) 2016.

ANR reference: ANR-16-CE23-0003.

Coordinator: R. Bardenet, CNRS & Université de Lille.

Duration: October 2016 - October 2020.

M. Simon is a member of the ANR EDNHS project.

Title: Diffusion de l'énergie dans des système hamiltoniens bruités.

Type: Défi de tous les savoirs (DS10) 2014.

ANR reference: ANR-14-CE25-0011.

Coordinator: C. Bernardin, Université de Nice.

Duration: October 2014 - October 2019.

5.2. European Initiatives

M. Simon is a collaborator of the ERC Starting Grant HyLEF project.

Title: Hydrodynamic Limits and Equilibrium Fluctuations: universality from stochastic systems

Duration: May 2017 - April 2022

Coordinator: P. Gonçalves, Instituto Superior Técnico, Lisbon.

5.3. International Research Visitors

5.3.1. Visits to International Teams

5.3.1.1. Research Stays Abroad

S. De Bièvre spent two months at the Centre de Recherche Mathématiques in Montréal as Simons Professor. M. Simon has been invited as Junior Scientific Leader of the Simons Semester "PDEs/SPDEs and Functional Inequalities" at IMPAN in Warsaw, Poland, for one month.

MINGUS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- A. Crestetto is a member of the regional initiative "Pari Scientifique Exprodil".
- M. Lemou is the head of the project "MUNIQ" of ENS Rennes. This two-years project (2018-2019) intends to gather multiscale numerical methods and uncertainty quantification techniques. The MINGuS members are P. Chartier, N. Crouseilles, M. Lemou and F. Méhats and colleagues from university of Madison-Wisconsin also belongs to this project.

9.2. National Initiatives

9.2.1. ANR

Participants: François Castella, Philippe Chartier, Nicolas Crouseilles, Mohammed Lemou, Florian Méhats, Arnaud Debussche, Anais Crestetto.

ANR MOONRISE: 2015-2019

The project *Moonrise* submitted by Florian Méhats has been funded by the ANR for 4 years, for the period 2015-2019. This project aims at exploring modeling, mathematical and numerical issues originating from the presence of high-oscillations in nonlinear PDEs from the physics of nanotechnologies (quantum transport) and from the physics of plasmas (magnetized transport in tokamaks). The partners of the project are the IRMAR (Rennes), the IMT (Toulouse) and the CEA Cadarache. In the MINGuS team, François Castella, Philippe Chartier, Nicolas Crouseilles and Mohammed Lemou are members of the project Moonrise.

Postdocs

- Loïc Le Treust has been hired as a Postdoc, under the supervision of Philippe Chartier and Florian Méhats. His contract started in september 2015 and ended in august 2016. Loïc Le Treust is now assistant professor at the university of Marseille.
- Yong Zhang has been hired as a Postdoc, under the supervision of Philippe Chartier and Florian Méhats. His contract started in september 2015 and ended in august 2016. Yong Zhang is now professor at the Tianjin university.
- Xiaofei Zhao has been hired as a Postdoc from september 2015 to september 2016 under the supervision of Florian Méhats. Xiaofei Zhao is now postdoc in the MINGuS team.

ANR MFG: 2016-2020

Mean Field Games (MFG) theory is a new and challenging mathematical topic which analyzes the dynamics of a very large number of interacting rational agents. Introduced ten years ago, the MFG models have been used in many areas such as, e.g., economics (heterogeneous agent models, growth modeling,...), finance (formation of volatility, models of bank runs,...), social sciences (crowd models, models of segregation) and engineering (data networks, energy systems...). Their importance comes from the fact that they are the simplest (“stochastic control"-type) models taking into account interactions between rational agents (thus getting beyond optimization), yet without entering into the issues of strategic interactions. MFG theory lies at the intersection of mean field theories (it studies systems with a very large number of agents), game theory, optimal control and stochastic analysis (the agents optimize a payoff in a possibly noisy setting), calculus of variations (MFG equilibria may arise as minima of suitable functionals) and partial differential equations (PDE): In the simplest cases, the value of each agent is found by solving a backward Hamilton-Jacobi equation whereas the distribution of the agents’ states evolves according to a forward Fokker-Planck equation. The “Master" equation (stated in the space of probability measures) subsumes the individual and collective

behaviors. Finally, modeling, numerical analysis and scientific computing are crucial for the applications. French mathematicians play a world-leading role in the research on MFG: The terminology itself comes from a series of pioneering works by J.-M. Lasry and P.-L. Lions who introduced most of the key ideas for the mathematical analysis of MFG; the last conference on MFG was held last June in Paris and organized by Y. Achdou, P. Cardaliaguet and J.-M. Lasry. As testifies the proposal, the number of researchers working on MFG in France (and also abroad) is extremely fast-growing, not only because the theoretical aspects are exciting and challenging, but also because MFG models find more and more applications. The aim of the project is to better coordinate the French mathematical research on MFG and to achieve significant progress in the theory and its applications.

The partners of the project are the CEREMADE laboratory (Paris Dauphine), the IRMAR laboratory (Rennes I), the university of Nice and of Tours.

ANR MoHyCon: 2017-2021

The MoHyCon project is related to the analysis and simulation of numerical methods for multiscale models of semiconductors. As almost all current electronic technology involves the use of semiconductors, there is a strong interest for modeling and simulating the behavior of such devices, which was recently reinforced by the development of organic semiconductors used for example in solar panels or in mobile phones and television screens (among others).

There exists a hierarchy of semiconductors models, including mainly three classes, which correspond to different scales of observation: microscopic, mesoscopic and macroscopic. At the microscopic scale, the particles are described one by one, leading to a huge system almost impossible to study, both theoretically and numerically. Within MoHyCon, we are then rather interested in the two other scales. The considered models at the mesoscopic scale are kinetic, of Boltzmann type, describing a distribution of particles submitted to an electric field. These models describe accurately the behavior of the semiconductor, but can be intricate and highly time and resource consuming to solve numerically. Thus, when the mean free path becomes small, it is preferable to consider fluid models, describing macroscopic quantities. Depending on the considered number of moments, various models can be obtained. The more common ones are the energy transport model, describing the densities of electron and energy, and the more simple drift-diffusion model, where the temperature is assumed to be a given function of the electron density.

In this project and provided this context, our aim is to construct and study rigorously numerical methods for these multiscale models. To this end, we will consider two distinct approaches: “Asymptotic Preserving” (AP) methods and coupling methods. The idea of AP methods is to design only one scheme which will be able to treat accurately every scale, without imposing restrictive stability conditions on the discretization parameters. Regarding the coupling methods, they consist in decomposing the domain into different regions on which the more relevant model (kinetic or macroscopic) will be considered. After locating the kinetic and fluid domains, the main difficulty is to obtain correct coupling conditions at each interface between two regions.

Considering the AP approach, our aim is to construct schemes for the linear Boltzmann equation for semiconductors, asymptotic preserving at the limit given by the drift-diffusion model. We will start with a very simplified model, with a linearized BGK collision operator. The constructed scheme will tend to an implicit discretization of Scharfetter-Gummel type for the drift-diffusion equation. The main objective will be then to lead a complete and rigorous study of the AP property by adapting to the discrete framework some continuous techniques: establish a discrete dissipation property yielding uniform estimates on the approximate solution which will allow to pass to the diffusion limit in the scheme.

As regards the second approach, the aim is to build a hybrid model coupling the kinetic equation on weakly collisional regions with macroscopic models on the remaining domain. We will first study specifically discretizations for energy-transport model, since we are then going to couple them with kinetic and other macroscopic schemes in our hybrid method. A particular attention will be paid to the implementation in order to obtain a robust and efficient code.

This ANR project is headed by M. Bessemoulin (CNRS, Nantes).

9.3. International Initiatives

9.3.1. Inria International Labs

IPL FRATRES MINGuS is associated to IPL FRATRES which started in june 2015. The aim of this project is to organize Inria teams activities which develop mathematical and numerical tools in magnetically confined nuclear fusion. The ambition is to prepare the next generation of numerical modeling methodologies able to use in an optimal way the processing capabilities of modern massively parallel architectures. This objective requires close collaboration between a) applied mathematicians and physicists that develop and study mathematical models of PDE; b) numerical analysts developing approximation schemes; c) specialists of algorithmics proposing solvers and libraries using the many levels of parallelism offered by the modern architecture and d) computer scientists. The project road map ambitions to contribute in close connection with National and European initiatives devoted to nuclear Fusion to the improvement and design of numerical simulation technologies applied to plasma physics and in particular to the ITER project for magnetic confinement fusion.

The IPL FRATRES ends at the end of the year. The final meeting was organized in november during which X. Zhao (former IPL postdoc), G. Morel (IPL postdoc) and N. Crouseilles have presented the kinetic activities of the IPL project.

Postdoc

- Xiaofei Zhao has been hired as a postdoc, under the supervision of Nicolas Crouseilles and Sever Hirstoaga (Inria-Nancy). His contract started in october 2016 and ended in september 2017. Xiaofei Zhao is now postdoc in the MINGuS team.
- Guillaume Morel has been hired as a postdoc, under the supervision of Nicolas Crouseilles and Michel Mehrenberger (AMU). His contract started in october 2018 and ended in september 2019.

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

ANTIpODE

Title: Asymptotic Numerical meThods for Oscillatory partial Differential Equations with uncertainties

International Partner (Institution - Laboratory - Researcher):

University of Wisconsin-Madison, USA (United States) - DEPARTMENT MATHEMATICS - Shi Jin

Start year: 2018

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

The proposed associate team assembles the Inria team MINGuS and the research group led by Prof. Shi Jin from the Department of Mathematics at the University of Wisconsin, Madison. The main scientific objective of ANTIpODE consists in marrying uniformly accurate and uncertainty quantification techniques for multi-scale PDEs with uncertain data. Multi-scale models, as those originating e.g. from the simulation of plasma fusion or from quantum models, indeed often come with uncertainties. The main scope of this proposal is thus (i) the development of uniformly accurate schemes for PDEs where space and time high oscillations co-exist and (ii) their extension to models with uncertainties. Applications to plasmas (Vlasov equations) and graphene (quantum models) are of paramount importance to the project.

9.3.3. Inria International Partners

Informal International Partners The members of the MINGuS have several interactions with the following partners

- the group of W. Bao (university of Singapore).
- university of Maryland (S. Cerrai)
- university of Ferrare (G. Dimarco)
- university of Madison-Wisconsin (S. Jin and Q. Li)
- university of Geneva (G. Vilmart)

9.4. International Research Visitors

9.4.1. Visits of International Scientists

The following scientists came in Rennes to visit some MINGuS members

- Fernando Casas (Professor, University of Jaume I, Castellon, Spain): invited professor for five months, from september 2018 to january 2019, funded by the Labex (CHL) Center Henri Lebesgue, collaboration on dissipative equations, splitting methods and gradient descent methods with P. Chartier, N. Crouseilles, M. Lemou and F. Méhats.
- Molei Tao (Associate professor, Georgia Tech, Atlanta, USA): eigth-days visit in november, funded by the ANR Moorise, collaboration on highly-oscillatory differential equations with P. Chartier, M. Lemou and F. Méhats.
- Di Fang (PhD student, University of Wisconsin, USA): ten-days visit in december 2019, funded by the associated team ANTIpODE, collaboration on highly-oscillatory differential equations with P. Chartier, M. Lemou and F. Méhats.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

Here we list the members of the team who did some research stays abroad

- P. Chartier, N. Crouseilles, M. Lemou, F. Méhats and P. Navaro: invited working visit (Eric Sonnendrücker), Max Planck Institute, Garching, Germany, March 19th-23th, 2018.
- P. Chartier, M. Lemou and F. Méhats: working visit, university of Madison-Wisconsin, USA, october 10th-20th, 2018.
- P. Chartier: invited working visit (Christophe Besse), University of Toulouse 3, Toulouse, February 26th-28th, 2018.
- P. Chartier: invited working visit (Gilles Vilmart), University of Geneva, Geneva, Switzerland, January 19th-26th, 2018.
- P. Chartier: invited working visit (Ander Murua), University of the Basque Country, San-Sebastian, Spain, January 15th-19th, 2018.
- N. Crouseilles: invited working visit (Giacomo Dimarco), University of Ferrare, Italy, october 2018.
- A. Debussche: invited working visit (Sandra Cerrai), university of Maryland, USA, april 2018.
- M. Lemou and F. Méhats: invited working visit (Ana Maria Luz), University Federal of Fluminence, Niteroi, Brazil, April 3th-8th, 2018.

MOKAPLAN Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

J-D. Benamou and G. Carlier are members of the ANR MFG (ANR-16-CE40-0015-01). Scientific topics of the project: Mean field analysis Analysis of the MFG systems and of the Master equation Numerical analysis Models and applications
J-D. Benamou G. Carlier F-X. Vialard and T. O. Gallouët are members of ANR MAGA (ANR-13-JS01-0007-01). The Monge-Ampère equation is a fully nonlinear elliptic equation, which plays a central role in geometry and in the theory of optimal transport. However, the singular and non-linear nature of the equation is a serious obstruction to its efficient numerical resolution. The first aim of the MAGA project is to study and to implement discretizations of optimal transport and Monge-Ampère equations which rely on tools from computational geometry (Laguerre diagrams). In a second step, these solvers will be applied to concrete problems from various fields involving optimal transport or Monge-Ampère equations such as computational physics: early universe reconstruction problem, congestion/incompressibility constraints economics: principal agent problems, geometry: variational problems over convex bodies, reflector and refractor design for non-imaging optics
T. O. Gallouët is member of the ANR GEOPOR (JCJC of C. Cancès) Scientific topic: geometrical approach, based on Wasserstein gradient flow, for multiphase flows in porous media. Theory and Numerics.
T. O. Gallouët is member of the ANR MESA (JCJC of M. Fathi) Scientific topic: Stein methods.

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

J-D. Benamou and G. Rukhaia are members of the ROMSOC ITN.

7.3. International Research Visitors

7.3.1. Visits of International Scientists

- Shuangjian Zhang, (PostDoc), Université de Toronto, June-August 2018.
- Clarice Poon, Imperial College London, January 2018
- Teresa Radice, Université de Naples, many short stays.

7.3.2. Visits to International Teams

7.3.2.1. Research Stays Abroad

- P. Pegon was invited for 10 days to Penn State College by Alberto Bressan in order to start a collaboration on the theory of ramified transport and applications to biology, and to give lectures (2) in the seminar series on Computational and Applied Mathematics.
- G. Carlier was a John von Neumann invited Professor at TUM (Munich) in 2018.

NACHOS Project-Team

8. Partnerships and Cooperations

8.1. European Initiatives

8.1.1. FP7 & H2020 Projects

8.1.1.1. EoCoE

Title: Energy oriented Centre of Excellence for computer applications
Program: H2020
See also: https://www.eocoe.eu
Duration: October 2015 - October 2018
Coordinator: CEA
Partners:

- Barcelona Supercomputing Center (Spain)
- CEA (France)
- CERFACS (France)
- CNR (Italy)
- The Cyprus Institute (Cyprus)
- ENEA (Italy)
- Fraunhofer–Gesellschaft (Germany)
- Instytut Chemii Bioorganicznej Polskiej Akademii Nauk (Poland)
- Forschungszentrum Julich (Germany)
- Max-Planck-Gesellschaft (Germany)
- University of Bath (United Kingdom)
- Universite Libre de Bruxelles (Belgium)
- Universita Degli Studi di Trento (Italy)

Inria contact: Michel Kern

The aim of the present proposal is to establish an Energy Oriented Centre of Excellence for computing applications, (EoCoE). EoCoE (pronounce “Echo”) will use the prodigious potential offered by the ever-growing computing infrastructure to foster and accelerate the European transition to a reliable and low carbon energy supply. To achieve this goal, we believe that the present revolution in hardware technology calls for a similar paradigm change in the way application codes are designed. EoCoE will assist the energy transition via targeted support to four renewable energy pillars: Meteo, Materials, Water and Fusion, each with a heavy reliance on numerical modelling. These four pillars will be anchored within a strong transversal multidisciplinary basis providing high-end expertise in applied mathematics and HPC. EoCoE is structured around a central Franco-German hub coordinating a pan-European network, gathering a total of 8 countries and 23 teams. Its partners are strongly engaged in both the HPC and energy fields; a prerequisite for the long-term sustainability of EoCoE and also ensuring that it is deeply integrated in the overall European strategy for HPC. The primary goal of EoCoE is to create a new, long lasting and sustainable community around computational energy science. At the same time, EoCoE is committed to deliver high-impact results within the first three years. It will resolve current bottlenecks in application codes, leading to new modelling capabilities and scientific advances among the four user communities; it will develop cutting-edge mathematical and numerical methods, and tools to foster the usage of Exascale computing. Dedicated services for laboratories and industries will be established to leverage this expertise and to foster an ecosystem around HPC for energy. EoCoE will give birth to new collaborations and working methods and will encourage widely spread best practices.

8.1.1.2. PRACE 5IP

Title: PRACE Fifth Implementation Phase (PRACE-5IP) project

See also: http://www.prace-ri.eu/prace-5ip

Duration: January 2017 - April 2019

Partners: see http://www.prace-ri.eu/member-systems

Inria contact: Stéphane Lanteri

The mission of PRACE (Partnership for Advanced Computing in Europe) is to enable high-impact scientific discovery and engineering research and development across all disciplines to enhance European competitiveness for the benefit of society. PRACE seeks to realise this mission by offering world class computing and data management resources and services through a peer review process. PRACE also seeks to strengthen the European users of HPC in industry through various initiatives. PRACE has a strong interest in improving energy efficiency of computing systems and reducing their environmental impact. 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 ananalysis of TransNational Access; strengthening the internationally recognised PRACE brand; continuing and extend advanced training which so far provided more than 18 800 persontraining 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.

8.1.1.3. EPEEC

Title: European joint effort toward a highly productive programming environment for heterogeneous exascale computing

Program: H2020

See also: https://epeec-project.eu

Duration: October 2018 - September 2021

Coordinator: Barcelona Supercomputing Center

Partner: Barcelona Supercomputing Center (Spain)

Coordinator: CEA

Partners:

- Fraunhofer–Gesellschaft (Germany)
- CINECA (Italy)
- IMEC (Blegium)
- INESC ID (Portugal)
- Appentra Solutions (Spain)
- Eta Scale (Sweden)
- Uppsala University (Sweden)
- Inria (France)
- Cerfacs (France)

Inria contact: Stéphane Lanteri

EPEEC's main goal is to develop and deploy a production-ready parallel programming environment that turns upcoming overwhelmingly-heterogeneous exascale supercomputers into manageable platforms for domain application developers. The consortium will significantly advance and integrate existing state-of-the-art components based on European technology (programming models, runtime systems, and tools) with key features enabling 3 overarching objectives: high coding productivity, high performance, and energy awareness. An automatic generator of compiler directives will provide outstanding coding productivity from the very beginning of the application developing/porting process. Developers will be able to leverage either shared memory or distributed-shared memory programming flavours, and code in their preferred language: C, Fortran, or C++. EPEEC will ensure the composability and interoperability of its programming models and runtimes, which will incorporate specific features to handle data-intensive and extreme-data applications. Enhanced leading-edge performance tools will offer integral profiling, performance prediction, and visualisation of traces. Five applications representative of different relevant scientific domains will serve as part of a strong inter-disciplinary co-design approach and as technology demonstrators. EPEEC exploits results from past FET projects that led to the cutting-edge software components it builds upon, and pursues influencing the most relevant parallel programming standardisation bodies.

8.2. International Initiatives

8.2.1. Participation in Other International Programs

8.2.1.1. International Initiatives

PHOTOM

Title: PHOTOvoltaic solar devices in Multiscale computational simulations

International Partners:

Center for Research in Mathematical Engineering, Universidad de Concepcion (Chile), Rodolfo Araya

Laboratório Nacional de Computação Científica (Brazil), Frédéric Valentin

Instituto de Matemáticas, PUCV (Chile), Diego Paredes

Duration: 2018 - 2019

Start year: 2018

See also: http://www.photom.lncc.br

The work consists of devising, analyzing and implementing new multiscale finite element methods, called Multiscale Hybrid-Mixed (MHM) method, for the Helmholtz and the Maxwell equations in the frequency domain. The physical coefficients involved in the models contain highly heterogeneous and/or high contrast features. The goal is to propose numerical algorithms to simulate wave propagation in complex geometries as found in photovoltaic devices, which are naturally prompt to be used in massively parallel computers. We demonstrate the well-posedness and establish the optimal convergence of the MHM methods. Also, the MHM methods are shown to induce a new face-based a posteriori error estimator to drive space adaptivity. An efficient parallel implementation of the new multiscale algorithm assesses theoretical results and is shown to scale on a petaflop parallel computer through academic and realistic two and three-dimensional solar cells problems.

8.2.2. Inria International Partners

8.2.2.1. Informal International Partners

Prof. Kurt Busch, Humboldt-Universität zu Berlin, Institut für Physik, Theoretical Optics & Photonics

Prof. Martijn Wubs, Technical University of Denmark (DTU), Structured Electromagnetic Materials Theory group

Dr. Urs Aeberhard and Dr. Markus Ermes, Theory and Multiscale Simulation, IEK-5 Photovoltaik, Forschungszentrum Jülich, Germany

8.3. International Research Visitors

8.3.1. Visits of International Scientists

Prof. Liang Li, School of Mathematical Sciences, University of Electronic Science and Technology of China, Chengdu. From July to August 2018.

Stéphane Lanteri and Théophile Chaumont-Frelet at LNCC, Petropolis, Brazil, March 12-16, 2018.

Stéphane Lanteri and Claire Scheid at UAM and CSIC, Spain, May 29-30, 2018.

Stéphane Lanteri and Claire Scheid at Humboldt-Universität zu Berlin, Berlin, Germany, July 12-13, 2018.

Stéphane Lanteri at Barcelona Supercomputing Center, Barcelona, Spain, July 23-24, 2018.

NANO-D Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

- Sergei Grudinin has obtained an IDEX UGA grant. It covers 2 years of post-doc of Didier Devaurs, starting from December 2018.
- Doctoral UGA grant covers PhD thesis of Maria Kadukova (supervised by Sergei Grudinin).

7.2. National Initiatives

7.2.1. ANR

In 2018, NANO-D had funding from one ANR program:

- **ANR PRCI**: covers PhD thesis of Guillaume Pages.

7.3. European Initiatives

7.3.1. Collaborations with Major European Organizations

Partner 1: The European Bioinformatics Institute (EMBL-EBI), Protein Data Bank in Europe (PDBe) team, Hinxton (UK)

We are collaborating on the integration of methods developed in the team into the PDBe web resource.

Partner 2: The Institute Laue-Langevin (ILL), the bioSANS team, Grenoble (France)

We are collaborating on the development of neutron small-angle scattering software.

Partner 3: The Ecole polytechnique fédérale de Lausanne (EPFL), Laboratory for Biomolecular Modeling, Lausanne (Switzerland)

We are collaborating on the integrative structural biology approaches.

7.4. International Initiatives

7.4.1. Inria International Partners

7.4.1.1. Declared Inria International Partners : BIOTOOLS

Title: Novel Computational Tools for Structural Bioinformatics

International Partner (Institution - Laboratory - Researcher):

MIPT (Russia (Russian Federation)) - Department of Control and Applied Mathematics - Vadim Strijov

Duration: 2016 - 2020

Start year: 2016

Abstract : The general scientific objectives of the forthcoming collaboration are the new developments of computational tools for structural bioinformatics. In particular, we plan to collaborate on several subjects: 1. Development of tractable approximations for intractable combinatorial problems in structural biology. 2. Development of new computational tools for scattering experiments. 3. Machine learning for structural bioinformatics.

7.4.1.2. Informal International Partners

- University of Stony Brook, lab of Dima Kozakov (USA). We have been collaborating on the development of novel protein docking methods.
- University of Vilnius, department of Bioinformatics (Lithuania). We have been collaborating on the development of novel protein docking methods.
- KU Copenhagen (Denmark), department of Chemistry. We collaborate on the integrative structural biology approaches.
- Autonomous University of Madrid (Spain), Bioinformatics Unit. We collaborate on the development of computational methods for protein flexibility.
- Francis Crick Institute, London (UK), Biomolecular Modelling Laboratory. We collaborate on the development of flexible protein docking methods.

7.4.2. Participation in Other International Programs

Our team has obtained the PHC Gilibert grant for a 2-year collaboration with the Vilnius University (Lithuania). Our partner is the Department of Bioinformatics, http://www.bti.vu.lt/en/departments/department-of-bioinformatics.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- Karina Dos Santos Machado, lecturer at the Federal University of Rio Grande (FURG, Brazil), Oct 2018 - Oct 2019.

7.5.1.1. Internships

- Amal Akkari (Mohammed V University, Rabat, Morocco), Jun 2018 - Nov 2018.
- Khalid Mustafin (MIPT Moscow, Russia), Sep 2018 - Feb 2019.

7.5.2. Visits to International Teams

Sergei Grudinin has visited and gave talks in the following research labs :

- Department of Bioinformatics, University of Vilnius, Lithuania, May 10-11, 2018.
- The team of Dima Kozakov,Stony Brook University, USA, November 12th-14th, 2018.
- The team of Simon Billinge, Columbia University, USA, November 15th, 2018.
- Department of Biology, University of Copenhagen, Denmark, November 19th, 2018.
- Department of Chemistry, University of Copenhagen, Denmark, November 22nd, 2018.
- Department of Bioinformatics, State Belorussian University, Minsk, Belarus, Dec 28, 2018.

RAPSODI Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

C. Chainais-Hillairet is a member of the ANR MOONRISE project. The MOONRISE project aims at exploring modeling, mathematical, and numerical issues originating from the presence of high oscillations in nonlinear PDEs mainly from the physics of nanotechnologies and from the physics of plasmas.

Title: MOdels, Oscillations, and NumeRIcal SchEmes

Type: Fondements du numérique (DS0705) - 2014

ANR reference: ANR-14-CE23-0007

Coordinator: F. Méhats (Université de Rennes 1)

Duration: October 2014 - June 2019

C. Chainais-Hillairet and T. Rey are members of the ANR MOHYCON project. The MOHYCON project is related to the analysis and simulation of multiscale models of semiconductors. As almost all current electronic technology involves the use of semiconductors, there is a strong interest for modeling and simulating the behavior of such devices, which was recently reinforced by the development of organic semiconductors used for example in solar panels or in mobile phones and television screens (among others).

Title: multiscale MOdels and HYbrid numerical methods for semiCONductors

Type: Société de l'information et de la communication (DS07) - 2017

ANR reference: ANR-17-CE40-0027

Coordinator: M. Bessemoulin-Chatard (CNRS and Université de Nantes)

Duration: January 2018 - December 2020

9.1.2. LabEx CEMPI

Title: Centre Européen pour les Mathématiques, la Physique et leurs Interactions

Coordinator: S. De Bièvre (Université de Lille)

Duration: January 2012 - December 2019

Partners: Laboratoire Paul Painlevé and Laser Physics department (PhLAM), Université de Lille

The "Laboratoire d'Excellence" Centre Européen pour les Mathématiques, la Physique et leurs Interactions (CEMPI), a project of the Laboratoire de Mathématiques Paul Painlevé and the Laboratoire de Physique des Lasers, Atomes et Molécules (PhLAM), was created in the context of the "Programme d'Investissements d'Avenir" in February 2012.

The association Painlevé-PhLAM creates in Lille a research unit for fundamental and applied research and for training and technological development that covers a wide spectrum of knowledge stretching from pure and applied mathematics to experimental and applied physics.

One of the three focus areas of CEMPI research is the interface between mathematics and physics. This focus area encompasses three themes. The first is concerned with key problems of a mathematical, physical and technological nature coming from the study of complex behavior in cold atoms physics and non-linear optics, in particular fibre optics. The two other themes deal with fields of mathematics such as algebraic geometry, modular forms, operator algebras, harmonic analysis and quantum groups that have promising interactions with several branches of theoretical physics.

9.2. International Research Visitors

9.2.1. Visits of International Scientists

The RAPSODI project-team invited several scientists in 2018. The following people came for long visits:

- J. Venel (Université Polytechnique Hauts-de-France) visited Inria Lille until July;
- J. Fuhrmann (WIAS Berlin) was invited for 1 month between May and June, thanks to a support of the LabEx CEMPI;
- A. Vasseur (UT Austin) was invited for 1 month in June, also thanks to a support of the LabEx CEMPI.

The following people came for shorter visits:

- S. Krell (Université de Nice) came in Lille on February 12-15;
- M. Rodrigues (Université de Rennes 1) came in Lille on December 3-7;
- M. Breden (TU Munich) came on December 17-21.

9.2.2. Internships

N. Staili, PhD student in the Faculté des Sciences de Meknès, came in Lille for a three-month visit between January and April.

9.2.3. Visits to International Teams

C. Cancès visited D. Matthes (TU Munich) during 1 week on December 3-7 to collaborate on the variational derivation of multiphase flow models.

9.2.4. Research Stays Abroad

A. Zurek spent 2 months (October-November) in the research team of A. Jüngel at TU Vienna to collaborate on the numerical simulation of a biofilm model. He was supported by the Institut Français d'Autriche and by EKINOX CNRS grant (Laboratoire Paul Painlevé).

CAGE Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- ANR SRGI, for *Sub-Riemannian Geometry and Interactions*, coordinated by **Emmanuel Trélat**, started in 2015 and runs until 2020. Other partners: Toulon University and Grenoble University. SRGI deals with sub-Riemannian geometry, hypoelliptic diffusion and geometric control.
- ANR Finite4SoS, for *Commande et estimation en temps fini pour les Systèmes de Systèmes*, coordinated by Wilfrid Perruquetti, started in 2015 and runs until 2019. Other partners: Inria Lille, CAOR - ARMINES. Finite4SoS aims at developing a new promising framework to address control and estimation issues of Systems of Systems subject to model diversity, while achieving robustness as well as severe time response constraints.
- ANR QUACO, for *QUAntum COntrol: PDE systems and MRI applications*, coordinated by Thomas Chambrion, started in 2017 and runs until 2021. Other partners: Lorraine University. QUACO aims at contributing to quantum control theory in two directions: improving the comprehension of the dynamical properties of controlled quantum systems in infinite-dimensional state spaces, and improve the efficiency of control algorithms for MRI.

8.2. European Initiatives

8.2.1. H2020 Projects

Program: ERC Proof of Concept

Project acronym: ARTIV1

Project title: An artificial visual cortex for image processing

Duration: From April 2017 to September 2018.

Coordinator: Ugo Boscain

Abstract: The ERC starting grant GECOMETHODS, on which this POC is based, tackled problems of diffusion equations via geometric control methods. One of the most striking achievements of the project has been the development of an algorithm of image reconstruction based mainly on non-isotropic diffusion. This algorithm is bio-mimetic in the sense that it replicates the way in which the primary visual cortex V1 of mammals processes the signals arriving from the eyes. It has performances that are at the state of the art in image processing. These results together with others obtained in the ERC project show that image processing algorithms based on the functional architecture of V1 can go very far. However, the exceptional performances of the primary visual cortex V1 rely not only on the particular algorithm used, but also on the fact that such algorithm 'runs' on a dedicated hardware having the following features: 1. an exceptional level of parallelism; 2. connections that are well adapted to transmit information in a non-isotropic way as it is required by the algorithms of image reconstruction and recognition. The idea of this POC is to create a dedicated hardware (called ARTIV1) emulating the functional architecture of V1 and hence having on one hand a huge degree of parallelism and on the other hand connections among the CPUs that reflect the non-isotropic structure of the visual cortex V1.

8.3. International Research Visitors

8.3.1. Research Stays Abroad

Jean-Michel Coron was at EPFL (Switzerland) from January to June 2018.

COMMANDS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. IPL

9.1.1.1. Algae in Silico

Inria Project Lab ALGAE IN SILICO (2014-2018) was dedicated to provide an integrated platform for numerical simulation of microalgae "from genes to industrial process". Commands joined the project in 2017 to tackle the optimization aspects. Our previous collaborations with teams Modemic and Biocore on bioreactors [31], [19] have been renewed in this framework, see [11]

9.1.1.2. Cosy

Inria Project Lab COSY (started in 2017) aims at exploiting the potential of state-of-art biological modelling, control techniques, synthetic biology and experimental equipment to achieve a paradigm shift in control of microbial communities. More precisely, we plan to determine and implement control strategies to make heterogeneous communities diversify and interact in the most profitable manner. Study of yeast cells has started in collaboration with team Lifeware (G. Batt) in the framework of the PhD of V. Andreani, and is pursued in the PhD of E. Weill (started 2018).

9.2. International Research Visitors

9.2.1. Visits of International Scientists

Several visits by L. Pfeiffer, U. Graz, and A. Kröner, U. Humboldt.

DISCO Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. Industrial-Academic Institute

Guillaume Sandou is the head of the RISEGrid Institute. The Institute is dedicated to the study, modelling and simulation of smart electric distribution grids and their interactions with the whole electric power system. It is located in CentraleSupélec and gathers about 20 people (academic and industrial researchers, PhD students, post-doctoral researchers). The Institute has been renewed in 2018 for 5 new years.

7.2. European Initiatives

7.2.1. Collaborations in European Programs, Except FP7 & H2020

Program: **COST Action**

Project acronym: FRACTAL

Project title: Fractional-order systems; analysis, synthesis and their importance for future design

Duration: November 2016 - October 2020

Coordinator: Jaroslav Koton Czech Republic

Abstract: Fractional-order systems have lately been attracting significant attention and gaining more acceptance as generalization to classical integer-order systems. Mathematical basics of fractional-order calculus were laid nearly 300 years ago and since that it has gained deeply rooted mathematical concepts. Today, it is known that many real dynamic systems cannot be described by a system of simple differential equation or of integer-order system. In practice we can encounter such systems in electronics, signal processing, thermodynamics, biology, medicine, control theory, etc. The Action will favor scientific advancement in above mentioned areas by coordinating activities of academic research groups towards an efficient deployment of fractal theory to industry applications.

Program: **PHC BALATON**

Project acronym: SadHuB

Project title: Analysis of stabilizability of delayed dynamical system as function of the systems parameters and the time delays with applications to human balancing

Duration: 01/2018-12/2019

Coordinator: Islam Boussaada

Other partners: Budapest University of Technology and Economics, Hungary

Abstract: Motivated by a class of Time-delay systems occurring in modeling of many mechanical engineering applications, this project aims to associate researchers from control theory, applied mathematics and mechanical engineering to build together a general methodology for the analysis and control of mechanical/bio-mechanical structures. In particular, the human balance is often considered as a control system which operates in the presence of delays, primarily due to the time it takes to acquire the information needed for decision-making, to create control decisions, and to execute these decisions. A particular interest will be devoted to the delayed human balance, where a depthful study of the delay effect on the stability is expected.

Program: **PHC BRANCUSI**

Project acronym: Proco

Project title: systems with propagation: new approaches in control design for oscillations quenching

Duration: 01/2017-12/2018

Coordinator: Islam Boussaada

Other partners: Craiova University, Romania

Abstract: Propagation systems are met and analyzed in various fields, in natural sciences (Physics, Chemistry, Biology etc.) as well as in engineering sciences (energy, mechanics, electricity, optics etc.). According to projects research objectives, the general object of analysis is represented by the controlled systems with distributed parameters which are usually met in technology dynamical systems with parameter space variation along a single space variable. The standard physical phenomena that are modeled are: diffusion, transport and propagation, thus leading to partial differential equations of parabolic (diffusion), hyperbolic (propagation) and advection first order (transportation), respectively. According to the project main subject, the main application of the studies aimed at the automatically controlled processes in the field of energy in a domain where propagation phenomena are dominant. The scientific novelty of the studies arises from the consideration of the systems described by conservation laws in the following fields: oil drilling and extraction, co-generation (combined heat-electricity generation), energy production in hydroelectric plants.

Program: **PHC CARLOS J FINLEY (Cuba)**

Project title: Modélisation et commande pour les processus de cryoconservation.

Duration: June 2017 - December 2018

Coordinator: Sorin Olaru (France), Marcos Martinez Montero (Turkey).

Abstract: The aim of this project is to initiat a collaboration on subjects related to the mathematical modelling of the dynamics involved in the cryopreservations process. In particular, the viability analysis of the vegetal material subject to cryogeny is one of the main objectives. The approach will realy on the evaluation electric leakage properties.

7.3. International Initiatives

7.3.1. Inria International Partners

7.3.1.1. Informal International Partners

- Louisiana State University, Baton Rouge, USA
- School of Electrical Engineering at the Tel-Aviv University, Israel
- The University of Texas at Austin, Dept. of Aerospace Engineering & Engineering Mechanics, USA
- Blikent University, Turkey
- Universidad de Chile, Chile
- School of Mathematics, University of Leeds, U.K.
- University Federale Rio de Janeiro, Brazil
- UNICAMP, Brazil
- Kyoto University, Japan

7.3.2. Participation in Other International Programs

Giorgio Valmorbida is leading the CNRS funded IRN - SPaDisCo (International Research Network - Systèmes à Paramètres Distribués et Contraintes) composed by more than 50 researchers from Belgium, Czech Republic, France, Italy, Sweden, Turkey and the United Kingdom.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

Stefanella Boatto, Federale University Rio de Janeiro, Brazil, 1 January- 2 March.

Pedro Luis Dias Peres, UNICAMP, Brazil, December 2018.

Valter Leite Junior, CEFET-MG, Brazil, May 2018.

Antonis Papachristodoulou, University of Oxford, UK, September 2018.

Yutaka Yamamoto, Kyoto University, Japan, 6 Sept - 6 Nov.

7.4.2. Visits to International Teams

7.4.2.1. Research Stays Abroad

Islam Boussaada spent one month during July 2018 as a Research Associate at the Department of Electronic Engineering at City University of Hong Kong. He started a research collaboration with Professor Jie Chen Team.

FACTAS Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- The team participates in the project WIMAG (Wave IMAGing) funded by the Idex UCA[Jedi]. It aims at identifying and gathering the research and development by partners of UCA involved in wave imaging systems. Other partners are UNS and CNRS (GéoAzur, I3S, LEAT, LJAD), together with Orange Labs.
- The team co-advises a PhD (G. Bose) with the CMA team of LEAT (http://leat.unice.fr/pages/activites/cma.html) funded by the Labex UCN@Sophia on the co-conception of Antennas and Filters.
- The team participates in the transverse action C4PO funded by the Idex UCA[Jedi]. This "Center for Planetary Origin" brings together scientists from various fields to advance and organize Planetary Science at the the University of Nice, and supports research and teaching initiatives within its framework, among which the workshop "Inverse problems and approximation techniques in planetary sciences" organized by members of Factas in May, about inverse problems in harmonic electromagnetism and approximation, with applications mainly dedicated to geomagnetism and paleomagnetism, see Section 9.1.1 .
- The team also participates in the project ToMaT, "Multiscale Tomography: imaging and modeling ancient materials, technical traditions and transfers", funded by the Idex UCA[Jedi] ("programme structurant Matière, Lumière, Interactions"). This project brings together researchers in archaeological, physical, and mathematical sciences, with the purpose of modeling and detecting low level signals in 3-D images of ancient potteries. The other concerned scientists are from CEPAM-CNRS-UCA (project coordinator: Didier Binder), Nice http://www.cepam.cnrs.fr, the team Morpheme, CNRS-I3S-Inria http://www.inria.fr/equipes/morpheme, and IPANEMA, CNRS, Ministère de la Culture et de la Communication, Université Versailles Saint Quentin http://ipanema.cnrs.fr/. Since March 2018, they co-advise together the post-doctoral research of Vanna Lisa Coli, see Section 6.5 .

8.2. National Initiatives

8.2.1. ANR MagLune

The ANR project MagLune (Magnétisme de la Lune) has been approved July 2014. It involves the Cerege (Centre de Recherche et d'Enseignement de Géosciences de l'Environnement, joint laboratory between Université Aix-Marseille, CNRS and IRD), the IPGP (Institut de Physique du Globe de Paris) and ISTerre (Institut des Sciences de la Terre). Associated with Cerege are Inria (Apics, then Factas team) and Irphe (Institut de Recherche sur les Phénomènes Hors Équilibre, joint laboratory between Université Aix-Marseille, CNRS and École Centrale de Marseille). The goal of this project (led by geologists) is to understand the past magnetic activity of the Moon, especially to answer the question whether it had a dynamo in the past and which mechanisms were at work to generate it. Factas participates in the project by providing mathematical tools and algorithms to recover the remanent magnetization of rock samples from the moon on the basis of measurements of the magnetic field it generates. The techniques described in Section 6.1 are instrumental for this purpose.

8.2.2. ANR Cocoram

The ANR (Astrid) project Cocoram (Co-design et co-intégration de réseaux d'antennes actives multi-bandes pour systèmes de radionavigation par satellite) started January 2014 and ended October 2018. We were associated with three other teams from XLIM (Limoges University), geared respectively towards filters, antennas and amplifiers design. The core idea of the project was to realize dual band reception an emission chains by co-conceiving the antenna, the filters, and the amplifier. A complete chain has been synthesized using matching filters placed after each of the accesses of a network of 4 bi-polarized antennas, resulting in a substantial gain in energy effectiveness of 30%. This communication chain has been manufactured by our partner XLIM, and presented to the final meeting of the ANR in October.

8.3. European Initiatives

8.3.1. Collaborations with Major European Organizations

Apics is part of the European Research Network on System Identification (ERNSI) since 1992.

System identification deals with the derivation, estimation and validation of mathematical models of dynamical phenomena from experimental data.

8.4. International Initiatives

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

8.4.1.1. IMPINGE

Title: Inverse Magnetization Problems IN GEosciences.

International Partner (Institution - Laboratory - Researcher):

Massachusetts Institute of Technology (United States) - Department of Earth, Atmospheric and Planetary Sciences - Benjamin P. Weiss

Start year: 2016

See also: http://www-sop.inria.fr/apics/IMPINGE/

This proposal is concerned with the inverse problem of recovering a magnetization distribution from measurements of the magnetic field in a portion of space nearby. The application domain is to Earth and planetary sciences. Indeed, the remanent magnetization of rocks provides valuable information on their history. The proposal aims at renewing the existing "Équipe Associée" Impinge ending 2015, between Apics (now Factas) team at Inria and the Department of Earth, Atmospheric and Planetary Sciences at MIT (Cambridge, MA, USA), with the Department of Mathematics at Vanderbilt University (Nashville, TN, USA) as a secondary partner. Several research paths were broken towards magnetization recovery and promising numerical experiments have been conducted. This initial effort must be continued to achieve a reasonably complete methodology for reconstructing magnetizations and checking for hypotheses by geophysicists (e.g., unidirectionality of magnetization distributions).

8.4.2. Inria International Partners

8.4.2.1. Informal International Partners

MIT-France seed funding is a competitive collaborative research program ran by the Massachusetts Institute of Technology (Cambridge, Ma, USA). Together with E. Lima and B. Weiss from the Earth and Planetary Sciences dept. at MIT, Apics obtained two-years support from the above-mentioned program to run a project entitled: "Development of Ultra-high Sensitivity Magnetometry for Analyzing Ancient Rock Magnetism"

NSF Grant L. Baratchart, S. Chevillard and J. Leblond are external investigators in the NSF Grant 2015-2018, "Collaborative Research: Computational methods for ultra-high sensitivity magnetometry of geological samples" led by E. B. Saff (Vanderbilt Univ.) and B. Weiss (MIT).

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Axel Ringh (KTH Royal Institute of Technology, Stockholm, Sweden), June 11 -July 10.
- Elodie Pozzi (St Louis Univ., St. Louis, Missouri, USA), Brett Wick (Washington University, St. Louis, Missouri, USA), July 25.
- Cristobal Villalobos, Douglas Hardin, Edward Saff (Vanderbilt University, Nashville, Tennessee, USA), December, 6-19, 13-19, and 13-20 respectively.
- M. Olivi proposed with B. Hanzon and R. Peeters a Research in Pair event at CIRM « A state-space approach to parametrization of lossless and stable systems ». which was accepted and took place on August 27-31 https://conferences.cirm-math.fr/2126.html

8.6. List of international and industrial partners

- Collaboration under contract with Thales Alenia Space (Toulouse, Cannes, and Paris), CNES (Toulouse), XLIM (Limoges), LEAT (Sophia Antipolis), University of Bilbao (Universidad del País Vasco / Euskal Herriko Unibertsitatea, Spain), Flextronics.
- Regular contacts with research groups at UST (Villeneuve d'Asq), Universities of Bordeaux-I (Talence), Orléans (MAPMO), Aix-Marseille (CMI-LATP), Nice Sophia Antipolis (Lab. JAD), Grenoble (IJF and LJK), Paris 6 (P. et M. Curie, Lab. JLL), Inria Saclay (Lab. Poems, ENSTA), IMT Atlantique (Institut Mines-Télécom., Brest), Cerege-CNRS (Aix-en-Provence), CWI (the Netherlands), MIT (Boston, USA), Vanderbilt University (Nashville USA), Steklov Institute (Moscow), Michigan State University (East-Lansing, USA), Texas A&M University (College Station USA), Indiana University-Purdue University at Indianapolis, St Louis University and Washington University (St Louis, Missouri, USA), Cinvestav (Queretaro, Mexico), Politecnico di Milano (Milan, Italy), University of Trieste (Italy), RMC (Kingston, Canada), University of Leeds (UK), of Maastricht (the Netherlands), of Cork (Ireland), Vrije Universiteit Brussel (Belgium), TU-Wien and Universität Wien (Austria), TFH-Berlin and Technische Universität Bergakademie Freiberg (Germany), ENIT (Tunis), KTH (Stockholm), University of Cyprus (Nicosia, Cyprus), University of Macau (Macau, China), SIAE Microelettronica (Milano), Université Picardie Jules Verne (France), National and Kapodistrian University of Athens (Greece).
- The project is involved in the GDR-project AFHP (CNRS), in the ANR (Astrid program) project Cocoram (with XLIM, Limoges, and DGA), in the ANR (Défis de tous les savoirs program) project MagLune (with Cerege, IPGP, ISTerre, Irphe), in a MIT-France collaborative seed funding, in the Associate Inria Team IMPINGE (with MIT, Boston), and in a NSF grant (with Vanderbilt University and MIT).

I4S Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. Interactive Communication (InterCom): Massive random access to subsets of compressed correlated data

Participants: Jean Dumoulin, Antoine Crinière, Frederic Gillot.

Type: Labex COMINLABS

Objectif: Massive random access to large-scale sensor network (Smart Cities)

Duration: Since November 2016 to Nov. 2019.

Coordinator :Aline Roumy, Thomas Maugey (Sirocco), Jean Dumoulin (I4S)

Partners: Elsa Dupraz (Lab-STICC), Aline Roumy (IRISA, Sirocco team), Michel Kieffer (L2S), Thomas Maugey(IRISA, Sirocco team), CentraleSupelec, Univ. Paris Sud.

Inria contact: Jean Dumoulin

Abstract: This project aims to develop novel compression techniques allowing massive random access to large databases. Indeed, we consider a database that is so large that, to be stored on a single server, the data have to be compressed efficiently, meaning that the redundancy/correlation between the data have to be exploited. The dataset is then stored on a server and made available to users that may want to access only a subset of the data. Such a request for a subset of the data is indeed random, since the choice of the subset is user-dependent. Finally, massive requests are made, meaning that, upon request, the server can only perform low complexity operations (such as bit extraction but no decompression/compression).

Algorithms for two emerging applications of this problem will be developed: Free-viewpoint Television (FTV) and massive requests to a database collecting data from a large-scale sensor network (such as Smart Cities) in which I4S is involved. Compression of spatio-temporally correlated and massive georeferenced Data have been investigated [42].

7.1.2. MAG2C-Pont Tabarly

Participants: Ivan Guéguen, Jean Dumoulin.

Type: GIS

Objectif: bridge instrumentation

Duration: Since 2014

Coordinator: LIRGEC

Partners: IFSTTAR, CSTB, Nantes Métropole, Université de Nantes

Inria contact: Ivan Guéguen

Abstract: The project deals with the instrumentation of the Tabarly Bridge. In collaboration with Nantes Métropole, CSTB, and Université de Nantes, instrumentation of both dynamical and InfraRed properties of an operational bridge are investigated. These measures coupled with a wireless data transmission system will allow remote monitoring of the evolution of the structure. Objective is to couple different kind of measurement to achieve thermo-vibration monitoring of the structure. This is a big milestone for the team and our objective to mix thermo-vibration data.

7.1.3. MAG2C-MOSIWIND (MOnitoring of Structural Integrity of an onshore WIND turbine slab foundation and tower)

Participants: Xavier Chapeleau, Ivan Guéguen.

Type: GIS

Objectif: MOnitoring of Structural Integrity of an onshore WIND turbine slab foundation and tower

Duration: Since 2015

Coordinator : LIRGEC

Partners: IFSTTAR, CSTB, Nantes Métropole, Université de Nantes, ECN, Valorem, Valréa and Valémo

Inria contact: Xavier Chapeleau

Abstract: The project deals with the instrumentation of an onshore WIND turbine's slab foundation and tower. The aim is to experiment sensors and methods for structural integrity monitoring of an onshore wind turbine under real conditions and to qualify them over long term. Fiber optic sensors were installed in the slab foundation before casting and accelerometers were placed at several level in the tower of the wind turbine. Since July 2017, data from accelerometers were logged on a web data server.

7.1.4. Collaboration with GeM

Participants: Laurent Mevel, Michael Doehler, Md Delwar Hossain Bhuyan.

Md Delwar Hossain Bhuyan has done his PhD on damage localisation on civil structures in collaboration with GeM (Institute of Civil and Mechanical Engineering), Université de Nantes. The thesis is co-directed by L. Mevel, and F. Schoefs from GeM, with supervision shared with M. Doehler and Y. Lecieux from GeM. It is funded by the Brittany region for 3 years and has been successfully defended in November 2017. In 2018, a mockup of the Saint Nazaire bridge has been funded by GAM and tested for damage localization.

7.1.5. Collaboration with IETR

Participants: Vincent Le Cam, David Pallier.

The thesis is directed by Sébastien Pillement at IETR. It is funded by RFI WISE Electronique Professionnelle within the SENTAUR project.

The subject of the thesis is to study, implement, and propose a deterministic and reliable dating solution for wireless sensor networks. This solution must take into account both the risks of loss of synchronization signals, environmental hazards and the desire to achieve the most sober possible solution in energy.

7.2. National Initiatives

7.2.1. ANR Resbati

Participants: Ludovic Gaverina, Jean Dumoulin.

Type: ANR

Objectif: In-situ measurements of thermal wall resistance

Duration: 10/2016 to 10/2019

Coordinator: Laurent Ibos

Partners : IFSTTAR, CERTES, CEREMA, CSTB, LNE, THEMACS, AFNOR

Inria contact: Jean Dumoulin

Abstract: RESBATI is an applied research project whose objective is to develop a field measurement device that meets precise specifications to systematically measure the level of thermal insulation of building walls. The preferred metrological tool is infrared thermography [31]. A smart logger and a protype have been developed and presented [44].

7.3. European Initiatives

7.3.1. FP7 & H2020 Projects

7.3.1.1. INFRASTAR(Innovation and Networking for Fatigue and Reliability Analysis of Structures – Training for Assessment of Risk)

Participants: Xavier Chapeleau, Antoine Bassil.

Call: H2020-MSCA-ITN-2015 (Horizon 2020 Marie-Sklodowska Curie Actions Innovative Training Networks)

Type of Action: MSCA-ITN-ETN

Objective: Improve energy performance of building design

Duration: 48 months since 2016 May 1st

Coordinator: Odile Abraham (IFSTTAR)

Academic and industrial Partners: IFSTTAR, UNIVERSITY OF AALBORG, BAM, EPFL, GuD Consult Gmbh, COWI A/S, NeoStrain, PHIMECA

Inria contact: X. Chapeleau

Website: http://infrastar.eu/

Abstract: The aim of INFRASTAR project is to develop tools combining modeling and measurements for the prediction of the fatigue behavior of concrete structures (bridges and foundations of wind turbines) with the ultimate objective of establishing an efficient strategy for inspection and reinforcement operations. In the second half of 2016, 12 young researchers were recruited to carry out and cross-examine research on monitoring and auscultation (WP 1), structural models (WP 2) and reliability of approaches for decision-making (WP 3). In this project, a phd student (Antoine Bassil) was recruited (Nov. 2016) on the fatigue monitoring of concrete structure by fiber-optic sensors.

A state of the Art about distributed optical fiber sensor's technology for crack detection in concrete was done together with experimental tests to assess linear models. More precisely, three points bending tests were performed on reinforced concrete beams instrumented with fiber optic cables embedded and attached to the concrete surface. The analytical expressions of linear models were fitted to strain measurements to deduce the cracks opening during the test. The comparison of these results with those obtained with traditional extensometers placed around the cracks showed a good agreement for crack openings reaching 150νm in single crack case. This model was also validated in multiple neighboring crack case until 400νm. In order to focus more on the sensor/host material system properties, wedge-splitting tests made it possible to attend higher crack openings for a single crack case allowing us to better analyze the transition from elastic to post elastic behavior of the optical cable. The use of different types of cables with relatively different mechanical properties will allow us in the near future to choose the best cable configuration for monitoring of concrete structures.

7.3.1.2. DESDEMONA(DEtection of Steel Defects by Enhanced MONitoring and Automated procedure for self-inspection and maintenance)

Participants: Jean Dumoulin, Laurent Mevel, Michael Doehler, Xavier Chapeleau.

Call: H2020 -Call: RFCS-2017 (Call of the research programme of the Research Fund for Coal and Steel - 2017)

Type of Action: RFCS-RPJ (Research project)

Objective: DESDEMONA objective is the development of novel design methods, systems, procedure and technical solution, to integrate sensing and automation technologies for the purpose of self-inspection and self-monitoring of steel structures.

Duration: 36 months since 2018 June 1st

Coordinator: Pr. Vincenzo Gatulli (La Sapienza University of Rome)

Academic and industrial Partners: Sapienza Università di Roma (Italy), Universidad de Castilla – La Mancha, (Spain), Universidade do Porto (Portugal), Università di Pisa (Italy), IFSTTAR (France), Aiviewgroup srl (Italy), Sixense systems (France), Ecisa compania general de construcciones sa (Spain), Università di Cassino e del Lazio Meridionale (Italy), Universidad de Alicante (Spain), Inria (France).

Inria contact: J. Dumoulin and L. Mevel

Website: http://www.desdemonaproject.eu//

Abstract: DESDEMONA objective is the development of novel design methods, systems, procedure and technical solution, to integrate sensing and automation technologies for the purpose of self-inspection and self-monitoring of steel structures. The approach will lead to an increment of the service life of existing and new steel civil and industrial infrastructure and to a decrease in the cost associated to inspections, improving human activities performed in difficult conditions, safety and workers' potential by the use of advanced tools. The research aims to expand beyond the current state-of-the-art new high-quality standard and practices for steel structure inspection and maintenance through the interrelated development of the following actions: i) steel structure geometry and condition virtualization through data fusion of image processing, thermography and vibration measurements; ii) developing a procedure for steel defect detection by robotic and automatic systems such as Unmanned Aerial Vehicles (UAV) and ground mobile robots iii) embedding sensor systems to revalorize and transform steel elements and structures into self-diagnostic (smart) elements and materials even through nanotechnologies, iv) realizing an experimental lab-based apparatus and a series of case studies inspected by intelligent and robotic systems. The project outcome will have an impact on the reduction of the cost of steel structures inspection and maintenance and on the increase of user safety and comfort in industrial and civil environment. The proposal with a multidisciplinary approach fulfils the objectives of the Strategic Research Agenda of the European Steel Technology Platform.

7.3.2. Collaborations in European Programs, Except FP7 & H2020

7.3.2.1. COST Action TU 1402

Participants: Michael Doehler, Laurent Mevel.

L. Mevel is member of the management committee of the COST Action.

M. Doehler is co-leader of working group 2 "SHM strategies and structural performance" and member of the steering committee.

Type: COST

Objective: Quantifying the value of structural health monitoring

Duration: 11/2014 - 4/2019

Coordinator: S. Thoens (DTU Denmark)

Partner: 29 countries, see https://www.cost.eu/actions/TU1402

Inria contact: Laurent Mevel

Abstract: Since 2014, until 2018, the COST Action has altogether around 120 participants from over 25 countries. This Action aims to develop and describe a theoretical framework, together with methods, tools, guidelines, examples and educational activities, for the quantification of the value of SHM.

7.3.2.2. PROCOPE 37826QE

Participants: Michael Doehler, Laurent Mevel, Eva Viefhues, Frederic Gillot.

Type: PHC PROCOPE

Objective: Statistical damage localization for civil structures

Duration: 01/2017 - 12/2018

Coordinator: M. Doehler

Partner: BAM German Federal Institute for Materials Research and Testing

Inria contact: M. Doehler

Abstract: Our main objective is the development of a theoretically solid damage localization method that does not only work in simulations and lab experiments, but on structures in the field under real operational conditions. This German-French mobility grant is in support of Eva Viefhues' PhD thesis.

7.3.2.3. Innobooster

Participants: Michael Doehler, Laurent Mevel.

Type: Danish Innovation Fund

Objective: Methods for mode shape uncertainty quantification

Duration: 2017 - 2018

Coordinator: M. Doehler

Partner: Structural Vibration Solutions A/S, Denmark

Inria contact: M. Doehler

Abstract: With this grant for industrial research and transfer, methods for uncertainty quantification of mode shapes are developed with the objective of producing a prototype for transfer to SVS' ARTeMIS software.

7.4. International Initiatives

7.4.1. Collaboration with University of British Columbia, Canada

Participants: Laurent Mevel, Michael Doehler, Alexander Mendler.

Alexander Mendler's PhD thesis started in September 2018 co-supervised by M. Doehler and C. Ventura.

7.4.2. Collaboration with BAM, Germany

Participants: Laurent Mevel, Michael Doehler, Eva Viefhues.

Eva Viefhues is currently PhD student of Laurent Mevel and Michel Doehler in Berlin, financed by BAM. M. Doehler is also associate researcher of the BAM institut since 2016.

7.4.3. Collaboration with Technical University of Denmark (DTU)

Participant: Michael Doehler.

During COST Action TU 1402 and previously at BAM, collaboration with Sebastian Thöns from DTU in Denmark started on risk analysis and SHM based reliability updating. Also, DTU's PhD student Lijia Long is involved.

7.4.4. Collaboration with Aalborg University, Denmark

Participant: Michael Doehler.

Together with Structural Vibration Solutions, collaboration with Aalborg University (professor Lars Damkilde, Department of Civil Engineering) has started during the PhD of Szymon Gres on damage detection methods.

7.4.5. Collaboration with Laval University, Canada

Participant: Jean Dumoulin.

In the Framework of On Duty Project (http://www.ondutycanada.ca) we are working on Non Destructive Testing techniques and automation of inspection process.

7.5. International Research Visitors

Szymon Gres visited us for 3 months from April to June 2018 during his thesis.

7.5.1. Visits to International Teams

7.5.1.1. Research Stays Abroad

During INFRASTAR project, Antoine Bassil

- visited BAM (3 months in 2017) on the assesment the relevant of coupling fIber optics and CODA waves techniques to crack monitoring
- visited EPFL (3 months in 2018) on the issue of long term monitoring of a special material like Ultra High Performance Reinforced Concrete (UHPFRC) using a distributed fiber optic system.

MCTAO Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

Sub-Riemannian Geometry and Interactions (SRGI). Started 2015 (decision ANR-15-CE40-0018), duration: 4 years. L. Rifford is a member.

Intéractions Systèmes Dynamiques Équations d'Évolution et Contrôle (ISDEEC). Started 2016 (decision ANR-16-CE40-0013), duration: 4 years. L. Rifford is a member.

Maximic: optimal control of microbial cells by natural and synthetic strategies. Started 2017, duration: 4 years. J.-B. Caillau, L. Giraldi, J.-B. Pomet are members.

9.1.2. Others

Défi InfIniti CNRS project, Control and Optimality of Magnetic Microrobots, (PI L. Giraldi). Started 2017, duration: 1 years. This project involves colleagues from Paris Sorbonne Université (around S. Régnier's team) and from University of Strasbourg (around C. Prud'Homme's team).

PGMO grant (2016-2018) on "Metric approximation of minimizing trajectories and applications" (PI J.-B. Caillau). This project involved colleagues from Université Paris Dauphine and has funding for two year (originally one, extended), including one intership (M2 level).

PGMO grant (2017-2019) on "Algebro-geometric techniques with applications to global optimal control for Magnetic Resonance Imaging (MRI)". B. Bonnard, A. Nolot and J. Rouot participate in this project, the PI is O. Cots, from ENSEIHHT, Toulouse.

The McTAO team participates in the GdR MOA, a CNRS network on Mathematics of Optimization and Applications.

J.-B. Caillau is associate researcher of the CNRS team Parallel Algorithms & Optimization at ENSEEIHT, Univ. Toulouse.

P. Lissy was the PI of a PEPS project JCJC (young researchers).

9.2. European Initiatives

9.2.1. Bilateral program with Portugal

Program: FCT (Fundação para a Ciência e a Tecnologia)

Grant no. : PTDC/MAT-CAL/4334/2014

Project title: "Extremal spectral quantities and related problems"

Duration: 05/2016-05/2019

Coordinator: P. Freitas (Univ. Lisbon)

Team member involved: J.-B. Caillau

Other partners: Univ. Lisbon, Univ. Luxembourg, Czech Nuclear Physics Institute, Univ. Bern

Link: https://team.inria.fr/mctao/fct-project-extremal-spectral-quantities-and-related-problems-2016-2019

9.2.2. Bilateral ANR-DFG program with Germany

Program: Projets de recherche collaborative-internationale ANR-DFG (Germany)

Grant no. : ANR-14-CE35-0013-01; DFG-Gl 203/9-1

Project title: "**Exploring the physical limits of spin systems (Explosys).**"

Duration: 11/2014-10/2018

Coordinator: D. Sugny (Univ. de Bourgogne) for France, Glaser (TU München) for Germany.

Team member involved: Bernard Bonnard.

Other partners: TU München, Univ. de Bourgogne (IMB and UCB).

This project involves specialists in physics and control theory in order to make important progresses in the use of spin dynamics, in particular for Magnetic Resonance Medical Imaging.

Link: http://www.agence-nationale-recherche.fr/fileadmin/aap/2014/selection/pa-2014-selection-franco-allemand-dfg.pdf

9.3. International Research Visitors

9.3.1. Visits of International Scientists

Zhen Chen, Technion. Two day visit in July, 2018. Gave a talk "Shortest Dubins Paths through Three Points" at McTAO seminar.

9.3.2. Visits to International Teams

Lamberto Dell'Elce visited Department of Aerospace Engineering at Technion (Haifa, Israel) for a week in July, 2018.

Pierre Lissy was invited one month at Fudan University (China) in March and June, 2018.

NECS Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Control of Cyber-Social Systems (C2S2)

C2C2 is a two-year project funded by the University Grenoble Alpes, MSTIC department. Evolving from recent research on network systems, this exploratory project has the objective to concentrate on cyber-social systems, that is, complex systems with interacting social and technological components. A strong motivation for this novel research direction comes from the need for innovative tools for the management of vehicular traffic. In this application, state-of-the-art approaches concentrate on hard control actions, like traffic lights: instead, future management methods should exploit soft control actions aimed at controlling the traffic demand, that is, the aggregated behaviors of the drivers.

8.1.2. Understanding data accidents for traffic safety (DATASAFE)

DATASAFE is a two years project funded by Grenoble Data Institute, with the aim to understand from real traffic data the behavior of traffic in the moments preceding an accident. The general approach is to use novel statistical techniques in order to learn traffic characteristics that can be used to develop new traffic models. Bayesian approaches are used to (supervised) classification and (unsupervised) clustering in order to respectively predict collision occurrences and discover traffic patterns.

8.1.3. Modeling autonomous vehicles in traffic flow (MAVIT)

MAVIT is a two year project funded by the University Grenoble Alpes, MSTIC department. The goal of this project is to develop a unified micro-macro approach for traffic management, involving human and autonomous vehicles drivers by providing analytical and numerical tools for traffic modeling, estimation and control. We will work towards field operational tests, by using instrumented cars to collect data on AVs trajectory and their interaction with the traffic flow with human drivers. The proposed research provides new mathematical models, computational/software tools, and engineering solutions for the control of human controlled vehicles via intelligently controlled AVs in the traffic stream. Moreover, the control of traffic via moving actuators provides a new alternative to contemporary control technologies, such as ramp metering and variable speed limits; even when AVs comprise a tiny fraction of the total fleet, these techniques may be viable, and rapidly configurable. This research considers new types of traffic models, new control algorithms for traffic flow regulation, and new sensing and control paradigms that are enabled by a small number of controllable systems anticipated in a flow. Specifically, the research focuses on new (1) micro-macro models to model few AVs in a flow; (2) estimation techniques for AV interactions with the traffic flow; (3) developing and assessing dynamical controllers to mitigate traffic events.

8.1.4. NanoSatellite Project: Advanced modelling and Control of attitude dynamics for quantum communication (SPACE)

SPACE is a two-year project funded by the IDEX University Grenoble Alpes. It aims to launch an exploratory study to find the required minimal data we need to collect and combine for software design of Nanosatellite Attitude Determination and Control System (ADCS).

8.1.5. caPture de mOuvements humainS par cenTrales inertielles/d'attitUde et smaRtphonEs : Vers l'analyse d'anomalies neurologiques et fonctions motrices (POSTURE)

POSTURE is a one-year project funded by CDP NeuroCog. The project is focused on 1) the identification and characterization of postures and reference movements in humans using appropriate algorithms of classification (machine learning), and 2) the analysis of the effects of the number, location and orientation of the inertial sensors on the performance of the methods of identification and classification of postures and movements.

8.2. National Initiatives

8.2.1. Models of Bubbles in Online Social Networks (MOB)

MOB is a PEPS S2IH INS2I 2018 interdisciplinary project. This exploratory project focuses on the effects of online recommendation systems on social dynamics, which may entail the formation of «filter bubbles» that distort the experience of the users. The project will develop a mathematical model to demonstrate these effects and propose designs for their mitigation. The research will be conducted by a blend of tools from dynamical systems, network theory, complex systems, and control systems.

8.2.2. AgileWorld-MRSEI

AgileWorld is an ANR-MRSEI project (2018-2020), which aims at building an European network for an innovative training on road transportation systems in a connected world. The funding will help to prepare and then submit a proposal for the MSCA-ITN 2019 call.

8.3. European Initiatives

8.3.1. Collaborations in European Programs, Except FP7 & H2020

8.3.1.1. Scale-FreeBack

Type: ERC Advanced Grant

Duration: Sep. 2016 to Aug. 2021

Coordinator: C. Canudas de Wit

Inria contact: C. Canudas de Wit

Abstract: The overall aim of Scale-FreeBack is to develop holistic scale-free control methods of controlling complex network systems in the widest sense, and to set the foundations for a new control theory dealing with complex physical networks with an arbitrary size. Scale-FreeBack envisions devising a complete, coherent design approach ensuring the scalability of the whole chain (modelling, observation, and control). It is also expected to find specific breakthrough solutions to the problems involved in managing and monitoring large-scale road traffic networks. Field tests and other realistic simulations to validate the theory will be performed using the equipment available at the Grenoble Traffic Lab center (see GTL), and a microscopic traffic simulator replicating the full complexity of the Grenoble urban network.

See also: http://scale-freeback.eu

8.4. International Initiatives

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

8.4.1.1. MEMENTO

Title: ModEling autonoMous vEhicles iN Traffic flOw

International Partner:

Vanderbilt University, Nashville (United States) - Dan Work

Start year: 2018

See also: http://necs.inrialpes.fr/memento/index.html

In recent years, the strategic priorities of automotive and transportation systems focus on research, development and adoption of automation-related technologies as they emerge. As these technology developments are introduced in the traffic stream, an open question is how the mathematical models that are at the heart of transportation planning and operations will need to be advanced to accommodate these changes. The goal of the NeCS-Vanderbilt, MEMENTO, associate team is to create a multidisciplinary environment to model autonomous vehicles (AV) in human traffic flow. Specifically, our goal is to develop a unified micro-macro approach for traffic management, involving human drivers and autonomous vehicles by providing analytical and numerical tools for traffic modeling, estimation and control. We will work towards field operational tests, by using instrumented cars to collect data on AVs trajectories and their interaction with the traffic flow with human drivers.

8.4.2. Participation in Other International Programs

8.4.2.1. TICO-MED

TicoMed (Traitement du signal, Traitement numérique multidimensionnel de l'Information avec applications aux Télécommunications et au génie Biomédical) is a French-Brazilian project funded by CAPES-COFECUB for the period 2015-2018. It involves University of Nice Sophia Antipolis (I3S Laboratory), CNAM, SUPELEC, University of Grenoble Alpes (Gipsa-Lab), Universidade Federal do Ceara, Universidade Federal do Rio de Janeiro, and Universidade Federal do Santa Catarina as partners.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Prof. Andrea Tosin (Politecnico di Torino, Italy) visited the team in February 2018 in the frame of the Scale-FreeBack ERC project. He gave a talk on "Control strategies for road risk mitigation in kinetic traffic modeling". He exchanged ideas with Carlos Canudas De Wit, Paolo Frasca, Stephane Mollier, Maria Laura Delle Monache and Thibault Liard.

Prof. Sandro Zampieri (Univ. Padova, Italy) visited the team in February 2018 in the frame of the Scale-FreeBack ERC project, to work with Carlos Canudas De Wit and Giacomo Casadei.

Prof. Karl Henrik Johansson (KTH, Stockholm, Sweden) visited the team in March 2018 in the frame of the Scale-FreeBack ERC project, and gave a talk on “Control of vehicle platoons and their influence on traffic”.

Prof. Dan Work (Vanderbilt University (USA)), visited the team in July 2018 to work with Maria Laura Delle Monache and Thibault Liard, in the framework of the associated team MEMENTO.

Mauro Franceschelli (University of Cagliari, Italy) visited the team in October 2018 to collaborate with P. Frasca.

Prof. Olga Lucia Quintero Montoya, Univ. EAFIT, Medellin, Colobmia, visited the team in September 2018. She worked with C. Canudas de Wit on the theoretical development of a normalized macroscopic fundamental diagram for urban traffic.

George Gunter and Raphael Stern (University of Illinois at Urbana-Champaign and Vanderbilt University (USA)) visited the team in November 2018 to work with Maria Laura Delle Monache and Thibault Liard, in the framework of the associated team MEMENTO.

Maolong Lyu is a PhD student from TU Delft (Netherlands) under the supervision of Prof. Simone Baldi. He visited the team for two months to work with M.L. Delle Monache and P. Frasca on string stability for microscopic traffic flow models describing mixed traffic (human drivers and autonomous vehicles).

Diego Deplano is a PhD student from Univ. Cagliari (Italy) under the supervision of Prof. Alessandro Giua. He is visiting the team since Sept. 2018, working with C. Canudas de Wit.

8.5.1.1. Internships

Alexandre Olikier, “Open multi-agent systems with fixed size and possibly not complete topologies”, December 2017–June 2018. Université catholique de Louvain, Belgium. Jointly advised by Paolo Frasca and Julien Hendrickx.

8.5.2. Visits to International Teams

8.5.2.1. Research Stays Abroad

P. Frasca is a Visiting Scientist at the IEIIT-CNR Institute, National Research Council CNR, Torino, Italy. By this collaboration, he performs research on distributed estimation in sensor networks and distributed control of social networks. He visited Torino three times in 2018.

P. Frasca is a Visiting Faculty at the Department of Applied Mathematics, University of Twente, Enschede, The Netherlands. By this collaboration, he performs research on vehicle platooning and on the dynamics of social media. He visited Enschede three times in 2018.

M. L. Delle Monache visited University of Alabama (USA) in April 2018.

M. L. Delle Monache visited Vanderbilt University (USA) in May 2018, and T. Liard visited the same university in May-June and December 2018. These visits are in the frame of the MEMENTO associate team.

F. Garin visited Rutgers University (Philadelphia, USA) in April 2018, to initiate a collaboration with Prof. Benedetto Piccoli and his students on metabolic networks.

A. Kibangou visited the University of Johannesburg (South Africa) in October 2018. During his stay, he gave a lecture to students of Department of Town and Regional Planning of Univ. of Johannesburg on Mobility and traffic management.

N. Martin visited Imura Laboratory at Tokyo University of Technology from June 20th to August 20th, in the frame of the JSPS summer program. The aim of this collaboration is to integrate controllability and/or observability notions in the network reduction problem at the core of this Ph.D. work.

M. U. B. Niazi visited Professor Jacquelien Scherpen at the University of Groningen, Netherlands, in October 2018, to work on model reduction for network systems.

NON-A POST Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Non-A POST team hosts CPER Data ControlHub (an on-line laboratory for control system experimentation) and participates at ContrATech subprogram of CPER ELSAT.

8.2. National Initiatives

- Inria Project Lab (IPL) IPL COSY.
- ANR project Finite4SoS (Finite time control and estimation for Systems of Systems), coordinator: W. Perruquetti, 2015-2020.
- ANR project WaQMoS (Coastal waters quality surveillance using bivalve mollusk-based sensors), coordinator: D. Efimov, 2015-2020.
- ANR project TurboTouch (High-performance touch interactions), coordinator: G. Casiez (MJOL-NIR team, Inria), 2014-2019.
- ANR project DIGITSLID (DIGITal set-valued and homogeneous SLIding mode control and Differentiators: the implicit approach), coordinator: Bernard Brogliato (TriPOP team, Inria), 2018-2022.
- ANR project ROCC-SYS (Robust Control of Cyber-Physical Systems), coordinator: L. Hetel (CNRS, EC de Lille), 2013-2018.
- We are also involved in several technical groups of the GDR MACS (CNRS, "Modélisation, Analyse de Conduite des Systèmes dynamiques", see http://www.univ-valenciennes.fr/GDR-MACS), in particular: Technical Groups "Identification", "Time Delay Systems", "Hybrid Systems", "Complex Systems, Biological Systems and Automatic Control," and "Control in Electrical Engineering".

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

UCoCoS: the objectives of the project are to create a control-oriented framework for complex systems, and to define a common language, common methods, tools and software for the complexity scientist. The principal investigators are: W. Michiels, J.-P. Richard and H. Nijmeijer.

8.4. International Initiatives

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

8.4.1.1. HoTSMoCE

Title: Homogeneity Tools for Sliding Mode Control and Estimation

International Partner (Institution - Laboratory - Researcher):

UNAM (Mexico)

Prof. Leonid Fridman

2016–2018

The team *Non-A POST* is developing an estimation theory, built around differential algebra and operational calculation on the one hand, and high gain algorithms (such as sliding mode) on the other hand. The Mexican partner team comes from "Sliding Mode Control" laboratory of UNAM. There exists a strong intersection of interests of both teams (application of homogeneity for design of sliding mode control and estimation algorithms, and analysis of finite-time stability). That is why there exists a long history of collaboration between these two teams. The goal of the project is development of control and estimation algorithms converging in fixed or in finite time by applying the last generation sliding mode techniques and the homogeneity theory. The project realization is planned in the form of short-time visits of permanent staff and visits of PhD students for a long period of stay. Such visits are very important for young scientists, and also help Non-A team to prepare and find good PhDs/post-docs for future.

8.4.2. Inria North European Lab

RECoT, "Robust Estimation and Control with Time Constraints", 2018–2020

International Partner: IBM Research, Dublin (Dr. Sergiy Zhuk)

Non-A Post team of Inria deals with control and estimation of on-line (dynamical) systems with applications to robotics, biological systems, human-machine interfaces and active ow control. The key feature of the developed algorithms is a robustness and a non-asymptotic convergence allowing to fulfill some time constraints. The main methodology is a homogeneity (dilation symmetry) approach. IBM Research team develops minimax algorithms for state estimation and identification of dynamical systems with applications to computational fluid dynamics and image assimilation problems. The key feature of the resulting algorithms is the exact or approximate description of the reachability set of the underlying dynamical system in finite or infinite dimensions. The methodology is relies upon duality and Lyapunov exponents. The objectives of the collaboration are an exchange of the scientific knowledge and the joint research of the following problems: homogeneous observers design using minimax approach; development of fast and consistent computational algorithms for digital implementation of homogeneous controllers and observers; extension of sliding mode control methodology to infinite-dimensional models using minimax approach; the minimax observer-based control design for turbulent flows.

8.4.3. Informal International Partners

- ITMO University, Saint-Petersburg, Russia
- Tel-Aviv University, Tel-Aviv, Israel
- CINVESTAV-IPN, Mexico, Mexico
- Hangzhou Dianzi University, Hangzhou, China
- Brandenburg University of Technology, Cottbus, Germany

QUANTIC Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

- **Paris EMERGENCE project ENDURANCE**: In the framework of the Paris Ile de France program “EMERGENCE”, Zaki Leghtas has received a funding for his research program "Multi-photon processes in superconducting circuits for quantum error correction". This grant of 230k euros has allowed us to purchase the experimental equipment to complement the experiment based at ENS.
- **DIM SIRTEQ project Sputthy**: Zaki Leghtas has received 50k euros from the DIM SIRTEQ to purchase a sputtering system. With this machine, we will fabricate high quality resonators made out of Niobium and high kinetic inductance material such as NbTiN.
- **DIM SIRTEQ PhD fellowship**: We have received funding from DIM SIRTEQ to cover half of the PhD of Jérémie Guillaud under supervision of Mazyar Mirrahimi.
- **FSMP postdoctoral fellowship**: Paolo Forni has been selected for a postdoctoral fellowship by the Fondation des Sciences Mathématiques de Paris (FSMP) for the academic year 2018-2019: this 12-month postdoc fellowship extends a previous one supported by the programme Math-PSL of PSL Research University.

7.2. National Initiatives

- **ANR project GEARED**: This four-year collaborative ANR project, entitled “Reservoir engineering quantum entanglement in the microwave domain” and coordinated by Mazyar Mirrahimi, started on October 2014 and ended on September 2018. The participants of the project were Mazyar Mirrahimi (QUANTIC project-team), Benjamin Huard (ENS Lyon), Daniel Esteve and Fabien Portier (Quantronics group, CEA Saclay), Nicolas Roch and Olivier Buisson (Institut Neel, Grenoble). This project deals with robust generation of entanglement as a key resource for quantum information processing (quantum simulation, computation and communication). QUANTIC receieved a funding of 114k in this framework.
- **ANR project ENDURANCE**: In the framework of the ANR program “Accueil de chercheur de haut niveau”, Zaki Leghtas has received a funding for his research program "Multi-photon processes in superconducting circuits for quantum error correction". This grant of 400k euros has allowed us to purchase the experimental equipment to build a new experiment based at ENS. The project started in March 2016 for 42 months.
- **ANR project HAMROQS**: In the framework of the ANR program JCJC, Alain Sarlette has received a funding for his research program "High-accuracy model reduction for open quantum systems". This grant of 212k euros will start on april 2019 and will run for 4 years.

7.3. European Initiatives

7.3.1. Collaborations with Major European Organizations

Partner 1: ENS Lyon

We are pursuing our interdisciplinary work about quantum control from theoretical aspects in direct collaboration with existing experiments (ENS Lyon) with the group of Benjamin Huard, former member of the QUANTIC team. Joint papers are published and underway. The ANR-JCJC project HAMROQS by Alain Sarlette has Benjamin Huard as external supporting collaborator.

Partner 2: Laboratoire Kastler Brossel

We have been collaborating with Samuel Deleglise and Emmanuel Flurin from Laboratoire Kastler Brossel to understand and analyze their experimental data. In this aim, we have developed new adiabatic elimination techniques for multi-partite open quantum systems with non-trivial zero-order dynamics.

Partner 3: University of Padova

Alain Sarlette has been pursuing a fruitful collaboration with the group of Francesco Ticozzi on "dynamical systems aspects of quantum systems". A novel line of work in the direction of quantum thermalization and quantum random walks has been explored, in the framework of the PhD of S. Apers (Ghent University) supervised by A. Sarlette.

Partner 4: Ghent University.

Alain Sarlette has been collaborating with applied mathematicians interested in quantum control at UGent (Dirk Aeyels, Lode Wylleman, Gert De Cooman) in the framework of thesis co-supervisions. Two PhD students have successfully defended their thesis this year (Arash Farnam, on distributed control of lattices; Simon Apers, on quantum walks). He is further coaching a Master thesis intern working on nonlinear deterministic structures in quantum SDEs.

7.4. International Initiatives

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

TAQUILLA: is an Inria associate team (between Quantic team and Yale university) with principal Inria investigator, Mazyar Mirrahimi, and principal Yale investigator Michel Devoret. In this framework we continued our collaborations between Inria and Yale in 2018. Jérémie Guillaud visited Yale for 3 months (Sept-Nov), and Mazyar Mirrahimi for 4 months (Sept-Dec). Clarke Smith and Steven Touzard, PhD students at Yale, visited us for 1 week at the occasion of PRACQSYS meeting. Clarke Smith joins Quantic team as a postdoc in January 2019.

7.4.2. Participation in Other International Programs

In the framework of the collaborations with Yale university, Quantic team has received a sub-award of 500k dollars over 4 years starting in 2018 from Yale university. This sub-award is part of an ARO (Army Research Office) grant received by our collaborators at Yale and covers the expenses related to our collaborations (hiring of new PhD students and postdocs at Inria and travels between Inria and Yale).

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- In the framework of Inria's invited professor program, Tryphon Georgiou (University of California at Irvine) visited us for about 2 months. This visit had for subject to initiate collaborations on the subject of open quantum systems and quantum channels.
- Yves Bérubé-Lauzière (University of Sherbrooke, Institut Quantique) accompanied by two PhD students made a 6-month visit from March to August 2018 to investigate with Pierre Rouchon feedback protocols for stabilizing quantum states in a high-quality cavity.
- P.S. Pereira da Silva (Escola Politécnica, PTC, University of SaoPaulo, Brazil) made a 2-week visit (June 25 to July 6) to investigate with Pierre Rouchon motion planning issues based on Lyapunov tracking for quantum gate generations.

7.5.2. Visits to International Teams

7.5.2.1. Research Stays Abroad

In the framework of our collaborations with the group of Michel Devoret at Yale university, Jérémie Guillaud and Mazyar Mirrahimi visited Yale for 3 months and 4 months, respectively, in fall 2018.

SPHINX Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Lorraine Université d'Excellence

Thomas Chambrion is deputy head of working group 2 of the Deepsurf project (a project of LUE). ...

8.2. National Initiatives

8.2.1. ANR

- **Project Acronym :** IFSMACS
  Project Title : Fluid-Structure Interaction: Modeling, Analysis, Control and Simulation
  Coordinator: Takéo Takahashi
  Participants: Julien Lequeurre, Alexandre Munnier, Jean-François Scheid, Takéo Takahashi
  Duration : 48 months (starting on October 1st, 2016)
  Other partners: Institut de Mathématiques de Bordeaux, Inria Paris, Institut de Mathématiques de Toulouse
  Abstract: The aim of this project is to analyze systems composed by structures immersed in a fluid. Studies of such systems can be motivated by many applications (motion of the blood in veins, fish locomotion, design of submarines, etc.) but also by the corresponding challenging mathematical problems. Among the important difficulties inherent to these systems, one can quote nonlinearity, coupling, free-boundaries. Our objectives include asymptotic analyses of FSIS, the study of controllability and stabilizability of FSIS, the understanding of locomotion of self-propelled structures and the analyze and development of numerical tools to simulate fluid-structure system.
  URL: http://ifsmacs.iecl.univ-lorraine.fr/
- **Project Acronym:** QUACO
  Project title: use of geometrical tools for the control of quantum system and application to MRI.
  Coordinator: Thomas Chambrion
  Duration: 48 months (starting January 1st 2018).
  URL: http://www.iecl.univ-lorraine.fr/~Thomas.Chambrion/QUACO/index.html
- **Project acronym:** ISDEEC
  Project title: Interaction entre Systèmes Dynamiques, Equations d'Evolution et Contrôle
  Coordinator: Romain Joly
  Participant: Julie Valein
  Other partners: Institut Fourier, Grenoble; Département de Mathématiques d'Orsay
  Duration: 36 months (2017-2020)
  URL: http://isdeec.math.cnrs.fr/

8.2.2. CNRS

Thomas Chambrion is the coordinator of the Research Project from CNRS Inphynity "DISQUO" (5300 euros, 2017).

8.3. International Initiatives

8.3.1. Participation in International Programs

8.3.1.1. Indo-French Center of Applied Mathematics

Analysis, Control and Homogenization of Complex Systems

International Partner: TIFR CAM, Bangalore

Heads: Takéo Takahashi (France) and Mythily Ramaswamy (India).

Duration: 2018 - 2021

scientific objectives

- Study the well-posedness of models arising from either structure in the fluid or structure on the boundary of the domain containing the fluid.
- Explore Controllability, Optimal Control and Stabilization of such fluid-structure interaction problems.
- Study systems describing fluid flows in a time dependent domain with a rapidly oscillating boundary using Homogenization Theory. The rapid oscillations of the boundary takes into account, the rough character of the boundary and its movements may take into account the displacement of a deformable body into a fluid flow.
- Carry out Finite Element Analysis for such models, including elastic structures as well as rigid ones.

8.4. International Research Visitors

8.4.1. Visits to International Teams

8.4.1.1. Research Stays Abroad

- Xavier Antoine was invited
  - to Beijing CSRC, Beijing + Department of Mechanics and Engineering Science, Beijing, July 2018 (one week);
  - to the Department of Mathematics, Sichuan University, Chengdu, Augutst 2018 (3.5 weeks);
  - to the Department of Mathematics, Sichuan University, Chengdu, January 2019 (2 weeks).
- Julie Valein staid for 10 days in Valparaiso (Chile) and gave a talk to the workshop ICoPS 2018; she staid in Santiago (2-14 December 2018) to collaborate with E. Cerpa.

TRIPOP Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

B. Brogliato coordinates the ANR project Digitslid (PRC, ANR-18-CE40-0008-01), Differentiateurs et commandes homogenes par modes glissants en temps discret: l'approche implicite. Partners: LS2N (Ecole Centrale de Nantes), Inria Lille Nord Europe (team Non-A-Post), and Tripop. October 2018-September 2021. 12 participants overall (3 post-doc students recruited by the project, 3 Ph.D. students supported by other means). Total financial support by the ANR: 338 362 euros (100 762 for Tripop, 18 months of post-doc to be recruited in 2019).

8.1.2. FUI Modeliscale.

https://team.inria.fr/modeliscale/

The ModeliScale FUI focuses on the modeling, simulation and analysis of large cyber-physical systems. It federates the research activities of several teams, covering a broad spectrum of topics, namely hybrid systems modeling & verification, numerical analysis, programming language design and automatic control. Our research agenda includes the following tracks:

- New compilation techniques for Modelica modelers: structural analysis of multimode DAE (Differential Algebraic Equations) systems, modular compilation, combining state-machines and non-smooth dynamical systems (complementarity dynamical systems and Filippov differential inclusions), contract-based specification of cyber-physical systems requirements, requirements capture using under-/over-determined DAE systems.
- Simulation of large cyber-physical systems: distributed simulation, discretization methods for non-smooth dynamical systems, space-/time-adaptive discretization methods for multimode DAE systems, quantized state solvers (QSS).
- Guaranteed numerics: guaranteed simulation of non-smooth and hybrid dynamical systems, numerical methods preserving invariant properties of hybrid systems, contract-based reasoning methods.

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

https://team.inria.fr/modeliscale/

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

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

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

Table 1. Member of IPL Modeliscale

Name	Team	Inria Center or Laboratory
Vincent Acary	Bipop	Inria Grenoble Rhône Alpes
Bernard Brogliato		
Albert Benveniste	Hycomes Inria Rennes	
Benoît Caillaud		Bretagne Atlantique
Khalil Ghorbal		
Marc Pouzet	Parkas	ENS
Tim Bourke		Inria Paris
Goran Frehse	Tempo	Verimag-univ. Grenoble Alpes
Antoine Girard		L2S-CNRS, Saclay
Eric Goubault	Cosynus	LIX, École Polytechnique,
Sylvie Putot		Saclay

8.2. International Research Visitors

8.2.1. Visits of International Scientists

- Mathias Legrand (McGill University, Mechanical Engineering).

TROPICAL Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- Projet ANR MALTHY (Méthodes ALgébriques pour la vérification de modèles Temporisés et HYbrides), responsable T. Dang. Partenaires : Verimag, CEA LIST, Inria Rennes, Inria Saclay, VISEO/Object Direct.
- Projet ANR DEMOCRITE ("DEmonstrateur d'un MOteur de Couverture des Risques sur un TErritoire), responsable Emmanuel Lapébie (CEA). Partenaires : CEA-GRAMAT, BSPP, Inria Saclay (Maxplus), Institut PPRIME - UPR3346 (CNRS, Univ. Poitiers, ISAE-ENSMA), IPSIS, SYSTEL, ARMINES-E.M. Alès-ISR, CERDACC (Univ. de Haute-Alsace).
- Projet ANR JCJC CAPPS ("Combinatorial Analysis of Polytopes and Polyhedral Subdivisions"), responsable Arnau Padrol (IMJ-PRG, Sorbonne Université). Partenaires : IMJ-PRG (Sorbonne Université), Inria Saclay (Tropical), LIGM (Université Paris-Est Marne-la-Vallée), LIF (Université Aix-Marseille), CERMICS (École Nationale des Ponts et Chaussées), LIX (École Polytechnique).

9.1.2. Programme Gaspard Monge pour l'Optimisation

- Projet intitulé "Méthodes tropicales pour l'optimisation", responsable X. Allamigeon, faisant intervenir M. Akian, V. Boeuf, S. Gaubert, A.Hochart, R. Katz, et M. Skomra.

9.2. European Initiatives

9.2.1. Collaborations with Major European Organizations

- Partner: Michael Joswig, TU-Berlin.
- Topic : Tropical geometry.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

- Collaboration with Ricardo D. Katz, CIFASIS-CONICET, Rosario (Argentina). Research invitation at CMAP during 2 months.
- Collaboration with Shmuel Friedland, University of Illinois at Chicago (invitation or Stéphane Gaubert at Chicago of one week in May 2018).
- Collaboration with Alejandro Jofre, CMM, University of Chili, Santiago: invitation of Paulin Jacquot of two months (May-June) 2018.
- Collaboration with Zheng Qu, Math. Department, Hongk Kong University.

9.3.2. Participation in Other International Programs

- Collaboration with Gleb Koshevoy, Poncelet Laboratory, Moscow (research invitation of Gleb Koshevoy at CMAP during one week).
- Collaboration with Aris Daniilidis, from CMM, University of Chile, Santiago.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Aris Daniilidis, from CMM, University of Chile, Santiago, Sept-Dec 2018. Invited to École polytechnique within the Gaspard Monge Visiting Professor Program (GMVP) of École polytechnique, with the support of Fondation de l'École polytechnique.
- Roberto Bobadilla Solari, invited PhD student, University of Chile, Santiago, from Sep 2018 until Nov 2018, funded by Inria, associated to the visit of Aris Daniilidis.
- Gonzalo Flores Garcia, invited PhD student, University of Chile, Santiago, from Sep 2018 until Dec 2018, associated to the visit of Aris Daniilidis.
- Sebastian Tapia Garcia, invited PhD student, University of Chile, Santiago, funded by GMVP, associated to the visit of Aris Daniilidis.
- Francisco Javier Antonio Venegas Martinez, invited PhD student, University of Chile, Santiago, from Sep 2018 until Nov 2018, funded by Inria, associated to the visit of Aris Daniilidis.
- Rajendra Bhatia (Ashoka University, India), June 2018.
- Gleb Koshevoy (Russian Academy of Siences), Nov 2018.

9.4.1.1. Internships

- Raphael Pellegrin (Imperial College, London), research summer internship, on tropical positivstellensätze.
- Marin Boyet (École Nationale Supérieure des Mines de Paris), research internship, colorful interior of convex bodies and solvability of tropical polynomial systems.

9.4.2. Visits to International Teams

9.4.2.1. Research Stays Abroad

- Marianne Akian, Institut Mittag Leffler, Jan 15-March 3, 2018.
- Stéphane Gaubert, Institut Mittag Leffler, Jan 15-March 3, 2018.
- Stéphane Gaubert, joint invitation by the Statistics Department of University of Chicago (Lek Heng Lim) and the Maths and Computer Science Department of University of Illinois at Chicago (Shmuel Friedland), May 20-26, 2018.

BONUS Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- *CPER Data (2015-2019)*: in this project, that promotes research and software development related to advanced data science, the BONUS team is the scientific leader (N. Melab) of one of the three research lines of the project "Optimization and High-Performance Computing". In this context, a two-year (2018-2019) engineer (J-Y. Ji) is supported to develop a software demonstrator on decomposition-based big optimization. In addition, the team is co-leader of the workpackage/lever "Research infrastructures" related to the Grid'5000 nation-wide experimental testbed. This allowed to extend the testbed at Lille with a GPU-powered cluster highly important for the BONUS project. In addition, two engineers have been hired for the system & network administration of the testbed, user support and development.
- *CPER ELSAT (2015-2019)*: in this project, focused on ecomobility, security and adaptability in transport, the BONUS team is involved in the transversal research line: planning and scheduling of maintenance logistics in transportation. The team got support for a one-year (2017-2018) post-doc position (M. Rahimi).

9.2. National Initiatives

9.2.1. ANR

- *Bilateral ANR/RGC France/Hong Kong PRCI* (2016-2021), "Big Multi-objective Optimization" in collaboration with City University of Hong Kong

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Program: H2020

Project acronym: SYNERGY

Project title: Synergy for Smart Multi-Objective Optimisation

Duration: 02 2016 - 01 2019

Coordinator: Jožef Stefan Institute (JSI), Ljubljana, Slovenia

Other partners: University of Lille (France), Cologne University of Applied Sciences (Germany)

Abstract: Many real-world application areas, such as advanced manufacturing, involve optimization of several, often time-consuming and conflicting objectives. For example, they require the maximization of the product quality while minimizing the production cost, and rely on demanding numerical simulations in order to assess the objectives. These, so-called multi-objective optimization problems can be solved more efficiently if parallelization is used to execute the simulations simultaneously and if the simulations are partly replaced by accurate surrogate models.

9.3.2. Collaborations in European Programs, Except FP7 & H2020

Program: COST CA15140

Project acronym: ImAppNIO

Project title: Improving applicability of nature-inspired optimization by joining theory and practice

Duration: 2016-2019

Coordinator: Thomas Jansen

Abstract: The main objective of the COST Action is to bridge this gap and improve the applicability of all kinds of nature-inspired optimisation methods. It aims at making theoretical insights more accessible and practical by creating a platform where theoreticians and practitioners can meet and exchange insights, ideas and needs; by developing robust guidelines and practical support for application development based on theoretical insights; by developing theoretical frameworks driven by actual needs arising from practical applications; by training Early Career Investigators in a theory of nature-inspired optimisation methods that clearly aims at practical applications; by broadening participation in the ongoing research of how to develop and apply robust nature-inspired optimisation methods in different application areas.

9.3.3. Collaborations with Major European Organizations

MARO: University of Mons (BELGIUM), Parallel surrogate-assisted optimization, large-scale exact optimization

University of Ceara (BRAZIL), Large-scale GPU-accelerated tree-based optimization

University of Luxembourg (LUXEMBOURG), Energy-aware scheduling in Cloud computing systems

University of Oviedo (SPAIN), Optimization under uncertainty for fuzzy flow shop scheduling

University of Coimbra and University of Lisbon (PORTUGAL), Exact and heuristic multi-objective search

University of Manchester (UNITED KINGDOM), Local optimality in multi-objective optimization

University of Elche and University of Murcia (SPAIN), Matheuristics for DEA

9.4. International Initiatives

9.4.1. Inria International Labs

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

9.4.1.1. MOHA

Title: Mixed Multi-objective Optimization using Hybrid Algorithms: Application to smart grids

International Partner (Institution - Laboratory - Researcher):

Ecole Mohammadia d'Ingénieurs (Morocco) - LERMA (Laboratoire d'Etudes et de Recherches en Mathématiques Appliquées) - Rachid Ellaia

Start year: 2016

See also: https://ocm.univ-lille1.fr/~talbi/momh/

The key challenge of this project is to propose new optimization models and new hybrid algorithms to the demand side management of smart grids in a context of uncertainty and in the presence of several conflicting objectives.

Those complex optimization problems are also characterized by the presence of both continuous and discrete variables. We need to design new efficient optimization algorithms combining state of the art exact and metaheuristic algorithms from the global optimization and combinatorial optimization communities.

9.4.1.2. Other IL projects

Title: Frontiers in Massive Optimization and Computational Intelligence

International Partner (Institution - Laboratory - Researcher): Shinshu University (JAPAN)

Start year: 2017

See also: https://sites.google.com/view/lia-modo/

Abstract: The aim of MODO is to federate French and Japanese researchers interested in the dimensionality, heterogeneity and expensive nature of massive optimization problems. The team receives a yearly support for international exchanges and shared manpower (joint PhD students).

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

Title: Three-fold decomposition in multi-objective optimization (D^3MO)

International Partner (Institution - Laboratory - Researcher): University of Exeter, UK

Start year: 2018

9.4.3. Inria International Partners

9.4.3.1. Informal International Partners

- Collaboration with Université de Mons (UMONS). The collaboration consists mainly in the joint supervision of two Phds (M. Gobert and G. Briffoteaux)
- University of Elche, Spain

9.4.4. Participation in Other International Programs

Title: **Evolutionary many-objective optimization: application to smart cities and engineering design**

International Partner (Institution - Laboratory - Researcher): CINVESTAV-IPN (MEXICO)

Start year: 2016

Abstract: The project is co-funded by ECOS Nord (FRANCE) and ANUIES (MEXICO). Abstract to be extended ...

Title: **Bridging the gap between exact methods and heuristics for multi-objective search (MOCO-Search)**

International Partner (Institution - Laboratory - Researcher): University of Coimbra and University of Lisbon, Portugal

Start year: 2018

Website: http://sites.google.com/view/moco-search/

Abstract: This international project for scientific cooperation (PICS), funded by CNRS and FCT, aims to fill the gap between exact and heuristic methods for multi-objective optimization. The goal is to establish the link between the design principles of exact and heuristic methods, to identify features that make a problem more difficult to be solved by each method, and to improve their performance by hybridizing search strategies. Special emphasis is given to rigorous performance assessment, benchmarking, and general-purpose guidelines for the design of exact and heuristic multi-objective search.

9.5. International Research Visitors

9.5.1. Visits of International Scientists

- Kiyoshi Tanaka, Shinshu University (JAPAN), March 2018 and November 2018
- Hernan Aguirre, Shinshu University (JAPAN), Invited Professor Univ Lille, from March 2018 until April 2018
- Kalyan Deb, University of Michiga (USA), Oct 2018
- Rachid Ellaia, EMI University of Rabat, Morocco, April 2018

9.5.1.1. Internships

- Alexandre Jesus, University of Coimbra (Portugal)

GEOSTAT Project-Team

9. Partnerships and Cooperations

9.1. 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).
- PhD grant for G. Singh from IIT Roorkee, under co-supervision with D. Singh (IIT Roorkee).
- The PHC-Toubkal project "Caractérisation multi-capteurs et suivi spatio-temporel de l'Upwelling sur la côte atlantique marocaine par imagerie satellitaire", led by K. Daoudi, is in its second year. The partners in this project are: Faculté des sciences de Rabat, Centre Royal de Télédetection Spatiale, Mercator-Ocean and GEOSTAT.
- GEOSTAT is a member of ISIS (Information, Image & Vision) and 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.

9.2. European Initiatives

9.2.1. 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.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. 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 foremergency, 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. Yet, the generalization ability of such systems often not accounts for spatial consistency. High scores are obtained on the reference points, but nearby points of the same class are incorrectly classified. Local context, pixels around the selected one, may help in recovering that spatial consistency and increase the recognition rate. This may also induce spurious patterns and overfit the learning algorithm, which is especially the case for with Convolutional Networks trained on limited number of data. 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.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- S. Bogning Dongue [CNRS, from Dec 2018]
- K. Minaoui [Rabat University, Jul 2018]

INOCS Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Lille

The ELSAT research program addresses the issues involved in sustainable transportation and mobility. Within ELSAT, INOCS is involved on two projects devoted to hybrid optimization methods in logistics and to city logistics in collaboration with LAMIH (University of Valenciennes), LGI2A (University of Artois) and LEOST (IFSTTAR). ELSAT is supported by the CPER 2015-2020 (State-Region Contract).

9.1.2. Brussels

ValueBugs is a citizen participatory research project, funded by INNOVIRIS (2018-2020). The objective of ValueBugs is to collectively develop a method for decentralized insect production in cities while enhancing the value of food waste on a small scale. In practical terms, peelings are consumed by insect larvae that have reached the end of their development and offer many promising outlets: feed for hens, farmed fish, pets... and much more! This new, totally innovative sector will be a new tool to be put in the hands of every citizen: we must therefore imagine it collectively.

9.2. National Initiatives

9.2.1. ANR

ANR project PI-Commodality "Co-modal freight transportation chains: an approach based on physical internet" in collaboration with CGS-ARMINES (Paris), LAAS (Toulouse), DHL (2016 - 2019). The PI-co-modality project aims to design new sustainable logistic services between preset origins and destinations. It is based on innovative approaches both in terms of: 1) Logistics and transportation services: by considering the PI-internet approach, specifically: mesh logistics and transportation networks based on available capacities, by designing consistent integrated co-modal chains; 2) Methodology: by addressing the underlying problems according to two approaches: centralized and decentralized, by proposing news realistic models relevant for practitioner taking into account the consistency, by developing state-of-the-art decision making algorithms.

9.2.2. F.R.S.-FNRS (Belgium)

Bilevel optimization is a branch of mathematical optimization that deals with problems whose constraints embed an auxiliary optimization problem. The F.R.S.-FNRS research project "bilevel optimization" (2018-2019) will study such bilevel problems with bilinear objectives and simple second level problems. Each follower chooses one strategy in a given fixed set of limited size. Two classes of such problems will be studied: Pricing Problems and Stackelberg Security Games.

In pricing problems, prices for products must be determined to maximize the revenue of a leader given specific behaviors of customers (followers). More precisely, we will consider the single minded pricing problem and the rank pricing problem.

In Stackelberg games, mixed strategies to cover targets,must be determined in order to maximize the defender expected payoff given that attackers (followers) attack targets that maximize their own payoffs.

9.3. International Initiatives

9.3.1. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

9.3.1.1. BIPLOS

Title: BIlevel Problems in LOgistics and Security

International Partner (Institution - Laboratory - Researcher):

Universidad de Chile (Chile) - Instituto Sistemas Complejos de Ingeieria (ISCI) - Ordonez Fernando

Start year: 2017

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

This projet is devoted to bilevel optimisation problems with application in the security and logistics domains. Stackelberg games, including one defender and several followers, and competitive location problems will be considered. Mixed integer linear optimisation models and efficient algorithms to solve them will be developed.

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

9.3.2.1. LOBI

Title: Learning within Bilevel Optimization

International Partner (Institution - Laboratory - Researcher):

Polytechnique Montréal (Canada) - Institut de Valorisation des Données (IVADO) - Gilles Savard

Start year: 2018

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

The interplay between optimization and machine learning is one of the most important developments in modern computational science. Simultaneously there is a tremendous increase in the availability of large quantities of data in a multitude of applications, and a growing interest in exploiting the information that this data can provide to improve decision-making. Given the importance of big data in business analytics, its explicit integration into an optimization process is a challenge with high potential impact. The innovative project is concerned with the interconnection between machine learning approaches and a particular branch of optimization called bilevel optimization in this “big data” context. More precisely, we will focus on the development of new approaches integrating machine learning within bilevel optimization (LOBI: “Learning au sein de l’Optimisation BIniveau”) for two important practical applications, the pricing problem in revenue management and the energy ressource aggregation problem in smart grids. The applications arise from current industry collaborations of the teams involved, and will serve as testbeds to demonstrate the potential impact of the proposed approach.

9.3.2.2. North-European associated team

Title: Physical-internet services for city logistics

International Partner (Institution - Laboratory - Researcher):

Norwegian School of Economics - Stein Wallace

Start year: 2017

In this project, we consider an urban logistic terminal and new logistics services which could be developed according to a Physical Internet approach. The main objective is to evaluate the services using optimization models created within the project. We are developing optimization models to identify win-win cooperation between carriers based on supply and demand. We aim to explore how to include stochasticity in the description of the supplies and demands, as well as travel times, and to what extent the plans within a day can improve by such knowledge. The second task is to develop solution algorithms for these models. These are real scientific challenges as we are facing stochastic mixed integer problems.

9.3.3. Inria International Partners

9.3.3.1. Informal International Partners

Department of Statistics and Operations Research, University of Vienna, Austria.

Centre for Quantitative Methods and Operations Management, HEC-Liège, Belgique.

Interuniversity Centre on Entreprise Networks, Transportation and Logistics (CIRRELT), Montreal, Canada.

Department of Industrial Engineering, Universidad de Talca, Curicó, Chile.

Instituto Sistemas Complejos de Ingeniería (ISCI), Santiago, Chile.

The Centre for Business Analytics, University College Dublin, Ireland.

Department of Electrical, Electronic, and Information Engineering, University of Bologna, Italy.

Department of Electrical and Information Engineering, University of Padova, Italy.

Department of Mathematics, University of Aveiro, Portugal.

Department of Statistics and Operations Research, University of Lisbon, Portugal.

Instituto de Matemáticas, University of Seville, Spain.

Departamento de Estadística e Investigación Operativa, Universidad de Murcia, Spain.

Dipartimento di Matematica, Universita degli studi di Padova, Italy.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

9.4.1.1. Visiting Professors and Ph.D. students

Claudia Archetti, Professor at Universita de Brescia, December 2018.

Stein Wallace, Professor at NHH Norwegian School of Economics, October 2018.

Martin Schmidt, Professor at Erlangen University, August 2018.

Alejandro Jofre, Professor at Universidad de Chile, from June 2018 until July 2018.

Sebastián Dávila, Ph.D. student at Universidad de Chile, June 2018.

Vladimir Marianov, Professor at Pontificia Universidad Católica de Chile, June 2018.

Fernando Ordónez, Professor at Universidad de Chile, June 2018.

Alfredo Marin, Professor at Universidad de Murcia, March 2018.

Eduardo Alvarez Miranda, Professor at Universidad de Talca, January - February 2018.

9.4.1.2. Internships

Brou Koua, Esatic, Abidjan, Cote d'Ivoire, December 2018 - January 2019.

Lilian Lopez Vera, Autonomous University of Nuevo León, Monterrey, Mexico February-June 2018.

MISTIS Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. Grenoble Idex projects

MISTIS is involved in a transdiciplinary project **NeuroCoG** and in a newly accepted cross-disciplinary project (CDP) **Risk@UGA**. F. Forbes is also a member of the executive committee and responsible for the *Data Science for life sciences* work package in another project entitled **Grenoble Alpes Data Institute**.

- The main objective of the RISK@UGA project is to provide some innovative tools both for the management of risk and crises in areas that are made vulnerable because of strong interdependencies between human, natural or technological hazards, in synergy with the conclusions of Sendai conference. The project federates a hundred researchers from Human and Social Sciences, Information & System Sciences, Geosciences and Engineering Sciences, already strongly involved in the problems of risk assessment and management, in particular natural risks. The PhD thesis of Meryem Bousebata is one of the eleven PhDs funded by this project.
- The NeuroCoG project aims at understanding the biological, neurophysiological and functional bases of behavioral and cognitive processes in normal and pathological conditions, from cells to networks and from individual to social cognition. No decisive progress can be achieved in this area without an aspiring interdisciplinary approach. The interdisciplinary ambition of NeuroCoG is particularly strong, bringing together the best scientists, engineers and clinicians at the crossroads of experimental and life sciences, human and social sciences and information and communication sciences, to answer major questions on the workings of the brain and of cognition. One of the work package entitled InnobioPark is dedicated to Parkinson's Disease. The PhD thesis of Veronica Munoz Ramirez is one of the three PhDs in this work package.
- The Grenoble Alpes Data Institute aims at undertaking groundbreaking interdisciplinary research focusing on how data change science and society. It combines three fields of data-related research in a unique way: data science applied to spatial and environmental sciences, biology, and health sciences; data-driven research as a major tool in Social Sciences and Humanities; and studies about data governance, security and the protection of data and privacy. In this context, a 2-year multi-disciplinary projects has been granted in November 2018 to Mistis in collaboration with the Grenoble Institute of Neuroscience. The objective of this project is to develop a statistical learning technique that is able to solve a problem of tracking and analyzing a large population of single molecules. The main difficulties are: 1) the large number of observations to analyse, 2) the noisy nature of the signals, 3) the definition of a quality index to allow the elimination of poor-quality data and false positive signals. We also aim at providing a powerful, well-documented and open-source software, that will be user-friendly for non-specialists.

Also in the context of the Idex associated with the Université Grenoble Alpes, Alexandre Constantin was awarded half a PhD funding from IRS (Initiatives de Recherche Stratégique), 50 keuros.

9.1.2. Competitivity Clusters

The MINALOGIC VISION 4.0 project: MISTIS is involved in a three-year (2016-19) project. The project is led by VI-Technology, a world leader in Automated Optical Inspection (AOI) of a broad range of electronic components. The other partners are the G-Scop Lab in Grenoble and ACTIA company based in Toulouse. Vision 4.0 (in short Vi4.2) is one of the 8 projects labeled by Minalogic, the digital technology competitiveness cluster in Auvergne-Rhône-Alpes, that has been selected for the Industry 4.0 topic in 2016, as part of the 22nd call for projects of the FUI-Régions, for a total budget of the project of 3,4 Meuros.

Today, in the printed circuits boards (PCB) assembly industry, the assembly of electronic cards is a succession of ultra automated steps. Manufacturers, in constant quest for productivity, face sensitive and complex adjustments to reach ever higher levels of quality. Project VI4.2 proposes to build an innovative software solution to facilitate these adjustments, from images and measures obtained in automatic optical inspection (AOI). The idea is - from a centralized station for all the assembly line devices - to analyze and model the defects finely, to adjust each automatic machine, and to configure the interconnection logic between them to improve the quality. Transmitted information is essentially of statistical nature and the role of sc mistis is to identify which statistical methods might be useful to exploit at best the large amount of data registered by AOI machines. Preliminary experiments and results on the Solder Paste Inspection (SPI) step, at the beginning of the assembly line, helped determining candidate variables and measurements to identify future defects and to discriminate between them. More generally, the idea is to analyze two databases at both ends (SPI and Component Inspection) of the assembly process so as to improve our understanding of interactions in the assembly process, find out correlations between defects and physical measures and generate accordingly proactive alarms so as to detect as early as possible departures from normality.

9.1.3. Networks

MSTGA and AIGM INRA (French National Institute for Agricultural Research) networks: F. Forbes and J.B Durand are members of the INRA network called AIGM (ex MSTGA) network since 2006, http://carlit.toulouse.inra.fr/AIGM, on Algorithmic issues for Inference in Graphical Models. It is funded by INRA MIA and RNSC/ISC Paris. This network gathers researchers from different disciplines. MISTIS co-organized and hosted 2 of the network meetings in 2008 and 2015 in Grenoble. Thibaud Rahier and Brice Olivier participated as speakers to meetings of the network in 2018.

9.2. International Initiatives

9.2.1. Inria International Labs

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

9.2.1.1. SIMERG2E

Title: Statistical Inference for the Management of Extreme Risks, Genetics and Global Epidemiology

International Partner:

UGB (Senegal) - Abdou Kâ Diongue

Start year: 2018

See also: http://mistis.inrialpes.fr/simerge

SIMERG2E is built on the same two research themes as SIMERGE, with some adaptations to new applications: 1) Spatial extremes, application to management of extreme risks. We address the definition of new risk measures, the study of their properties in case of extreme events and their estimation from data and covariate information. Our goal is to obtain estimators accounting for possible variability, both in terms of space and time, which is of prime importance in many hydrological, agricultural and energy contexts. 2) Classification, application to genetics and global epidemiology. We address the challenge to build statistical models in order to test association between diseases and human host genetics in a context of genome-wide screening. Adequate models should allow to handle complexity in genomic data (correlation between genetic markers, high dimensionality) and additional statistical issues present in data collected from a family-based longitudinal survey (non-independence between individuals due to familial relationship and non-independence within individuals due to repeated measurements on a same person over time).

9.2.2. Inria International Partners

9.2.2.1. Informal International Partners

The context of our research is also the collaboration between MISTIS and a number of international partners such as the statistics department of University of Michigan, in Ann Arbor, USA, the statistics department of McGill University in Montreal, Canada, Université Gaston Berger in Senegal and Universities of Melbourne and Brisbane in Australia.

The main active international collaborations in 2018 are with:

- G. Stupfler, Nottingham University, UK.
- K. Qin, H. Nguyen and Kerrie Mengersen, D. Wraith resp. from Swinburne University and La Trobe university in Melbourne, Australia and Queensland University of Technology in Brisbane, Australia.
- E. Deme and S. Sylla from Gaston Berger university and IRD in Senegal.
- M. Houle from National Institute of Informatics, Tokyo, Japan.
- N. Wang and C-C. Tu from University of Michigan, Ann Arbor, USA.
- R. Steele, from McGill university, Montreal, Canada.
- Guillaume Kon Kam King, Stefano Favaro, Pierpaolo De Blasi, Collegio Carlo Alberto, Turin, Italy.
- Igor Prünster, Antonio Lijoi, and Riccardo Corradin Bocconi University, Milan, Italy.
- Bernardo Nipoti, Trinity College Dublin, Ireland.
- Yeh Whye Teh, Oxford University and DeepMind, UK.
- Stephen Walker, University of Texas at Austin, USA.

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Hien Nguyen, researcher at La Trobe University in Melbourne visited for a month in October 2018.
- Eric Marchand Professor at University of Sherbrook Canada, visited from March to June 2018.
- Riccardo Corradin, PhD student at Bocconi University, Milan, Italy visited for a month in March 2018.
- Aboubacrène Ag Ahmad, PhD student at Univ. Gaston Berger, Senegal visited from September 2018 until November 2018.

9.3.1.1. Internships

Caroline Lawless from University College Dublin visited for 2 months as part of her internship.

MODAL Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

9.1.1. Bilille partnership

Participant: Guillemette Marot.

Bilille, the bioinformatics platform of Lille, officially gathers from Nov. 2015 a few bioinformaticians, biostatisticians and bioanalysts from the following teams:

EA2694 (Univ. Lille, CHRU, Inria)

FRABIO, FR3688 (Univ. Lille,CNRS)

CBP / GFS (Univ. Lille, CHRU)

TAG (Univ. Lille, CNRS, INSERM, Institut Pasteur de Lille)

U1167 (Univ. Lille, CHRU, INSERM et Institut Pasteur de Lille)

U1011 (Univ. Lille, INSERM)

UMR8198 (Univ. Lille, CNRS)

LIGAN PM (Univ. Lille, CNRS)

BONSAI (Inria, Univ. Lille, CNRS).

These last teams are thus the main partners of Modal concerning biostatistics for bioinformatics. Guillemette Marot is the co-head of the platform and works in close collaboration with the following people for the leadership of the scientific strategy related to the platform:

H. Touzet, BONSAI, UMR 9189 (co-head of bilille)

P. Touzet, UMR 8198 (deputy head of bilille)

C. Bellenguez, U1167

M. Figeac, CBP / GFS

D. Hot, TAG

V. Leclère, Insitut Charles Viollette

M. Lensink, UMR 8576.

O. Sand, IFB-Core.

9.1.2. Bilille collaborations

Participants: Guillemette Marot, Vincent Vandewalle.

Guillemette Marot and Vincent Vandewalle have supervised the data analysis part or support in biostatistics tools testing for the following research projects involving engineers from bilille (only the names of the principal investigators of the project are given even if several partners are sometimes involved in the project):

CIIL, C. Faveeuw, Analysis of cytometry data

CIIL, P. Brodin, Analysis of phenotypic screening data

JPARC, J.M. Taymans, Analysis of translation chips

JPARC, M.C. Chartier-Harlin, RNA-Seq meta-analysis

JPARC, A. Vincent, Microarray analysis

UMR 1167, F. Pinet, Analysis of proteomic data.

9.2. National Initiatives

9.2.1. Programme of Investments for the Future (PIA)

Bilille is a member of two PIA "Infrastructures en biologie-santé":

France Génomique (https://www.france-genomique.org/spip/?lang=en)

IFB, French Institute of Bioinformatics (https://www.france-bioinformatique.fr/en)

As the leader of the platform, Guillemette Marot is thus involved in these networks.

9.2.2. RHU PreciNASH

Participant: Guillemette Marot.

RHU PreciNASH

Acronym: PreciNASH

Project title: Non-alcoholic steato-hepatitis (NASH) from disease stratification to novel therapeutic approaches

Coordinator: F. Pattou

Duration: 5 years

Partners: FHU Integra and Sanofi

Abstract: PreciNASH, project coordinated by Pr. F. Pattou (UMR 859, EGID), aims at better understanding non alcoholic stratohepatitis (NASH) and improving its diagnosis and care. In this RHU, Guillemette Marot supervises a 2 years post-doc, as her team EA 2694 is a member of the FHU Integra. EA 2694 is involved in the WP1 for the development of a clinical-biological model for the prediction of NASH. Other partners of the FHU are UMR 859, UMR 1011 and UMR 8199, these last three teams being part of the labex EGID (European Genomic Institute for Diabetes). Sanofi is the main industrial partner of the RHU PreciNASH. The whole project will last 5 years (2016-2021).

9.2.3. INS2I-CNRS project PEPS JCJC 2018 "PaRaFF"

Participant: Pascal Germain.

Projet PaRaFF: PAC-Bayesian Random Fourier Features

Coordinator: Emilie Morvant, Hubert Curien Lab, University Jean Monnet, Saint-Etienne

Year: 2018

Abstract: In data science, any method is based on a representation of the data. In this project, we study the learning of representation in the context of automatic learning methods called kernel methods. Our analysis is based on the Random Fourier Features, a method of approximating a kernel function based on a combination random attributes (combination defined by a probability distribution on the attributes). We aim to provide a theoretical understanding of this approach via PAC-Bayesian theory, and to propose a representation learning procedure by exploiting the specificities of this theory.

9.2.4. ANR

9.2.4.1. ANR APRIORI

Participants: Benjamin Guedj, Pascal Germain.

APRIORI 2019–2023, ANR PRC

PAC-Bayesian theory and algorithms for deep learning and representation learning.

Main coordinator of the project: Emilie Morvant, Université Jean Monnet.

Funding: 300k EUR.

2 partners - MODAL (Inria LNE), Hubert Curien Lab. (UMR CNRS 5516).

9.2.4.2. ANR BEAGLE

Participants: Benjamin Guedj, Pascal Germain.

BEAGLE 2019–2023, ANR JCJC

PAC-Bayesian theory and algorithms for agnostic learning

Main coordinator of the project: Benjamin Guedj

Funding: 180k EUR

The consortium also includes Pierre Alquier (ENSAE ParisTech), Peter Grünwald (CWI, The Netherlands), Rémi Bardenet (UMR CRIStAL 9189).

9.2.4.3. ANR SMILE

Participants: Christophe Biernacki, Vincent Vandewalle.

SMILE Project-2018-2022

ANR project (ANR SMILE - Statistical Modeling and Inference for unsupervised Learning at LargE-Scale)

Main coordinator of the project: Faicel Chamroukhi, LMNO, Université de Caen

4 partners - MODAL (Inria LNE), LMNO UMR CNRS 6139 (Caen), LMRS UMR CNRS 6085 (Rouen), LIS UMR CNRS 7020 (Toulon).

9.2.4.4. ANR ClinMine

Participants: Cristian Preda, Vincent Vandewalle.

ClinMine Project-2014-2017

ANR project (ANR TECSAN - Technologie de la santé)

Main coordinator of the project: Clarisse Dhaenens, CRIStAL, USTL

7 partners - EA 1046 (Maladie d'Alzheimer et pathologies vasculaires, Faculté de Médecine, Lille), EA 2694 (Centre d'Etudes et de Recherche en Informatique Médicale - Faculté de Médecine, Lille), MODAL (Inria LNE), Alicante (Entreprise), CHRU de Montpelier, GHICL (Groupe Hospitalier de l'Institut Catholique de Lille), CRIStAL, USTL.

9.2.4.5. ANR TheraSCUD2022

Participant: Guillemette Marot.

Acronym: TheraSCUD2022

Project title: Targeting the IL-20/IL-22 balance to restore pulmonary, intestinal and metabolic homeostasis after cigarette smoking and unhealthy diet

Coordinator: P. Gosset

Duration: 3 years

Partners: CIIL Institut Pasteur de Lille and UMR 1019 INRA Clermont-Ferrand

Abstract: TheraSCUD2022, project coordinated by P. Gosset (Institut Pasteur de Lille), studies inflammatory disorders associated with cigarette smoking and unhealthy diet (SCUD). Guillemette Marot is involved in this ANR project as head of bililleplatform, and will supervise 1 year engineer on integration of omic data. The duration of this project is 3 years (2017-2020).

9.2.5. Working groups

Sophie Dabo-Niang belongs to the following working groups:

- STAFAV (STatistiques pour l'Afrique Francophone et Applications au Vivant)
- ERCIM Working Group on computational and Methodological Statistics, Nonparametric Statistics Team
- Ameriska

Benjamin Guedj belongs to the following working groups (GdR) of CNRS:

- ISIS (local referee for Inria Lille - Nord Europe)
- MaDICS
- MASCOT-NUM (local referee for Inria Lille - Nord Europe).

Guillemette Marot belongs to the StatOmique working group.

9.2.6. Other initiatives

Participants: Serge Iovleff, Cristian Preda, Vincent Vandewalle.

Serge Iovleff is the head of the project CloHe granted in 2016 by the Mastodons CNRS challenge "Big data and data quality". The project is axed on the design of classification and clustering algorithms for mixed data with missing values with applications to high spatial resolution multispectral satellite image time-series. Website. Cristian Preda and Vincent Vandewalle are also members of the CloHe project.

9.3. European Initiatives

9.3.1. FP7 & H2020 Projects

Benjamin Guedj and Vincent Vandewalle are involved on the European H2020 porject PERF-AI

Program: H2020

Project acronym: PERF-AI

Project title: Enhance Aircraft Performance and Optimisation through utilisation of Artificial Intelligence

Duration: November 2018 - November 2020.

Coordinator: Safety Line

Other partners: Safety Line

Abstract: PERF-AI will apply Machine Learning techniques on flight data (parametric and non-parametric approaches) to accurately measure actual aircraft performance throughout its lifecycle.

Within current airline operations, both at flight preparation (on-ground) and at flight management (in-air) levels, the trajectory is first planned, then managed by the Flight Management System (FMS) using a single manufacturer's performance model that is the same for every aircraft of the same type, and also on weather forecast that is computed long before the flight. It induces a lack of accuracy during the planning phase with a flight route pre-established at specific altitudes and speeds to optimize fuel burn, from take-off to landing using aircraft performances that are not those of the real aircraft. Also, the actual flight will usually shift from the original plan because of Air Traffic Control (ATC) constraints, adverse weather, wind changes and tactical re-routing, without possibility for the flight crew, either using the FMS or through connected services to tactically recompute the trajectory in order to continuously optimize the flight path. This is in particular due to the limitations of the performance databases that the current systems are using.

Hence, PERF-AI is focusing on identifying adequate machine learning algorithms, testing their accuracy and capability to perform flight data statistical analysis and developing mathematical models to optimize real flight trajectories with respect to the actual aircraft performance, thus, minimizing fuel consumption throughout the flight.

The consortium consists of Safety-Line (FR) and Inria (FR), having full expertise at Aircraft Performance and Data Science, hence, able to fully propose, test and validate different statistical models that will allow to accurately solve some optimization challenges and implement them in an operational environment.

9.3.2. Collaborations with Major European Organizations

Sophie Dabo-Niang is vice-chair of EMS-CDC (European Mathematical Society-Committe of Developing Countries). She is also a member of the executive committee of CIMPA (International Centre of Pure and Applied Mathematics)

Alain Celisse is a member of a one-year EIT European project called SysBooster with ApSys and Nokia.

9.4. International Initiatives

9.4.1. Inria International Labs

IIL CWI-Inria
Associate Team involved in the International Lab:

9.4.1.1. 6PAC

Title: Making Probably Approximately Correct Learning Active, Sequential, Structure-aware, Efficient, Ideal and Safe

International Partner (Institution - Laboratory - Researcher):

CWI (Netherlands) - Machine Learning Group

PI: Benjamin Guedj

Consortium: Peter Grünwald (co-PI), Wouter Koolen (CWI), Emilie Kaufmann (Inria LNE EPI SequeL).

Start year: 2018 (until 2021)

Webpage: https://bguedj.github.io/6pac/index.html

This project roots in statistical learning theory, which can be viewed as the theoretical foundations of machine learning. The most common framework is a setup in which one is given n training examples, and the goal is to build a predictor that would be efficient on new (similar) data. This efficiency should be supported by PAC (Probably Approximately Correct) guarantees, e.g. upper bounds on the excess risk of a predictor that hold with high probability. Such guarantees however often hold under stringent assumptions which are typically never met in real-life application, e.g., independent, identically distributed data. More realistic modelling of data has triggered many research efforts in several directions: first, accommodating possible data (e.g., dependent, heavy-tailed), and second, in the direction of sequential learning, in which the predictor can be built on the fly, while new data is gathered. We believe that an ever more realistic paradigm is active learning, a setup in which the learner actively requests data (possibly facing constraints, such as storage, velocity, cost, etc.) and adapts its queries to optimize its performance. The 3-years objective of 6PAC (where 6 stands for Sequential, Active, Efficient, Structured, Ideal, Safe - the six research directions we intend to contribute to) is to pave the way to new PAC generalization and sample-complexity upper and lower bounds beyond batch learning. Our ambition is to contribute to several learning setups, ranging from sequential learning (where data streams are collected) to adaptive and active learning (where data streams are requested by the learning algorithm).

9.4.2. Participation in Other International Programs

Starting December 2018, Benjamin Guedj is on sabbatical leave at University College London, Computer Science department, to lead a research team within the UCL AI center.

9.4.2.1. SIMERGE

Title: Statistical Inference for the Management of Extreme Risks and Global Epidemiology

International Partner (Institution - Laboratory - Researcher):

UGB (Senegal) - LERSTAD - Abdou Ka Diongue

Serge Iovleff and Sophie Dabo-Niang are associated members of SIMERGE.

9.5. International Research Visitors

9.5.1. Visits to International Teams

9.5.1.1. Research Stays Abroad

Sophie Dabo-Niang visited the University of Kuala Lumpur, November 2018, the University of Melbourne (Australia), December 2018, and the University of Nador (Morroco), end of December 2018.

Serge Iovleff visited several institutions in Senegal (April 22 – May 18, 2018). He gave a lecture at University Gaston Berger (UGB) of Saint-Louis and collaborated with Cheikh Loucoubar, Seydou Nourou Syllla and Cheikh Loucoubar of the team G4BBM of the Pasteur Institute of Dakar.

RANDOPT Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- PGMO/FMJH project "AESOP: Algorithms for Expensive Simulation-Based Optimization", 7kEUR, 2017–2019

9.2. National Initiatives

9.2.1. ANR

- ANR project "Big Multiobjective Optimization (BigMO)", Dimo Brockhoff participates in this project through the Inria team BONUS in Lille (2017–2020)

9.3. International Research Visitors

9.3.1. Visitors to RandOpt

- Filip Matzner, October 15–19 and December 10-14, 2018

9.3.2. Internships

- Eugenie Marescaux, March–July 2018
- Xudong Zhang, March–August 2018

REALOPT Project-Team

9. Partnerships and Cooperations

9.1. Regional Initiatives

- **HPC scalable ecosystem**: This project is funded by Region Nouvelle Aquitaine for 4 years, starting in 2018. It is coordinated by Emmanuel Agullo (Hiepacs Inria project-team) and it gathers researchers from Inria, Inra, LaBRI but also from UPPA (University of Pau), Pprime Institute (Poitiers), CEA and Airbus. It aims at building a convergent approach between numerical simulation and HPC on the one hand, and Data Science and Big Data on the other hand. The goal is to study the feasibility of approaches based on runtime schedulers to achieve a high level of scalability.
- **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.
  - Olivier Beaumont is leading the methodological WP on Modeling and numerical systems. Mathematical modeling and numerical simulation are by now highly important tools currently used in physics, chemistry, biology, medicine and humanities. The forthcoming development of exaflopic computers should allow to simulate with High Performance Computing new multi-scale and multi-physics phenomena, generating massive data (High Performance Data Analytics). One of the major challenges of the years to come is thus both to build new robust numerical modeling tools, working on several millions processors computers and to be able to accommodate on a single platform both HPC and BigData applications.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

- **EXDCI-2**: EXDCI-2 is a H2020 project (type: CSA – Coordination & support action), coordinated by PRACE for a duration of 30 months, starting on March 2018.

  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:
  - 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). The expertise of the partners and stakeholders will permit to elaborate a transversal prospective vision.

– Coordination of the stakeholder community for European HPC at the Exascale through joint community structuring and synchronisation. This entails ensuring EXDCI-2 stakeholder representation in the main development of the European HPC eco-system towards Exascale, such as: The development of relationships with other ecosystems including upstream technologies as photonics and electronics, High Performance Embedded Computing (HiPEAC) and Big Data (BDVA) 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 The continuation of BDEC activities, for international participation of European stakeholders on the integration from edge computing to HPC, including Data Analytics and AI The mapping and analysis of related national and international R&I research agendas EXDCI-2 gives particular attention to creating synergies with the CoEs – for example with the CSA FocusCoE – and to building on the outcomes of FET HPC projects.

Olivier Beaumont is involved the task that will work on building a consensus based transversal vision and aims at proposing Ecosystem level concepts. Recommendations implementing the vision will be proposed. The work will benefit from the CoE connection established in the first EXDCI CSA. It is on purpose implemented on the first year of the CSA in order to allow it to be taken into account in the other WP.

9.3. International Initiatives

9.3.1. Inria International Partners

9.3.1.1. Informal International Partners

We continue close collaboration with the LOGIS laboratory (Universidade Federal Fluminense, Niteroi, Brazil) after the end of the Inria Associate Team SAMBA. In 2018, we had two two-weeks visits of Prof. Eduardo Uchoa. Prof. Artur Pessoa spent his sabbatical of 11 months with us.

Orlando Rivera Letelier is pursuing a co-tutelle thesis (with Universidad Adolfo Ibáñez, Peñalolén, Santiago, Chile)

9.4. International Research Visitors

Prof. Artur Pessoa (Universidade Federal Fluminense, Niteroi, Brazil) spent his sabbatical of 11 months with us (February–December 2018).

SELECT Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Sylvain Arlot and Pascal Massart co-organize a working group at ENS (Ulm) on statistical learning.

8.2. National Initiatives

8.2.1. ANR

SELECT is part of the ANR-funded MixStatSeq.

Sylvain Arlot and Matthieu Lerasle are part of the ANR grant FAST-BIG (Efficient Statistical Testing for high-dimensional Models: application to Brain Imaging and Genetics), which is lead by Bertrand Thirion (Inria Saclay, Parietal).

8.3. International Initiatives

Gilles Celeux is one of the co-organizers of the international working group on model-based clustering. This year this workshop took place in Ann Arbor (USA).

8.4. International Research Visitors

8.4.1. Visits to International Teams

8.4.1.1. Research Stays Abroad

Kevin Bleakley stayed at the Pasteur Institute, Cambodia, while working on several collaborations in dengue fever and encephalitis, from February–March 2018.

Jean-Michel Poggi: Universidad de la República (Montevideo, Uruguay), Facultad de Ingeniería, Instituto de Matemática y Estadística “Prof. Ing. Rafael Laguardia”, 17-28 February 2018.

SEQUEL Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR BoB

Participant: Michal Valko.

- *Title*: Bayesian statistics for expensive models and tall data
- *Type*: National Research Agency
- *Coordinator*: CNRS (Rémi Bardenet)
- *Duration*: 2016-2020
- *Abstract*:

  Bayesian methods are a popular class of statistical algorithms for updating scientific beliefs. They turn data into decisions and models, taking into account uncertainty about models and their parameters. This makes Bayesian methods popular among applied scientists such as biologists, physicists, or engineers. However, at the heart of Bayesian analysis lie 1) repeated sweeps over the full dataset considered, and 2) repeated evaluations of the model that describes the observed physical process. The current trends to large-scale data collection and complex models thus raises two main issues. Experiments, observations, and numerical simulations in many areas of science nowadays generate terabytes of data, as does the LHC in particle physics for instance. Simultaneously, knowledge creation is becoming more and more data-driven, which requires new paradigms addressing how data are captured, processed, discovered, exchanged, distributed, and analyzed. For statistical algorithms to scale up, reaching a given performance must require as few iterations and as little access to data as possible. It is not only experimental measurements that are growing at a rapid pace. Cell biologists tend to have scarce data but large-scale models of tens of nonlinear differential equations to describe complex dynamics. In such settings, evaluating the model once requires numerically solving a large system of differential equations, which may take minutes for some tens of differential equations on today's hardware. Iterative statistical processing that requires a million sequential runs of the model is thus out of the question. In this project, we tackle the fundamental cost-accuracy trade-off for Bayesian methods, in order to produce generic inference algorithms that scale favorably with the number of measurements in an experiment and the number of runs of a statistical model. We propose a collection of objectives with different risk-reward trade-offs to tackle these two goals. In particular, for experiments with large numbers of measurements, we further develop existing subsampling-based Monte Carlo methods, while developing a novel decision theory framework that includes data constraints. For expensive models, we build an ambitious programme around Monte Carlo methods that leverage determinantal processes, a rich class of probabilistic tools that lead to accurate inference with limited model evaluations. In short, using innovative techniques such as subsampling-based Monte Carlo and determinantal point processes, we propose in this project to push the boundaries of the applicability of Bayesian inference.

9.1.2. ANR Badass

Participants: Odalric Maillard, Émilie Kaufmann.

- *Title*: BAnDits for non-Stationarity and Structure
- *Type*: National Research Agency
- *Coordinator*: Inria Lille (O. Maillard)
- *Duration*: 2016-2020

- *Abstract*: Motivated by the fact that a number of modern applications of sequential decision making require developing strategies that are especially robust to change in the stationarity of the signal, and in order to anticipate and impact the next generation of applications of the field, the BADASS project intends to push theory and application of MAB to the next level by incorporating non-stationary observations while retaining near optimality against the best not necessarily constant decision strategy. Since a non-stationary process typically decomposes into chunks associated with some possibly hidden variables (states), each corresponding to a stationary process, handling non-stationarity crucially requires exploiting the (possibly hidden) structure of the decision problem. For the same reason, a MAB for which arms can be arbitrary non-stationary processes is powerful enough to capture MDPs and even partially observable MDPs as special cases, and it is thus important to jointly address the issue of non-stationarity together with that of structure. In order to advance these two nested challenges from a solid theoretical standpoint, we intend to focus on the following objectives: *(i)* To broaden the range of optimal strategies for stationary MABs: current strategies are only known to be provably optimal in a limited range of scenarios for which the class of distribution (structure) is perfectly known; also, recent heuristics possibly adaptive to the class need to be further analyzed. *(ii)* To strengthen the literature on pure sequential prediction (focusing on a single arm) for non-stationary signals via the construction of adaptive confidence sets and a novel measure of complexity: traditional approaches consider a worst-case scenario and are thus overly conservative and non-adaptive to simpler signals. *(iii)* To embed the low-rank matrix completion and spectral methods in the context of reinforcement learning, and further study models of structured environments: promising heuristics in the context of e.g. contextual MABs or Predictive State Representations require stronger theoretical guarantees.

  This project will result in the development of a novel generation of strategies to handle non-stationarity and structure that will be evaluated in a number of test beds and validated by a rigorous theoretical analysis. Beyond the significant advancement of the state of the art in MAB and RL theory and the mathematical value of the program, this JCJC BADASS is expected to strategically impact societal and industrial applications, ranging from personalized health-care and e-learning to computational sustainability or rain-adaptive river-bank management to cite a few.

9.1.3. ANR ExTra-Learn

Participants: Jérémie Mary, Michal Valko.

- *Title*: Extraction and Transfer of Knowledge in Reinforcement Learning
- *Type*: National Research Agency (ANR-9011)
- *PI*: M. Valko
- *Duration*: 2014-2018
- *Abstract*: ExTra-Learn is directly motivated by the evidence that one of the key features that allows humans to accomplish complicated tasks is their ability of building knowledge from past experience and transfer it while learning new tasks. We believe that integrating transfer of learning in machine learning algorithms will dramatically improve their learning performance and enable them to solve complex tasks. We identify in the reinforcement learning (RL) framework the most suitable candidate for this integration. RL formalizes the problem of learning an optimal control policy from the experience directly collected from an unknown environment. Nonetheless, practical limitations of current algorithms encouraged research to focus on how to integrate prior knowledge into the learning process. Although this improves the performance of RL algorithms, it dramatically reduces their autonomy. In this project we pursue a paradigm shift from designing RL algorithms incorporating prior knowledge, to methods able to incrementally discover, construct, and transfer "prior" knowledge in a fully automatic way. More in detail, three main elements of RL algorithms would significantly benefit from transfer of knowledge. *(i)* For every new task, RL algorithms need exploring the environment for a long time, and this corresponds to slow learning processes for large environments. Transfer learning would enable RL algorithms to dramatically reduce the exploration

of each new task by exploiting its resemblance with tasks solved in the past. *(ii)* RL algorithms evaluate the quality of a policy by computing its state-value function. Whenever the number of states is too large, approximation is needed. Since approximation may cause instability, designing suitable approximation schemes is particularly critical. While this is currently done by a domain expert, we propose to perform this step automatically by constructing features that incrementally adapt to the tasks encountered over time. This would significantly reduce human supervision and increase the accuracy and stability of RL algorithms across different tasks. *(iii)* In order to deal with complex environments, hierarchical RL solutions have been proposed, where state representations and policies are organized over a hierarchy of subtasks. This requires a careful definition of the hierarchy, which, if not properly constructed, may lead to very poor learning performance. The ambitious goal of transfer learning is to automatically construct a hierarchy of skills, which can be effectively reused over a wide range of similar tasks.

9.1.4. Grant of Fondation Mathématique Jacques Hadamard

Participants: Michal Valko, Matteo Pirotta, Alessandro Lazaric, Ronan Fruit.

- *Title*: Theoretically grounded efficient algorithms for high-dimensional and continuous reinforcement learning
- *Type*: PGMO-IRMO, funded by Criteo
- *PI*: M. Valko
- *Criteo contact*: Marc Abeille
- *Duration*: 2018-2020
- *Abstract*: While learning how to behave optimally in an unknown environment, a reinforcement learning (RL) agent must trade off the exploration needed to collect new information about the dynamics and reward of the environment, and the exploitation of the experience gathered so far to gain as much reward as possible. A good measure of the agent's performance is the regret, which measures the difference between the performance of optimal policy and the actual rewards accumulated by the agent. Two common approaches to the exploration-exploitation dilemma with provably good regret guarantees are the optimism in the face of uncertainty principle and Thompson Sampling. While these approaches have been successfully applied to small environments with a finite number of states and action (tabular scenario), existing approach for large or continuous environments either rely on heuristics and come with no regret guarantees, or can be proved to achieve small regret but cannot be implemented efficiently. In this project, we propose to make a significant contribution in the understanding of large and/or continuous RL problems by developing and analyzing new algorithms that perform well both in theory and practice. This research line can have a practical impact in all the applications requiring continuous interaction with an unknown environment. Recommendation systems belong to this category and, by definition, they can be modeled has a sequence of repeated interaction between a learning agent and a large (possibly continuous) environment.

9.1.5. National Partners

- ENS Paris-Saclay
  - M. Valko collaborated with V. Perchet on structured bandit problem. They co-supervise a PhD student (P. Perrault) together.
- Institut de Mathématiques de Toulouse, then Ecole Normale Supérieure de Lyon
  - E. Kaufmann collaborated with Aurélien Garivier on sequential testing and structured bandit problems.
- Centrale-Supélec Rennes
  - E. Kaufmann co-advises Lilian Besson, who works at CentraleSupélec with Christophe Moy on MAB for cognitive radio and Internet-of-Things communications.

- Participation to the Inria Project Lab (IPL) "HPC – Big Data". Started in 2018, this IPL gathers a dozen Inria team-projects, mixing researchers in HPC with researchers in machine learning and data science. SEQUEL contribution in this project is about how we can take advantage of HPC for our computational needs regarding deep learning and deep reinforcement learning, and also how such learning algorithms might be redesigned or re-implemented in order to take advantage of HPC architectures.

9.2. European Initiatives

9.2.1. FP7 & H2020 Projects

9.2.1.1. H2020 BabyRobot

Program: H2020

Project acronym: BabyRobot

Project title: Child-Robot Communication and Collaboration

Duration: 01/2016 - 12/2018

Coordinator: Alexandros Potamianos (Athena Research and Innovation Center in Information Communication and Knowledge Technologies, Greece)

Other partners: Institute of Communication and Computer Systems (Greece), The University of Hertfordshire Higher Education Corporation (UK), Universitaet Bielefeld (Germany), Kunlgliga Tekniska Hoegskolan (Sweden), Blue Ocean Robotics ApS (Denmark), Univ. Lille (France), Furhat Robotics AB (Sweden)

Abstract: The crowning achievement of human communication is our unique ability to share intentionality, create and execute on joint plans. Using this paradigm we model human-robot communication as a three step process: sharing attention, establishing common ground and forming shared goals. Prerequisites for successful communication are being able to decode the cognitive state of people around us (mind reading) and building trust. Our main goal is to create robots that analyze and track human behavior over time in the context of their surroundings (situational) using audio-visual monitoring in order to establish common ground and mind-reading capabilities. On BabyRobot we focus on the typically developing and autistic spectrum children user population. Children have unique communication skills, are quick and adaptive learners, eager to embrace new robotic technologies. This is especially relevant for special education where the development of social skills is delayed or never fully develops without intervention or therapy. Thus our second goal is to define, implement and evaluate child-robot interaction application scenarios for developing specific socio-affective, communication and collaboration skills in typically developing and autistic spectrum children. We will support not supplant the therapist or educator, working hand-in hand to create a low risk environment for learning and cognitive development. Breakthroughs in core robotic technologies are needed to support this research mainly in the areas of motion planning and control in constrained spaces, gestural kinematics, sensorimotor learning and adaptation. Our third goal is to push beyond the state-of-the-art in core robotic technologies to support natural human-robot interaction and collaboration for edutainment and healthcare applications. Creating robots that can establish communication protocols and form collaboration plans on the fly will have impact beyond the application scenarios investigated here.

9.2.1.2. CHIST-ERA DELTA

Participants: Michal Valko, Émilie Kaufmann.

Program: CHIST-ERA

Project acronym: DELTA

Project title: Dynamically Evolving Long-Term Autonomy

Duration: October 2017 - December 2021

Coordinator: Anders Jonsson (PI)

Inria Coordinator: Michal Valko

Other partners: UPF Spain, MUL Austria, ULG Belgium

Abstract: Many complex autonomous systems (e.g., electrical distribution networks) repeatedly select actions with the aim of achieving a given objective. Reinforcement learning (RL) offers a powerful framework for acquiring adaptive behavior in this setting, associating a scalar reward with each action and learning from experience which action to select to maximise long-term reward. Although RL has produced impressive results recently (e.g., achieving human-level play in Atari games and beating the human world champion in the board game Go), most existing solutions only work under strong assumptions: the environment model is stationary, the objective is fixed, and trials end once the objective is met. The aim of this project is to advance the state of the art of fundamental research in lifelong RL by developing several novel RL algorithms that relax the above assumptions. The new algorithms should be robust to environmental changes, both in terms of the observations that the system can make and the actions that the system can perform. Moreover, the algorithms should be able to operate over long periods of time while achieving different objectives. The proposed algorithms will address three key problems related to lifelong RL: planning, exploration, and task decomposition. Planning is the problem of computing an action selection strategy given a (possibly partial) model of the task at hand. Exploration is the problem of selecting actions with the aim of mapping out the environment rather than achieving a particular objective. Task decomposition is the problem of defining different objectives and assigning a separate action selection strategy to each. The algorithms will be evaluated in two realistic scenarios: active network management for electrical distribution networks, and microgrid management. A test protocol will be developed to evaluate each individual algorithm, as well as their combinations.

9.2.1.3. CHIST-ERA IGLU

Program: CHIST-ERA

Project acronym: IGLU

Project title: Interactively Grounded Language Understanding

Duration: 11/2015 - 10/2018

Coordinator: Jean Rouat (Université de Sherbrooke, Canada)

Other partners: UMONS (Belgique), Inria (France), Univ-Lille (France), KTH (sweden), Universidad de Zaragoza (Spain)

Abstract: 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.

9.3. International Initiatives

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

9.3.1.1. Allocate

Participants: Pierre Perrault, Julien Seznec, Michal Valko, Émilie Kaufmann, Odalric Maillard.

Title: Adaptive allocation of resources for recommender systems

Inria contact: Michal Valko

International Partner (Institution - Laboratory - Researcher):

Otto-von-Guericke-Universität Magdeburg A. Carpentier

Start year: 2017

We plan to improve a practical scenario of *resource allocation in market surveys*, such as product appraisals and music recommendation. In practice, the market is typically divided into segments: geographic regions, age groups, ...These groups are then queried for preference with some fixed rule of a number of queries per group. This testing is *costly and non-adaptive*. The reason is some groups are easier to estimate than others, but this is impossible to know a priori. Our challenge is **adaptively allocate the optimal number of samples** to each group and improve the efficient of market studies, by providing *sample-efficient* solutions. In 2018 we made big advances that resulted in two new research results, currently under review.

9.3.2. Inria International Partners

9.3.2.1. Declared Inria International Partners

SequeL

Title: The multi-armed bandit problem

International Partner (Institution - Laboratory - Researcher):

University of Leoben (Austria) Peter Auer

Duration: 2014 - 2018

Start year: 2014

In a nutshell, the collaboration is focusing on nonparametric algorithms for active learning problems, mainly involving theoretical analysis of reinforcement learning and bandits problems beyond the traditional settings of finite-state MDPs (for RL) or i.i.d. rewards (for bandits). Peter Auer from University of Leoben is a worldwide leader in the field, having introduced the UCB approach around 2000, along with its finite-time analysis. Today, SequeL is likely to be the largest research group working in this field in the world, enjoying worldwide recognition. SequeL and P. Auer's group have been collaborating for a couple of years now; they have co-authored papers, visited each other (sabbatical stay, post-doc), coorganized workshops; the STREP Complacs partially funds this very active collaboration.

9.3.2.2. CWI

We also collaborate with P. Grunwald, and W. Koolen through the associate team headed by Benjamin Guedj from Modal.

9.3.3. Participation in Other International Programs

In 2017, we mentioned many collaborations with: Adobe, MIT, Stanford, Leoben, ...

Massachusetts Institute of Technology

Victor-Emmanuel Brunel *Collaborator*

M. Valko collaborated with V.-E. Brunel on the estimation of low rank determinantal point processes useful for diverse recommender systems.

Otto-von-Guericke-Universität Magdeburg

Alexandra Carpentier *Collaborator*

M. Valko collaborated with A. Carpentier on adaptive estimation of the block-diagonal matrices with application to market segmentations. This collaboration formalized in September 2017 by creating a north-european associate team. which results in two finished results.

Adobe Research

Y. Abbasi-Yadkori *Collaborator*

M. Valko collaborated on learning in unpredictable but potentially easy environment. This led to a publication in COLT 2018.

University of California, Berkeley

Peter Bartlett *Collaborator*

Victor Gabillon *Collaborator*

Alain Malek *Collaborator*

M. Valko collaborated with P.Barlett, V. Gabillon, and A. Malek on the sample complexities in unknown type of environments.

DeepMind London

Rémi Munos *Collaborator*

M. Valko collaborated with R. Munos on Brownian motion maximization, important for stock value predictions. This led to a publication in NIPS 2018.

Mila, Université de Montréal

A. Courville *Collaborator*

A. Touati *Collaborator*

F. Strub and O. Pietquin collaborate on deep reinforcement learning for language acquisition. This led to several papers at IJCAI, CVPR, and NIPS, as well as the Guesswhat?! dataset and protocol, and the HOME dataset.

M. Valko collaborates on faster learning in submodular learning with limited feedback. This setting has application in marketing when we want to select the inventory while maximizing the profit.

McGill University, Montreal

A. Durand, J. Pineau *Collaborator*

A. Durand and OA. Maillard collaborate on a project of structured bandits, with application in physics (calibration).

Northeastearn University, Boston

M. Aziz, J. Anderton, J. Aslam *Collaborator*

E. Kaufmann collaborate with M. Aziz, J. Anderton and J. Aslam on a project on infinite bandits, which led to an ALT 2018 publication. E. Kaufmann also collaborates with M. Aziz on bandits for phase I clinical trials. This led to the submission of a paper to the Biometrics journal.

9.4. International Research Visitors

9.4.1. Visits of International Scientists

- Xiotian Yu, 1 week, the Chinese University of Hong-Kong
- Junpei Komiyama, 6 weeks, Tokyo University
- Abbas Mehrabian, 1 week, McGill University
- Audrey Durand, 2 weeks, McGill University
- Andrea Locatelli, 2 weeks, Otto-von-Guericke-Universität Magdeburg, Germany
- Jill-Jênn Vie, 1 week, RIKEN AIP, Tokyo, Japan
- Peter Grünwald, 2 times two days (8 hour lectures), CWI and Leiden University, Amsterdam, Netherlands
- Wouter Koolen, 1 week, CWI, Amsterdam, Netherlands

9.4.1.1. Internships

- Quentin Burthier, ENSTA ParisTech, from Jun 2018 until Aug 2018
- Edouard Dendauw, from May 2018 until Jul 2018
- Thibault Felicite, Jul 2018
- Robert Lindland, MIT, from May 2018 until Aug 2018
- Jian Qian, ENS, from May 2018 until Oct 2018
- Hassan Saber, Centrale Paris, from Apr 2018 until Aug 2018
- Benoit Schmitt, Centrale Nantes, from Mar 2018 until Aug 2018
- Han Shao, PhD student from the Chinese University in Hong-Kong, from Oct 2018 until Nov 2018
- Annie Yun, MIT, from May 2018 until Aug 2018
- Arnaud Fanthomme, ENS, from Apr 2018 until Aug 2018

9.4.2. Visits to International Teams

9.4.2.1. Other visits

- OA. Maillard: August, Visit of Aufrey Durand at Mc Gill University (2 weeks)
- OA. Maillard: Novembre, Invited visit of Junya Honda at Tokyo University (4 days)
- E. Kaufmann: March, April, Visit of Wouter Koolen at CWI, Amsterdam (2 times 1 week)

SIERRA Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

Alexandre d'Aspremont: IRIS, PSL "Science des données, données de la science".

9.2. European Initiatives

- **ITN Spartan**
  Title: Sparse Representations and Compressed Sensing Training Network
  Type: FP7
  Instrument: Initial Training Network
  Duration: October 2014 to October 2018
  Coordinator: Mark Plumbley (University of Surrey)
  Inria contact: Francis Bach
  Abstract: The SpaRTaN Initial Training Network will train a new generation of interdisciplinary researchers in sparse representations and compressed sensing, contributing to Europe's leading role in scientific innovation. By bringing together leading academic and industry groups with expertise in sparse representations, compressed sensing, machine learning and optimisation, and with an interest in applications such as hyperspectral imaging, audio signal processing and video analytics, this project will create an interdisciplinary, trans-national and inter-sectorial training network to enhance mobility and training of researchers in this area. SpaRTaN is funded under the FP7-PEOPLE-2013-ITN call and is part of the Marie Curie Actions — Initial Training Networks (ITN) funding scheme: Project number - 607290
- **ITN Macsenet**
  Title: Machine Sensing Training Network
  Type: H2020
  Instrument: Initial Training Network
  Duration: January 2015 - January 2019
  Coordinator: Mark Plumbley (University of Surrey)
  Inria contact: Francis Bach
  Abstract: The aim of this Innovative Training Network is to train a new generation of creative, entrepreneurial and innovative early stage researchers (ESRs) in the research area of measurement and estimation of signals using knowledge or data about the underlying structure. We will develop new robust and efficient Machine Sensing theory and algorithms, together methods for a wide range of signals, including: advanced brain imaging; inverse imaging problems; audio and music signals; and non-traditional signals such as signals on graphs. We will apply these methods to real-world problems, through work with non-Academic partners, and disseminate the results of this research to a wide range of academic and non-academic audiences, including through publications, data, software and public engagement events. MacSeNet is funded under the H2020-MSCA-ITN-2014 call and is part of the Marie Sklodowska- Curie Actions — Innovative Training Networks (ITN) funding scheme.

- **ERC Sequoia** Title: Robust algorithms for learning from modern data
  Programm: H2020
  Type: ERC
  Duration: 2017-2022
  Coordinator: Inria
  Inria contact: Francis Bach
  Abstract: Machine learning is needed and used everywhere, from science to industry, with a growing impact on many disciplines. While first successes were due at least in part to simple supervised learning algorithms used primarily as black boxes on medium-scale problems, modern data pose new challenges. Scalability is an important issue of course: with large amounts of data, many current problems far exceed the capabilities of existing algorithms despite sophisticated computing architectures. But beyond this, the core classical model of supervised machine learning, with the usual assumptions of independent and identically distributed data, or well-defined features, outputs and loss functions, has reached its theoretical and practical limits. Given this new setting, existing optimization-based algorithms are not adapted. The main objective of this project is to push the frontiers of supervised machine learning, in terms of (a) scalability to data with massive numbers of observations, features, and tasks, (b) adaptability to modern computing environments, in particular for parallel and distributed processing, (c) provable adaptivity and robustness to problem and hardware specifications, and (d) robustness to non-convexities inherent in machine learning problems. To achieve the expected breakthroughs, we will design a novel generation of learning algorithms amenable to a tight convergence analysis with realistic assumptions and efficient implementations. They will help transition machine learning algorithms towards the same widespread robust use as numerical linear algebra libraries. Outcomes of the research described in this proposal will include algorithms that come with strong convergence guarantees and are well-tested on real-life benchmarks coming from computer vision, bioin- formatics, audio processing and natural language processing. For both distributed and non-distributed settings, we will release open-source software, adapted to widely available computing platforms.

9.3. International Initiatives

9.3.1. BigFOKS2

Title: Learning from Big Data: First-Order methods for Kernels and Submodular functions

International Partner (Institution - Laboratory - Researcher):

IISc Bangalore (India) - Computer Science Department - Chiranjib Bhattacharyya

Start year: 2016

See also: mllab.csa.iisc.ernet.in/indo-french.html

Recent advances in sensor technologies have resulted in large amounts of data being generated in a wide array of scientific disciplines. Deriving models from such large datasets, often known as “Big Data”, is one of the important challenges facing many engineering and scientific disciplines. In this proposal we investigate the problem of learning supervised models from Big Data, which has immediate applications in Computational Biology, Computer vision, Natural language processing, Web, E-commerce, etc., where specific structure is often present and hard to take into account with current algorithms. Our focus will be on the algorithmic aspects. Often supervised learning problems can be cast as convex programs. The goal of this proposal will be to derive first-order methods which can be effective for solving such convex programs arising in the Big-Data setting. Keeping this broad goal in mind we investigate two foundational problems which are not well addressed in existing literature. The first problem investigates Stochastic Gradient Descent Algorithms in the context of First-order methods for designing algorithms for Kernel based prediction functions on Large Datasets. The second problem involves solving discrete optimization problems arising in Submodular formulations in Machine Learning, for which first-order methods have not reached the level of speed required for practical applications (notably in computer vision).

9.4. International Research Visitors

- Vijaya Bollapragada from Northwestern University, Chicago, IL, United States, Apr - Jul 2018.
- Aaron De Fazio from Facebook Research NY, New York, United States, Feb 2018.
- Gauthier Gidel from University of Montreal - MILA, Montreal, Canada, Jan 2018.
- Sharan Vaswani from University of British Columbia, Vancouver, Canada, Apr - Jul 2018
- Simon Lacoste-Julien from University of Montreal - MILA, Montreal, Canada, Aug 2018.

TAU Team

9. Partnerships and Cooperations

9.1. National Initiatives

9.1.1. ANR

- **ACTEUR** 2014-2018 (236kEuros). Cognitive agent development for urban simulations,
  Coordinator: P. Taillandier (IDEES, Univ Rouen)
  Participant: Philippe Caillou
- **EPITOME** 2017-2020 (225kEuros), *Efficient rePresentatIon TO structure large-scale satellite iMagEs* (Section 7.5.2).
  Coordinator: Yuliya Tarabalka (Titane team, Inria Sophia-Antipolis)
  Participant: Guillaume Charpiat

9.1.2. Others

- **E-LUCID** 2014-2018 (194 kEuros), anomaly detection in network packets.
  Coordinator: Thales Communications & Security S.A.S
  Participants: Marc Schoenauer, Cyril Furtlehner, Luis Marti (until 12/2017)
- **Nutriperso** 2017-2020, 87 kEuros. Personalized recommendations toward healthier eating practices (Section 7.3.2).
  U. Paris-Saclay IRS (*Initiative de Recherche Stratégique*)
  Partners: INRA (coordinator), INSERM, Agro Paristech, Mines Telecom
  Participants: Philippe Caillou, Flora Jay, Michèle Sebag, Paola Tubaro
- **PIA Adamme** 2015-2018 (258 kEuros) Machine Learning on a mass-memory architecture.
  Coordinator: Bruno Farcy (Bull SAS)
  Participants: Marc Schoenauer, Guillaume Charpiat, Cécile Germain-Renaud, Yasmina Bouzbiba, Etienne Brame
- **NEXT** 2017-2021 (675 kEuros). Simulation, calibration, and optimization of regional or urban power grids (Section 4.2).
  ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie)
  Coordinator: ARTELYS
  Participants Isabelle Guyon, Marc Schoenauer, Michèle Sebag, Victor Berger (PhD), Herilalaina Rakotoarison (PhD), Berna Bakir Batu (Post-doc)
- **DATAIA Vadore** 2018-2020 (105 kEuros) VAlorizations of Data to imprOve matching in the laboR markEt, with CREST (ENSAE) and Pôle Emploi (Section 7.3.1).
  Coordinator: Michèle Sebag
  Participants: Philippe Caillou, Isabelle Guyon
- **PIA JobAgile** 2018-2021 (379 kEuros) *Evidence-based Recommandation pour l'Emploi et la Formation* (Section 7.3.1).
  Coordinator: Michèle Sebag and Stéphanie Delestre (Qapa)
  Participants: Philippe Caillou, Isabelle Guyon
- **HADACA** 2018-2019 (50 kEuros), within EIT Health, for the organization of challenges toward personalized medicine (Section 7.6).
  Coordinator: Magali Richard (Inria Grenoble)
  Participants: Isabelle Guyon

- **IPL HPC-BigData** 2018-2022 (100 kEuros) High Performance Computing and Big Data (Section 7.5.5)
  Coordinator: Bruno Raffin (Inria Grenoble)
  Participants: Guillaume Charpiat, Loris Felardos (PhD)

9.2. European Initiatives

9.2.1. Collaborations with Major European Organizations

MLSpaceWeather 2015-2019. Coupling physics-based simulations with Artificial Intelligence (Section 7.5.3).
Coordinator: CWI
Participants: Aurélien Decelle, Cyril Furtlehner, Michèle Sebag

9.3. International Initiatives

9.3.1. Inria International Labs

IIL CWI-Inria
Associate Team involved in the International Lab:

9.3.1.1. MDG-TAO

Title: Data-driven simulations for Space Weather predictions

International Partner (Institution - Laboratory - Researcher):

CWI (Netherlands) - Multiscale Dynamics Group - Enrico Camporeale

Start year: 2017

See also: http://pages.saclay.inria.fr/cyril.furtlehner/html/mdg-tao.html and Section 7.5.3 .

We propose an innovative approach to Space Weather modeling: the synergetic use of state-of-the-art simulations with Machine Learning and Data Assimilation techniques, in order to adjust for errors due to non-modeled physical processes, and parameter uncertainties. We envision a truly multidisciplinary collaboration between experts in Computational Science and Data assimilation techniques on one side (CWI), and experts in Machine Learning and Data Mining on the other (Inria). Our research objective is to realistically tackle long-term Space Weather forecasting, which would represent a giant leap in the field. This proposal is extremely timely, since the huge amount of (freely available) space missions data has not yet been systematically exploited in the current computational methods for Space Weather. Thus, we believe that this work will result in cutting-edge results and will open further research topics in space Weather and Computational Plasma Physics.

9.3.2. Inria International Partners

9.3.2.1. Declared Inria International Partners

Isabelle Guyon partner of Google Zurich *Preparation of a competition AutoDL: Automatic Deep Learning*. See Section 7.6 .

9.3.2.2. Informal International Partners

Marc Schoenauer partner of the ARC-DP (Australian Research Council Discovery Project) *Bio-inspired computing methods for dynamically changing environments*. Coordinator: University of Adelaide (Frank Neumann), 5 years from Nov. 2015, 400 k$-AUS. Visit to Adelaide: 2 weeks in Feb. 2017, 2 weeks planned in 2019.

Isabelle Guyon Partner of UC Berkeley *Fingerprint verification with deep siamese neural networks using ultratonic sensor data.* Co-advisor of a master student (Baiyu Chen). Partners: Alyosha Efros, Bernhard Boser.

Guillaume Charpiat partner of Boulder University *Hurricane trajectory prediction*. Co-advisor of a master student (Mo Yang). Partners: Sophie Giffard-Roisin, Claire Monteleoni. See Section 7.5.6 .

CQFD Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. 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.

8.1.2. 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.

8.1.3. 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.

8.2. 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. Inria International Partners

8.3.1.1. 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 2018.

Tomas Prieto-Rumeau (Department of Statistics and Operations Research, UNED, Madrid, Spain) visited the team during 2 weeks in 2018. The main subject of the collaboration is the approximation of Markov Decision Processes.

MATHRISK Project-Team

9. Partnerships and Cooperations

9.1. National Initiatives

- ANR Cosmos 2015-2018, Participant: B. Jourdain ; Partners : Ecole des Ponts, Telecom, Inria Rennes and IBPC
- Labex Bezout
  http://bezout.univ-paris-est.fr

9.1.1. Competitivity Clusters

Pôle Finance Innovation

9.2. International Initiatives

9.2.1. Informal International Partners

- Center of Excellence program in Mathematics and Life Sciences at the Department of Mathematics, University of Oslo, Norway, (B. Øksendal).
- Kings College, London (R. Dumitrescu)
- Department of Mathematics, University of Manchester (Tusheng Zhang, currently in charge of an EU-ITN program on BSDEs and Applications).
- Kensas University (Yaozhong Hu)
- Cornell University, ORIE department (Andreea Minca)
- Mannheim University (Alexander Schied, Chair of Mathematics in Business and Economics, Department of Mathematics)
- Roma Tor Vergata University (Lucia Caramellino)
- Ritsumeikan University (A. Kohatsu-Higa).

9.3. International Research Visitors

9.3.1. Visits of International Scientists

- Oleg Kudryavtsev, Rostov University (Russia)
- B. Stemper (Weierstrass Institute Berlin)
- A. Kohatsu Higa (Ritsumeikan University)

9.3.2. Internships

Oussama Bellalah, Inria, May-August

SIMSMART Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Inter-Labex SEACS: V. Monbet, F. Le Gland, C. Herzet and Thi Tuyet Trang Chau (PhD student) are part of the *inter Labex Cominlabs-Lebesgue-Mer SEACS, https://seacs.cominlabs.u-bretagneloire.fr/*, which stands for Stochastic modEl-dAta-Coupled representationS for the analysis, simulation and reconstruction of upper ocean dynamics. This project which concerns mainly Objectives 2 and 3, aims at exploring novel statistical and stochastic methods to address the emulation, reconstruction and forecast of fine-scale upper ocean dynamics.maths-computer-sea science for ocean dynamics.

CMEMS 3DA (2018-2019): C. Herzet is part of the project *CMEMS 3DA* on data assimilation of oceanographic events with non-parametric data assimilation methods. The goal of the project is to demonstrate the relevance of data-driven strategies to improve satellite derived interpolated products and especially the geostrophic surface currents. The project is made in collaboration with IMT Atlantique Brest, Ifremer and the Institue of Geosciences and Environment in Grenoble.

Action Exploratoire – Labex Cominlabs: C. Herzet is part of a project on sparse representations in continuous dictionaries. Partners: R. Gribonval (Inria Rennes PANAMA), A. Drémeau (IMT Atlantique) and P. Tandeo (IMT Atlantique).

8.2. National Initiatives

8.2.1. ANR

ANR COSMOS (2014-2018): F. Cérou and A. Guyader are part of *ANR Cosmos* on molecular simulation and statistics (PI G. Stoltz of MATHERIALS). COSMOS aims at developing numerical techniques dedicated to the sampling of high-dimensional probability measures describing a system of interest. There are two application fields of interest: computational statistical physics (a field also known as molecular simulation), and computational statistics, both sharing a common history and mathematical tools. Our specific role in the project is to study the theoretical aspects of the simulation of reactive trajectories (short trajectories linking two metastable states of the system), which can be viewed as a special type of rare event. These algorithms are then incorporated in molecular simulation softwares by members of MATHERIALS team. They also contribute to popularize them within the wider computational statistical physics community.

ANR Geronimo (2014-2018): C. Herzet (PI) and P. Héas are part of the ANR Geronimo. Its objective is the conception of new techniques for the construction of geophysical reduced-order models (ROMs) from image data. The project both arises from the crucial need of accurate low-order descriptions of highly-complex geophysical phenomena and the recent numerical revolution which has supplied the geophysical scientists with an unprecedented volume of image data. As the output of the project, we devised several methodologies to build effective reduced-order models from data. The research objectives of Objective 4 are in the continuation of the Geronimo project. In particular, we intend to tackle model-order reduction in a probabilistic setup and provide new tools to address the non-linear case.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

ERC MsMaths (2015-2019): M. Rousset is part of *ERC MSMaths* on molecular simulation (PI T. Lelièvre). With the development of large-scale computing facilities, simulations of materials at the molecular scale are now performed on a daily basis. The objective of the MSMath ERC project is to develop and study efficient algorithms to simulate such high-dimensional systems over very long, macroscopic times. ERC MsMaths especially focus on the computational issues related to 'metastable' states, that is to say specific molecular configurations that do evolve only on very large time scales. This results in a multi-timescale computational bottleneck that needs to be addressed by specific algorithms.

8.3.2. Collaborations with Major European Organizations

The agency European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) of Darmstadt. The transfer focuses on the estimation of atmospheric 3D winds from the future hyperspectral instrument (IRS on MTG-S, developed by ESA and IASI-NG on Metop-SG developed by CNES). The work consists in the design of an efficient and physically-based methodology for the estimation of vertically resolved 3D atmospheric motion vector (AMV) fields at various altitude levels. The estimation is based on image sequence observations, depicting temperature, specific humidity or ozone fields at different pressure levels. The final objective is the operational production of 3D AMV fields, which should be used by the different international institutes of meteorology, such as *Meteo France* or the *Met Office*. It is expected that these image-based wind estimates will significantly impact data-assimilation for weather forecasts or climate studies. We mention that the problem of 3D AMVs estimation has several specificities which makes it particularly challenging (high-dimensionality, non-convex and non-differentiable problem). We are working on an overall algorithmic solution to address this problem. Type of collaboration: supervision of an engineer with one or two week-long visits per year. A first prototype (free software licence LGPL 2.1) is currently under evaluation.

8.4. International Initiatives

8.4.1. Participation in Other International Programs

ECOS ARGENTINE (2018-2021): V. Monbet has obtained a funding program through the ECOS Sud - MINCyT intiative (http://www.univ-paris13.fr/cofecub-ecos/). The program involves a collaboration with the French-Argentinian Climate Institute (http://www.cima.fcen.uba.ar/UMI/), and focuses on non-parametric, analog methods, combined with data assimilation techniques to reconstruct complex meteorological dynamics (Objective 3).

TOSCA Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

- A. Lejay is a member of the Executive board of LUE Impact digistrust on citizens' trust in the digital world (grant of the i-site, U. Lorraine), since 2018.

7.2. National Initiatives

7.2.1. ANR

N. Champagnat is member of the ANR NONLOCAL (Phénomènes de propagation et équations non locales, 2014–2018) coordinated by F. Hamel (Univ. Aix-Marseille).

7.2.2. GDR

A. Lejay is leader of the GdR Project TRAG on rough path. This project has been accepted in October and should start on January 1st, 2019.

7.2.3. ITMO project

N. Champagnat, C. Fritsch and D. Villemonais are involved in an ITMO Cancer project (INSERM funding) on "Modeling ctDNA dynamics for detecting targeted therapy resistance" (2017-2020), involving researchers from IECL (Institut Elie Cartan de Lorraine), the Inria teams BIGS and TOSCA, ICL (Institut de Cancérologie de Lorraine), CRAN (Centre de Recherche en Automatique de Nancy) and CHRU Strasbourg (Centre Hospitalier Régional Universitaire). This project is coordinated by N. Champagnat.

7.2.4. PEPS

D. Villemonais has obtained a "PEPS jeune chercheur" grant.

7.3. European Initiatives

7.3.1. FP7 & H2020 Projects

- Mireille Bossy is involved in the VIMMP H2020 project, started in January 2018, as responsible for the partner Inria. VIMMP is a four years development for a software platform and simulation market place on the topic of complex multiscale CFD simulations.

7.4. International Initiatives

7.4.1. Participation in Other International Programs

7.4.1.1. International Initiatives

Discrelongmem (C15E05)

Title: On discretization procedures in Non-Gaussian long memory processes with applications in non parametric statistics and time series analysis (C15E05)

International Partner (Institution - Laboratory - Researcher):

Universidad de Valparaiso (Chile) - CIMFAV – Facultad de Ingenieria

PI: E. Tanré (France), S. Torrès (Chile)

Duration: 2016 - 2018

Start year: 2016

Keywords: Approximations of non-Gaussian long-memory processes. Fractional Poisson processes (fPp). Skew Fractional Process (SfP).

BRN

Title: Biostochastic Research Network

International Partner (Institution - Laboratory - Researcher):

Universidad de Valparaiso (Chile) - CIMFAV – Facultad de Ingenieria - Soledad Torres, Rolando Rebolledo

CNRS, Inria & IECL - Institut Élie Cartan de Lorraine (France) - N. Champagnat, A. Lejay, D. Villemonnais, R. Schott.

Duration: 2018 - 2022

Start year: 2018

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- A. Kohatsu-Higa (Ritsumeikan University, Japan) - 1 month, with an invited professor position.

7.5.1.1. Internships

- Walid El Wahabi

  subject: processus de fragmentation pour les avalanches

  date: sept. 2018 - june. 2019

  institution: École des Mines de Nancy

- Vincent Hass

  Subject: Modèles de diffusion et estimation des dynamiques d'ADN tumoral circulant pour la détection d'une résistance à une thérapie ciblée

  Date: April 2018 - Sept. 2018

  Institution: Université Paris Sud

- Azer Mimouni

  subject: Méthodes de signature en apprentissage statistique

  date: sept. 2018 - june. 2019

  institution: École des Mines de Nancy

7.5.1.2. Sabbatical programme

D. Villemonais has obtained a *délégation CNRS* starting in September.