



RESEARCH CENTER  
Bordeaux - Sud-Ouest

FIELD

Activity Report 2015

# Section Partnerships and Cooperations

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## **LFANT Project-Team**

# **7. Partnerships and Cooperations**

## **7.1. National Initiatives**

### **7.1.1. ANR Peace – Parameter spaces for Efficient Arithmetic and Curve security Evaluation**

**Participants:** Bill Allombert, Karim Belabas, Jean-Marc Couveignes, Andreas Enge, Hamish Ivey-Law, Enea Milio, Damien Robert.

<http://chic2.gforge.inria.fr/>

The PEACE project is joint between the research teams of Institut de Recherche en Mathématiques de Rennes (IRMAR), LFANT and Institut Mathématiques de Luminy (IML).

The project aims at constituting a comprehensive and coherent approach towards a better understanding of theoretical and algorithmic aspects of the discrete logarithm problem on algebraic curves of small genus. On the theoretical side, this includes an effective description of moduli spaces of curves and of abelian varieties, the maps that link these spaces and the objects they classify. The effective manipulation of moduli objects will allow us to develop a better understanding of the algorithmic difficulty of the discrete logarithm problem on curves, which may have dramatic consequences on the security and efficiency of already deployed cryptographic devices.

One of the anticipated outcomes of this proposal is a new set of general criteria for selecting and validating cryptographically secure curves (or families of curves) suitable for use in cryptography. Instead of publishing fixed curves, as is done in most standards, we aim at proposing generating rationales along with explicit theoretical and algorithmic criteria for their validation.

The ANR organised the conference “Effective moduli spaces and applications to cryptography” in June 2014 as a part of the Centre Henri Lebesgue’s Thematic Semester 2014 “Around moduli spaces”.

### **7.1.2. ANR Simpatric – SIM and PAiring Theory for Information and Communications security**

**Participants:** Guilhem Castagnos, Damien Robert, Sorina Ionica, Cyril Bouvier.

The SIMPATRIC project is an industrial research project, formed by academic research teams and industrial partners: Orange Labs, École Normale Supérieure, INVIA, Oberthur Technologies, ST-Ericsson France, Université de Bordeaux 1, Université de Caen Basse-Normandie, Université de Paris 8.

The aim of the SIMPATRIC project is to provide the most efficient and secure hardware/software implementation of a bilinear pairing in a SIM card. This implementation will then be used to improve and develop new cryptographic algorithms and protocols in the context of mobile phones and SIM cards. The project will more precisely focus on e-ticketing and e-cash, on cloud storage and on the security of contactless and of remote payment systems.

D. Robert is a participant in the Task 2 whose role is to give state of the art algorithms for pairing computations, adapted to the specific hardware requirements of the Simpatric Project.

G. Castagnos is a participant in the Task 4 whose role is to design new cryptographic primitives adapted to the specific applications of the Simpatric Project.

## 7.2. European Initiatives

### 7.2.1. FP7 & H2020 Projects

#### 7.2.1.1. ANTICS

Title: Algorithmic Number Theory in Computer Science

Programm: FP7

Duration: January 2012 - December 2016

Coordinator: Inria

Inria contact: Andreas Enge

'During the past twenty years, we have witnessed profound technological changes, summarised under the terms of digital revolution or entering the information age. It is evident that these technological changes will have a deep societal impact, and questions of privacy and security are primordial to ensure the survival of a free and open society. Cryptology is a main building block of any security solution, and at the heart of projects such as electronic identity and health cards, access control, digital content distribution or electronic voting, to mention only a few important applications. During the past decades, public-key cryptology has established itself as a research topic in computer science; tools of theoretical computer science are employed to "prove" the security of cryptographic primitives such as encryption or digital signatures and of more complex protocols. It is often forgotten, however, that all practically relevant public-key cryptosystems are rooted in pure mathematics, in particular, number theory and arithmetic geometry. In fact, the so-called security "proofs" are all conditional to the algorithmic untractability of certain number theoretic problems, such as factorisation of large integers or discrete logarithms in algebraic curves. Unfortunately, there is a large cultural gap between computer scientists using a black-box security reduction to a supposedly hard problem in algorithmic number theory and number theorists, who are often interested in solving small and easy instances of the same problem. The theoretical grounds on which current algorithmic number theory operates are actually rather shaky, and cryptologists are generally unaware of this fact. The central goal of ANTICS is to rebuild algorithmic number theory on the firm grounds of theoretical computer science.'

#### 7.2.1.2. Open Dream Kit

Title: Algorithmic Number Theory in Computer Science

Programm: FP7

Duration: September 2015 - August 2019

Inria contact: Karim Belabas

OpenDreamKit is a Horizon 2020 European Research Infrastructure project (#676541, call e-infrastructures for virtual research environments) that will run for four years, starting from September 2015. It will provide substantial funding to the open source computational mathematics ecosystem, and in particular popular tools such as LinBox, MPIR, SageMath, GAP, Pari/GP, LMFDB, Singular, MathHub, and the IPython/Jupyter interactive computing environment.

From this ecosystem, OpenDreamKit will deliver a flexible toolkit enabling research groups to set up Virtual Research Environments, customised to meet the varied needs of research projects in pure mathematics and applications, and supporting the full research life-cycle from exploration, through proof and publication, to archival and sharing of data and code.

The project involves about 50 people spread over 15 sites in Europe, with a total budget of about 7.6 million euros. The largest portion of that will be devoted to employing an average of 11 researchers and developers working full time on the project. Additionally, the participants will contribute the equivalent of six other people working full time.

Countries involved include France (Universités Paris-Sud, Versailles, Bordeaux, Grenoble and the industrial partner Logilab), Germany (Kaiserslautern, Bremen), United Kingdom (Oxford, Southampton, Sheffield, St Andrews, Warwick), Norway (Simula), Poland (University Silesia), Switzerland (University Zürich).

## 7.3. International Initiatives

### 7.3.1. Inria International Labs

The *MACISA* project-team (Mathematics Applied to Cryptology and Information Security in Africa) is one of the new teams of LIRIMA. Researchers from Inria and the universities of Bamenda, Bordeaux, Dakar, Franceville, Maroua, Ngaoundéré, Rennes, Yaoundé cooperate in this team.

The project is concerned with public key cryptology and more specifically the role played by algebraic maps in this context. The team focus on two themes:

- Theme 1: Rings, primality, factoring and discrete logarithms;
- Theme 2: Elliptic and hyperelliptic curve cryptography.

The project is managed by a team of five permanent researchers: G. Nkiet, J.-M. Couveignes, T. Ezome, D. Robert and A. Enge. Since Sep. 2014 the coordinator is T. Ezome and the vice-coordinator is D. Robert. The managing team organises the cooperation, schedules meetings, prepares reports, controls expenses, reports to the LIRIMA managing team and administrative staff.

A non-exhaustive list of activities organised or sponsored by Macisa includes

- The Summer school (EMA) in Libreville with the International Center for Pure and Applied Mathematics (ICPAM/CIMPA), March 2015, attended by most of the members of Macisa;
- The visit of Abdoul Aziz Ciss (Dakar) and Emmanuel Fouotsa (Bamenda) to Bordeaux, September 2015, for the Elliptic Curve Cryptography and Summer School conference;
- The visit of Tony Ezome to Bordeaux, October 2015;
- The visit of Damien Robert to Yaoundé, Cameroun, to give courses on cryptography for a special seminar on security event.

### 7.3.2. Inria International Partners

#### 7.3.2.1. Informal International Partners

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

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

## 7.4. International Research Visitors

### 7.4.1. Visits of International Scientists

Researchers visiting the team to give a talk to the team seminar include David Kohel (Université d'Aix-Marseille), Tony Ezome (Université des Sciences et Techniques de Masuku, Franceville), Abdoul Aziz Ciss (Ecole Polytechnique de Thiès, Sénégal), Emmanuel Fouotsa (École Normale Supérieure de l'Université de Bamenda), Renate Scheidler (University Calgary), Eduardo Friedman (Universidad de Chile), Benjamin Smith (Inria & LIX, École Polytechnique), Bernadette Perrin-Riou (Paris-Sud).

The visit of Ciss, Ezome and Fouotsa were also part of the collaboration through the Macisa team.

## POSET Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. SCRIME

The **Studio de Création et de Recherche en Informatique et Musiques Expérimentales (SCRIME)** located on Bordeaux University Campus, is a *Groupement d'Intérêt Scientifique et Artistique (GIS&A)* gathering Université de Bordeaux, CNRS, Bordeaux INP, Ministère de la Culture et de la Communication, Ville de Bordeaux and Région Aquitaine. It is a privileged partner of the PoSET project. Most PoSET artistic projects are organized in cooperation with the SCRIME.

### 9.1.2. Idex Bordeaux

- 4 *Arts & Science* projects of Bordeaux eventually granted in 2015 by the Initiative of Excellence (Idex) of Bordeaux,

## 9.2. National Initiatives

### 9.2.1. ANR

- ANR **INEDIT**, *Interactivité dans l'écriture De l'Interaction et du Temps*, coordinated by Ircam (Paris), 3 years, from 2012 to 2015, together with GRAME (Lyon); this project aimed at developing and integrating the existing formalisms to represent and perform interactive pieces of art,
- ANR **OSSIA**, *Open Scenario System for Interactive Application*, coordinated by GMEA (Albi), 3 years, from 2012 to 2015, together with Blue Yeti (Royan), ENJMIN (Poitiers), RSF (Toulouse); this project aimed at offering software services, especially within the Jamoma platform, to design, implement and perform open, non-linear and multi-user scenarios.

## 9.3. International Initiatives

### 9.3.1. Inria International Partners

PoSET members have regular though often informal collaboration with various international teams including:

- Camillo Rueda, Universidad Javeriana, Cali, Colombia,
- Paul Hudak, University of Yale, New-Haven, USA,
- Gregory M. Kobele, University of Chicago, USA,
- Makoto Kanazawa, National Institute of Informatics, Tokyo, Japan.

## 9.4. International Research Visitors

### 9.4.1. Visits of International Scientists

- Shlomo Dubnov, UCSD (USA), visiting Scholar from November 2015 until June 2016,
- Eduardo Miranda, University of Plymouth, UK, invited professor from May the 15th until June the 15th.

### 9.4.2. Visits to International Teams

- D. Janin visiting Stuart Margolis, Bar Illan (Israël), April 2015,

## **CAGIRE Team**

# **9. Partnerships and Cooperations**

## **9.1. Regional Initiatives**

### **9.1.1. Predicting pressure losses in aeronautical fuel injectors**

This is a 3-year programme, funded by Conseil Régional d'Aquitaine (call 2014) and two small-size companies, AD Industrie (Gurmençon, France) and GDTECH ( Bordes, France). A one-year post-doc [YM] started in May 2015. The objective is to investigate the possibility of using advanced RANS or hybrid RANS-LES approaches to better predict the pressure losses in aeronautical fuel nozzles.

## **9.2. National Initiatives**

### **9.2.1. GIS Success**

We are members of the CNRS GIS Success (Groupement d'Intérêt Scientifique) organised around the two major codes employed by the Safran group, namely AVBP and Yales 2. Apart our participation in the annual meeting of the GIS technical committee, no specific technical activity has been devoted around those codes during 2015.

## **9.3. European Initiatives**

### **9.3.1. FP7 & H2020 Projects**

**Participants:** Vincent Perrier [responsible of the team contribution], Pascal Bruel [substitute], Simon Delmas [PhD].

Program: Propulsion

Project acronym: IMPACT-AE

Project title: Intelligent Design Methodologies for Low Pollutant Combustors for Aero-Engines

Duration: 01/11/2011 - 31/05/2016

Coordinator: Roll Royce Deutschland

Other partners:

- France: Insa of Rouen, ONERA, Snecma, Turbomeca.
- Germany: Rolls-Royce Deutschland, MTU Aero Engine GmbH, DLR, Technology Institute of Karlsruhe, University of Bundeswehr (Munich)
- Italy: AVIOPROP SRL, AVIO S.P.A., University of Florence
- United Kingdom: Rolls Royce PLC, Cambridge University, Imperial College of Science, Technology and Medicine, Loughborough University.

**Abstract:** The environmental benefits of low emission lean burn technology in reducing NOx emissions up to 80% will only be effective when these are deployed to a large range of new aero-engine applications. While integrating methodologies for advanced engine architectures and thermodynamic cycles. It will support European engine manufacturers to pick up and keep pace with the US competitors, being already able to exploit their new low emission combustion technology to various engine applications with short turn-around times. Key element of the project will be the development and validation of design methods for low emission combustors to reduce NOx and CO emissions by an optimization of the combustor aero-design process. Preliminary combustor design tools will be coupled with advanced parametrisation and automation tools. Improved heat transfer and NOx models will increase the accuracy of the numerical prediction. The contribution of our team is to create with AeroSol a direct numerical simulations (DNS) database relevant to the configuration of film cooling for subsequent improvement of RANS based simulations of isothermal and non isothermal wall flows with discrete mass transfer.



## 9.4. International Initiatives

- April-June 2015: A. Javadi (PhD student) from Chalmers University, Gothenburg, Sweden (3 months).

### 9.4.1. Informal International Partners

- Collaboration [PB, VP, YM] with E. Dick (University of Ghent, Belgium) on the development of schemes for the simulation of unsteady low Mach number flows.
- Collaboration [PB] with A. Allouhi, A. Jamil, Y. Mourad (Ecole Supérieure de Technologie of Fès, Morocco) related to solar driven cooling systems.
- Collaboration [PB] with A. Beketaeva and A. Naïmanova (Institute of Mathematics, Almaty, Kazakhstan) related to the simulation of supersonic flows.
- Collaboration [RM] with H. Nilsson and A. Javadi (University of Chalmers, Gothenburg, Sweden) on the development of RANS and hybrid RANS/LES for the turbomachinery computations.
- Collaboration [RM] with E. Juntasaro (King Mongkut's TU, Bangkok, Thailand) about the modeling of bypass transition.
- Collaboration [RM] with Tran Thanh Tinh and Anh Thi NGuyen (TU Ho Chi Minh City, Viet Nam) on temporal hybrid RANS/LES.

## 9.5. International Research Visitors

### 9.5.1. Visits of International Scientists

- April-June 2015: A. Javadi (PhD student) from Chalmers University, Gothenburg, Sweden (3 months).
- November 2015: Prof. Erik Dick from Ghent University (Belgium) (4 days).
- November 2015: Dr. A. Naïmanova from the Institute of Mathematics (Ministry of Education), Almaty, Kazakhstan (4 weeks).
- November-December 2015: N. Shakhan (PhD student) from Al Farabi University, Almaty, Kazakhstan (7 weeks).

## CARDAMOM Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

Title: TIDES: Robust simulation tools for non-hydrostatic free surface flows

Type: Apple à Projets Recherche du Conseil de la Région Aquitaine

Coordinator: M. Ricchiuto

Other partners: UMR EPOC (P. Bonneton)

Abstract: This project proposes to combine modern high order adaptive finite elements techniques with state of the art nonlinear and non-hydrostatic models for free surface waves to provide an accurate tool for the simulation of near shore hydrodynamics, with application to the study and prediction of tidal bores. The Garonne river will be used as a case study. This project co-funds (50%) the PhD of A. Filippini.

## 9.2. National Initiatives

### 9.2.1. ANR MAIDESC

Title: Maillages adaptatifs pour les interfaces instationnaires avec deformations, etirements, courbures.

Type: ANR

Duration: 48 months

Starting date : 1st Oct 2013

Coordinator: Dervieux Alain (Inria Sophia)

Abstract: Mesh adaptive numerical methods allow computations which are otherwise impossible due to the computational resources required. We address in the proposed research several well identified main obstacles in order to maintain a high-order convergence for unsteady Computational Mechanics involving moving interfaces separating and coupling continuous media. A priori and a posteriori error analysis of Partial Differential Equations on static and moving meshes will be developed from interpolation error, goal-oriented error, and norm-oriented error. From the minimization of the chosen error, an optimal unsteady metric is defined. The optimal metric is then converted into a sequence of anisotropic unstructured adapted meshes by means of mesh regeneration, deformation, high stretching, and curvature. A particular effort will be devoted to build an accurate representation of physical phenomena involving curved boundaries and interfaces. In association with curved boundaries, a part of studies will address third-order accurate mesh adaptation. Mesh optimality produces a nonlinear system coupling the physical fields (velocities, etc.) and the geometrical ones (unsteady metric, including mesh motion). Parallel solution algorithms for the implicit coupling of these different fields will be developed. Addressing efficiently these issues is a compulsory condition for the simulation of a number of challenging physical phenomena related to industrial unsolved or insufficiently solved problems. Non-trivial benchmark tests will be shared by consortium partners and by external attendees to workshops organized by the consortium. The various advances will be used by SME partners and proposed in software market.

### 9.2.2. PIA TANDEM

Title: Tsunamis in the Atlantic and the English Channel: Definition of the Effects through numerical Modeling (TANDEM)

Type: PIA - RSNR (Investissement d'Avenir, "Recherches en matière de Sûreté Nucléaire et Radioprotection")

Duration: 48 months

Starting date : 1st Jan 2014

Coordinator: H. Hebert (CEA)

Abstract: TANDEM is a project dedicated to the appraisal of coastal effects due to tsunami waves on the French coastlines, with a special focus on the Atlantic and Channel coastlines, where French civil nuclear facilities have been operated since about 30 years. As identified in the call RSNR, this project aims at drawing conclusions from the 2011 catastrophic tsunami, in the sense that it will allow, together with a Japanese research partner, to design, adapt and check numerical methods of tsunami hazard assessment, against the outstanding observation database of the 2011 tsunami. Then these validated methods will be applied to define, as accurately as possible, the tsunami hazard for the French Atlantic and Channel coastlines, in order to provide guidance for risk assessment on the nuclear facilities.

### **9.2.3. FUI Rodin**

Title: Robust structural Optimization for Design in Industry (Rodin)

Type: FUI

Duration: July 2012 - July 2015

Coordinator: ALBERTELLI Marc (Renault)

Abstract: From the research point of view, the RODIN project will focus on: (1) extending level set methods to nonlinear mechanical or multiphysics models and to complex geometrical constraints, (2) developing algorithms for moving meshes with a possible change of topology, (3) adapting in a level-set framework second-order optimization algorithms having the ability of handling a large number of design variables and constraints.

The project will last 3 years and will be supported by a consortium of 7 partners: (1) 2 significant end-users, Renault and EADS, who will provide use-cases reflecting industrial complexity; (2) 3 academics partners, CMAP, J.-L. Lions laboratory and Inria of Bordeaux, who will bring expertise in applied mathematics, structural optimization and mesh deformation; (3) A software editor, ESI Group, who will provide mechanical software package and will pave the way of an industrialization; (4) A SME, Eurodecision, specialized in large-scale optimization.

### **9.2.4. APP Bordeaux 1**

Title : Reactive fluid flows with interface : macroscopic models and application to self-healing materials

Type : Project Bordeaux 1

Duration : 36 months

Starting : September 2014

Coordinator : M. Colin

Abstract : Because of their high strength and low weight, ceramic-matrix composite materials (CMCs) are the focus of active research, for aerospace and energy applications involving high temperatures. Though based on brittle ceramic components, these composites are not brittle due to the use of a fiber/matrix interphase that manages to preserve the fibers from cracks appearing in the matrix. The lifetime-determining part of the material is the fibers, which are sensitive to oxidation; when the composite is in use, it contains cracks that provide a path for oxidization. The obtained lifetimes can be of the order of hundreds of thousands of hours. These time spans make most experimental investigations impractical. In this direction, the aim of this project is to furnish predictions based on computer models that have to take into account: 1) the multidimensional topology of the composite made up of a woven ceramic fabric; 2) the complex chemistry taking place in the material cracks; 3) the flow of the healing oxide in the material cracks.

### 9.3. European Initiatives

#### 9.3.1. FP7 & H2020 Projects

##### 9.3.1.1. STORM

Type: COOPERATION

Defi: NC

Instrument: Specific Targeted Research Project

Objectif: NC

Duration: October 2013 - September 2016

Coordinator: SNECMA (France)

Partner: SNECMA SA (FR), AEROTEX UK LLP (UK), AIRBUS OPERATIONS SL (ES), Airbus Operations Limites (UK), AIRCELLE SA (FR), ARTTIC (FR), CENTRO ITALIANO RICERCHE AEROSPAZIALI SCPA (IT), CRANFIELD UNIVERSITY (UK), DEUTSCHES ZENTRUM FUER LUFT - UND RAUMFAHRT EV (DE), EADS DEUTSCHLAND GMBH (DE), ONERA (FR), TECHSPACE AERO SA (BE)

Inria contact: Héloïse Beaugendre

Abstract: During the different phases of a flight, aircraft face severe icing conditions. When this ice then breaks away, and is ingested through the remainder of the engine and nacelle it creates multiple damages which have a serious negative impact on the operations costs and may also generate some incident issues. To minimise ice accretion, propulsion systems (engine and nacelle) are equipped with Ice Protection Systems (IPS), which however have themselves performance issues. Design methodologies used to characterise icing conditions are based on empirical methods and past experience. Cautious design margins are used non-optimised designs solutions. In addition, engine and nacelle manufacturers are now limited in their future architectures solutions development because of lack of knowledge of icing behaviour within the next generation of propulsive systems solutions, and of new regulations adopted that require aero engine manufacturers to address an extended range of icing conditions.

In this context that STORM proposes to: characterise ice accretion and release through partial tests ; Model ice accretion, ice release and ice trajectories ; Develop validated tools for runback ; characterise ice phobic coatings ; select and develop innovative low cost and low energy anti-icing and de-icing systems. Thus, STORM will strengthen the predictability of the industrial design tools and reduce the number of tests needed. It will permit lower design margins of aircraft systems, and thus reduce the energy consumption as well as prevent incidents and break downs due to icing issues.

#### 9.3.2. Collaborations in European Programs, except FP7 & H2020

Program: OCEANEraNET

Project acronym: MIDWEST

Project title: Multi-fidelity Decision making tools for Wave Energy SysTems

Duration: December 2015 - December 2018

Coordinator: Mario Ricchiuto

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

Abstract: Wave energy converters (WECs) design currently relies on low-fidelity linear hydrodynamic models. While these models disregard fundamental nonlinear and viscous effects - which might lead provide sub-optimal designs - high-fidelity fully nonlinear Navier-Stokes models are prohibitively computational expensive for optimization. The MIDWEST project will provide an efficient asymptotic nonlinear finite element model of intermediate fidelity, investigate the required fidelity level to resolve a given engineering output, construct a multi-fidelity optimization platform using surrogate models blending different fidelity models. Combining know how in wave energy technology, finite element modelling, high performance computing, and robust optimization, the MIDWEST project will provide a new efficient decision making framework for the design of the next generation WECs which will benefit all industrial actors of the European wave energy sector.

## 9.4. International Initiatives

### 9.4.1. Inria International Labs

#### **Inria@SiliconValley**

Associate Team involved in the International Lab:

#### 9.4.1.1. AQUARIUS2

Title: Advanced methods for uncertainty quantification in compressible flows

International Partner (Institution - Laboratory - Researcher):

Stanford (United States) - Department of Mechanical Engineering - Gianluca Iaccarino

Start year: 2014

See also: <http://www.stanford.edu/group/uq/aquarius/index3.html>

This research project deals with uncertainty quantification in computational fluid dynamics. Uncertainty Quantification (UQ) aims at developing rigorous methods to characterize the impact of limited knowledge on quantities of interest. Main objective of this collaboration is to build a flexible and efficient numerical platform, using intrusive methods, for solving stochastic partial differential equations. In particular, the idea is to handle highly non-linear system responses driven by shocks.

#### 9.4.1.2. AMoSS

Title: Advanced Modeling on Shear Shallow Flows for Curved Topography : water and granular flows.

International Partner (Institution - Laboratory - Researcher):

Inria Sophia-Antipolis and University of Nice (France)

Inria Bordeaux and University of Bordeaux (France)

University of Marseille (France)

National Cheng Kung University, Tainan, Taiwan

National Taiwan University and Academia Sinica, Taipei, Taiwan

Duration: 2014 - 2016

See also: <https://team.inria.fr/amoss/>

Our objective is to generalize the promising modeling strategy proposed in G.L. Richard and S.L. Gavriluk 2012, to genuinely 3D shear flows and also take into account the curvature effects related to topography. Special care will be exercised to ensure that the numerical methodology can take full advantage of massively parallel computational platforms and serve as a practical engineering tool. At first we will consider quasi-2D sheared flows on a curve topography defined by an arc, such as to derive a model parameterized by the local curvature and the nonlinear profile of the bed. Experimental measurements and numerical simulations will be used to validate and improve the proposed modeling on curved topography for quasi-2D flows. Thereafter, we will focus on 3D flows first on simple geometries (inclined plane) before an extension to quadric surfaces and thus prepare the generalization of complex topography in the context of geophysical flows.

#### 9.4.1.3. Informal International Partners

University of Zurich : R. Abgrall. Collaboration on penalisation on unstructured grids and 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, free surface flows with moving shorelines).

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. With Pr. H. Deconinck we work on the design of high order methods, including goal oriented mesh adaptation strategies

University of Nottingham, Department of Mathematics : Dr. M.E. Hubbard. Collaboration on high order schemes for time dependent shallow water flows

Technical University of Crete, School of Production Engineering & Management : Pr. A.I. Delis. Collaboration on high order schemes for depth averaged free surface flow models, including robust code to code validation

Chalmers University (C. Eskilsson) and Technical University of Denmark (A.-P. Engsig-Karup) : our collaboration with Chalmers and with DTU compute in Denmark aims at developing high order non hydrostatic finite element Boussinesq type models for the simulation floating wave energy conversion devices such as floating point absorbers ;

## **9.5. International Research Visitors**

### ***9.5.1. Visits of International Scientists***

From april 2015 (up to april 2016), Tatsuya Watanabe (Department of Mathematics, Faculty of Science, Kyoto Sangyo University Motoyama, Kamigamo, Kita-Ku, Kyoto-City 603-8555, Japan) comes to visit Mathieu Colin. During his stay, T. Watanabe is funded by a JSPS-grant.

From 09/04/2015 to 24/04/2015 F. Morency () has visited us to work with H. Beaugendre on the construction of penalization methods for the analysis of de-anti icing systems.

From 01/06/2015 to 08/06/2015, T. Magin (von Karman Institute for Fluid Dynamics) has visited us to work with P.M. Congedo on the robust analysis of Reentry flows.

From 01/07/2015 to 28/07/2015 Prof. A. Kurganov (Tulane University, New Orleans) has visited us to work with M. Ricchiuto on semi-implicit time integration methods and adaptive mesh deformation techniques.

### ***9.5.2. Visits to International Teams***

In May 2015, P.M. Congedo visited the Uncertainty Quantification Laboratory in Stanford University. Andrea Cortesi visited NASA-Ames (California) in November-December 2015.

## **CQFD Project-Team**

# **9. Partnerships and Cooperations**

## **9.1. Regional Initiatives**

### **9.1.1. MATCHABLE project**

Matchable is a startup incubated at IRA (Incubateur Régional d'Aquitaine) since Mars 2014. This startup predicts how players will behave, who is likely to spend money, who you should target with promotions/product placement, and who the developer has to pay attention to in order to prevent churners. The members of CQFD have supervised two masters internships and a postdoctoral researcher, granted by two PEPS contracts from AMIES.

### **9.1.2. Inter-LabEx project between CPU and TRAIL**

The topic of the project is "Advanced statistical methods for analysis of multidimensional databases of human brain imaging". The project focuses on the analysis of variability factors driving hemispheric specialization (HS) of the brain, a human specific character, for which a dedicated database has recently been built by GIN (Neurofunctional Imaging Group from L). GIN provides the database and pe./irabotrforms genotyping of fifty loci potentially affecting HS. The "Probability and Statistics" group (EPS) from the LabEx CPU works on the methodological developments of statistical tools to analyze these high dimensional data. Interactions between GIN and EPS allow to identify and to characterize the best variables, to perform additional analyses, and to suggest appropriate additional variables, especially in the case of the voxel being implemented. GIN is also involved in the interpretation of the statistical results generated throughout the project.

Dr Solveig Badillo has been hired as Postdoctoral researcher in may 2014 on this project for 20 months.

### **9.1.3. GIS ALBATROS, HUMO (HUMAN MONITORING) project**

Approche interdisciplinaire de l'évaluation de l'état cognitif de l'utilisateur. Participants: Jean-Marc André, Liliانا Audin Garcia, Veronique Lespinet, Frédérique Faïta, Jérôme Sarraco, Pierrick Legrand.

Le but de ce micro-projet est de valider un protocole de recueil, traitement, et interprétation des données physiologiques pour l'évaluation de l'état de l'utilisateur. Les objectifs en sont :

- Mise en place d'un protocole de recueil de données reposant sur un des modèles théoriques classiques en psychologie cognitive (ex. modèle de la mémoire de travail, modèle attentionnel, etc.) pour servir de base à la comparaison des états cognitifs (comparaison de 2 conditions expérimentales reconnues en terme de performances cognitives).
- Mise en oeuvre d'une diversité de capteurs physiologiques conduisant au recueil de signaux variés durant les conditions expérimentales issus des protocoles de psychologie cognitive.
- Conduire une analyse statistique multivariée avec les tests existants permettant de tirer des informations quant à la structure des paramètres de monitoring.
- Discriminer les variables pertinentes : choix des signaux à retenir ; efficacité/pertinence vs diversité
- Etablir et décrire le lien éventuel de significativité entre les données physiologiques recueillies et l'état cognitif de l'utilisateur.

### **9.1.4. EMG analysis**

Participants: Luis Herrera, Eric Grivel, Gregory Barrière, Marie chavent, Pierrick Legrand

L'analyse spectrale et temporelle des activités électromyographiques (EMGs, activités musculaires) occupe une place importante dans l'aide au diagnostic de pathologies sensorimotrices chez l'homme. Néanmoins, les outils actuellement utilisés en EMGs (transformée de Fourier notamment) demeurent limités et dans certains cas obsolètes pour le diagnostic différentiel de certaines pathologies. Tel est le cas par exemple de la maladie de Parkinson, du tremblement essentiel et de troubles cérébelleux qui s'accompagnent de tremblements similaires en termes de fréquence et d'amplitude. Notre projet, qui s'inscrit à la convergence de plusieurs disciplines (mathématiques, traitement du signal, neurobiologie et neurologie), vise à enrichir la quantité d'information pouvant être extraite des signaux EMGs à l'aide d'outils d'analyse à la pointe en matière de traitement du signal, avec pour objectif d'identifier des signatures EMG spécifiques de chaque pathologie et utilisables pour le diagnostic différentiel.

## 9.2. National Initiatives

### 9.2.1. ANR ADAPTEAU

The ANR project ADAPTEAU has been obtained for the period 2012-2016.

ADAPTEAU aims to contribute to the analysis and management of global change impacts and adaptation patterns in River-Estuarine Environments (REEs) by interpreting the scientific challenges associated with climate change in terms of: i) scale mismatches; ii) uncertainty and cognitive biases between social actors; iii) interdisciplinary dialogue on the "adaptation" concept; iv) critical insights on adaptive governance and actions, v) understanding the diversity of professional, social and economic practices vis-à-vis global change. The project aims to build an integrative and interdisciplinary framework involving biophysical and social sciences, as well as stakeholders and civil society partners. The main objective is to identify adaptive strategies able to face the stakes of global change in REEs, on the basis of what we call 'innovative adaptation options'.

We consider the adaptation of Social-Ecological Systems (SES) through the expected variations of the hydrological regimes (floods / low-flow) of the Garonne-Gironde REE—a salient issue in SW France, yet with a high potential for genericity The ADAPTEAU project will be organised as follows:

- Achieve and confront socio-economic and environmental assessments of expected CC impacts on the Garonne-Gironde river-estuarine continuum (task 1);
- Identify the emerging 'innovative adaptation options' endorsed by various social, economic, political actors of the territory (depolderisation, 'room for rivers' strategies, changes in economic activities, agricultural systems or social practices), then test their environmental, economic and social robustness through a selected subset (task 2);
- Scientists, representatives from administrators and civil society collaborate to build adaptation scenarios, and discuss them in pluralistic arenas in order to evaluate their social and economic feasibility, as well as the most appropriate governance modes (task 3).
- Disseminate the adaptation strategies to academics and managers, as well as to the broader society (task 4).

The expected results are the definition and diffusion of new regional-scale reference frameworks for the discussion of adaptation scenarios in REE and other SESs, as well as action guidelines to better address climate change stakes.

The CQFD team work on tasks 1 and 3.

### 9.2.2. ANR Piece

ANR Piece (2013-2016) of the program *Jeunes chercheuses et jeunes chercheurs* of the French National Agency of Research (ANR), lead by F. Malrieu (Univ. Tours). The Piecewise Deterministic Markov Processes (PDMP) are non-diffusive stochastic processes which naturally appear in many areas of applications as communication networks, neuron activities, biological populations or reliability of complex systems. Their mathematical study has been intensively carried out in the past two decades but many challenging problems remain completely open. This project aims at federating a group of experts with different backgrounds



(probability, statistics, analysis, partial derivative equations, modeling) in order to pool everyone's knowledge and create new tools to study PDMPs. The main lines of the project relate to estimation, simulation and asymptotic behaviors (long time, large populations, multi-scale problems) in the various contexts of application.

### **9.2.3. 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.

## **9.3. European Initiatives**

### **9.3.1. FP7 & H2020 Projects**

IRSES ACOBSEC

Project reference: 612689 Funded under: FP7-PEOPLE

Coordinator : Pierrick Legrand

Participants :

Université Victor Segalen Bordeaux II participation ended

Université de Bordeaux

Fundacao da Faculdade de Ciencias da Universidade de Lisboa Portugal

Universidad de Extremadura Spain

INESC ID - Instituto de Engenharia de Sistemas e Computadores, Investigacao e Desenvolvimento em Lisboa  
Participation ended

Over the last decade, Human-Computer Interaction (HCI) has grown and matured as a field. Gone are the days when only a mouse and keyboard could be used to interact with a computer. The most ambitious of such interfaces are Brain-Computer Interaction (BCI) systems. BCI's goal is to allow a person to interact with an artificial system using brain activity. A common approach towards BCI is to analyze, categorize and interpret Electroencephalography (EEG) signals in such a way that they alter the state of a computer. ACOBSEC's objective is to study the development of computer systems for the automatic analysis and classification of mental states of vigilance; i.e., a person's state of alertness. Such a task is relevant to diverse domains, where a person is required to be in a particular state. This problem is not a trivial one. In fact, EEG signals are known to be noisy, irregular and tend to vary from person to person, making the development of general techniques a very difficult scientific endeavor. Our aim is to develop new search and optimization strategies, based on evolutionary computation (EC) and genetic programming (GP) for the automatic induction of efficient and accurate classifiers. EC and GP are search techniques that can reach good solutions in multi-modal, non-differentiable and discontinuous spaces; and such is the case for the problem addressed here. This project combines the expertise of research partners from five converging fields: Classification, Neurosciences, Signal Processing, Evolutionary Computation and Parallel Computing in Europe (France Inria, Portugal INESC-ID, Spain UNEX, Bordeaux university, Sciences University of Lisbon) and South America (Mexico ITT,

CICESE). The exchange program goals and milestones give a comprehensive strategy for the strengthening of current scientific relations amongst partners, as well as for the construction of long-lasting scientific relationships that produce high quality theoretical and applied research.

### **9.3.2. Collaborations in European Programs, except FP7 & H2020**

Program: MTM2012-31393

Project acronym: NMMDP

Project title: Numerical methods for Markov decision processes

Duration: 01/2013 - 12/2015

Coordinator: Tomas Prieto-Rumeau

Other partners: Department of Statistics and Operations Research, UNED (Spain)

Abstract:

This project is funded by the Gobierno de Espana, Direccion General de Investigacion Cientifica y Tecnica (reference number: MTM2012-31393) for three years to support the scientific collaboration between Tomas Prieto-Rumeau, Jonatha Anselmi and François Dufour. This research project is concerned with numerical methods for Markov decision processes (MDPs). Namely, we are interested in approximating numerically the optimal value function and the optimal controls for different classes of constrained and unconstrained MDPs. Our methods are based on combining the linear programming formulation of an MDP with a discretization procedure referred to as quantization of a probability distribution, underlying the random transitions of the dynamic system. We are concerned with optimality criteria such as the total expected cost criterion (for finite horizon problems) and, on the other hand, the total expected discounted cost and the average cost optimality criteria (for infinite horizon problems).

## **9.4. International Initiatives**

### **9.4.1. Inria Associate Teams not involved in an Inria International Labs**

#### **9.4.1.1. CDSS**

Title: Control of Dynamic Systems Subject to Stochastic Jumps

International Partner (Institution - Laboratory - Researcher):

Universidade de São Paulo (Brazil) - Departamento de Matemática Aplicada e Estatística (ICMC) - Costa Eduardo

Start year: 2014

See also: <https://team.inria.fr/cdss/fr/>

The main goals of this joint team CDSS is to study the control of dynamic systems subject to stochastic jumps. Three topics will be considered throughout the next 3 years. In the first topic we study the control problem of piecewise-deterministic Markov processes (PDMP?s) considering constraints. In this case the main goal is to obtain a theoretical formulation for the equivalence between the original optimal control of PDMP?s with constraints and an infinite dimensional static linear optimization problem over a space of occupation measures of the controlled process. F. Dufour (CQFD, Inria) and O. Costa (Escola Politécnica da Universidade de São Paulo, Brazil) mainly carry out this topic. In the second topic we focus on numerical methods for solving control and filtering problems related to Markov jump linear systems (MJLS). This project will allow a first cooperation between B. de Saporta (Univ. Montpellier II) and E. Costa (Universidade de São Paulo, Brazil). The third research subject is focused on quantum control by using Lyapunov-like stochastic methods conducted by P. Rouchon (Ecole des Mines de Paris) and P. Pereira da Silva (Escola Politécnica da Universidade de São Paulo, Brazil).

## **9.4.2. Inria International Partners**

### *9.4.2.1. 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.

## **9.5. International Research Visitors**

### *9.5.1. Visits of International Scientists*

Tomas Prieto-Rumeau (Department of Statistics and Operations Research, UNED, Madrid, Spain) visited the team during 2 weeks in 2015. The main subject of the collaboration is the approximation of Markov Decision Processes.

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 2015 supported by the Associate Team Inria: CDSS.

Alexey Piunovskiy (University of Liverpool) visited the team during 5 weeks in 2015. The main subject of the collaboration is the linear programming approach for Markov Decision Processes. This research was supported by the Clusters d'excellence CPU.

#### *9.5.1.1. Internships*

- Emigdio Z. Flores: 1 months, hosted by P. Legrand
- Luis Herrera: 3 months, hosted by P. Legrand

## **GEOSTAT Project-Team**

# **9. Partnerships and Cooperations**

## **9.1. Regional Initiatives**

Conseil Regional Aquitaine Project CAVERNOM (ref. 9129): *Cardiac Arrhythmia Complexity and Variability by Means of Robust Nonlinear Methods*. One year.

## **9.2. National Initiatives**

- ICARODE [2013-2016]. Participants : Hussein Yahia, Oriol Pont, Véronique Garçon, Joel Sudre, Antonio Turiel, Christine Provost [ LOCEAN ]. 4-year contract, CNES-NASA funding, started 2013. Title: *ICARODE: Integration and cascading for high resolution ocean dynamics*. Project leader: H. Yahia.
- PhD grant provided by CNES and Conseil Regional Aquitaine, in collaboration with Laboratoire d'Astrophysique de Bordeaux. Starting: end 2016. Subject: understanding the dynamics of galactic dust clouds and their relation with star formation process.
- PhD grant for C. Artnana from UPMC University, under co-supervision with H. Yahia and C. Provost (LOCEAN, Paris).

## **9.3. International Initiatives**

- The Toubkal project "Caractérisation multi-capteurs et suivi spatio-temporel de l'Upwelling sur la côte atlantique marocaine par imagerie satellitaire", led by K. Daoudi, has been accepted. The partners in this project are: Faculté des sciences de Rabat, Centre Royal de Télédetection Spatiale, Mercator-Ocean and Geostat.

### **9.3.1. Inria Associate Teams not involved in an Inria International Labs**

#### **9.3.1.1. OPTIC**

Title: Optimal inference in Complex and Turbulent data.

International Partner (Institution - Laboratory - Researcher):

IITR (India), Department of Electronics and Communication Engineering: Dharmendra Singh

Start year: 2014

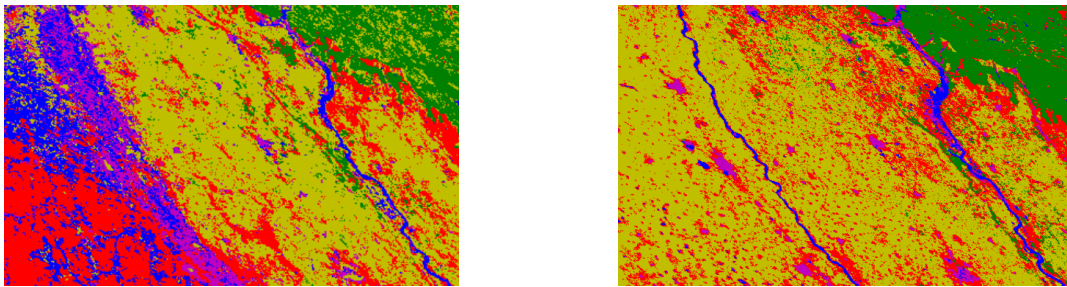
See also: <https://optic.bordeaux.inria.fr/>.

The OptIC associated team is co-managed by Prof. D. Singh (IIT Roorkee) and N. Brodu, H. Yahia (Inria Geostat).

The OptIC associated team targets the extension and development of a strong collaboration between Inria Geostat team and Indian Institute of Technology Roorkee, Dept of Electronics and Computer Engineering (Prof. D. Singh's group) on non-linear Signal Processing for Universe Sciences, with a strong emphasis on data fusion in Earth Observation and monitoring. Non-linear Physics puts strong evidence of the fundamental role played by multiscale hierarchies in complex and turbulent data: in these data, the information content is statistically localized in geometrical arrangements in the signal's domain, while such geometrical organization is not attainable by classical methods in linear signal processing. This is one of the major drawbacks in the classical analysis of complex and turbulent signals. The goal of this associated team is to show that inference of physical variables along the scales of complex and turbulent signals can be performed through optimal multiresolution analysis performed on non-linear features and data extracted from the signals,

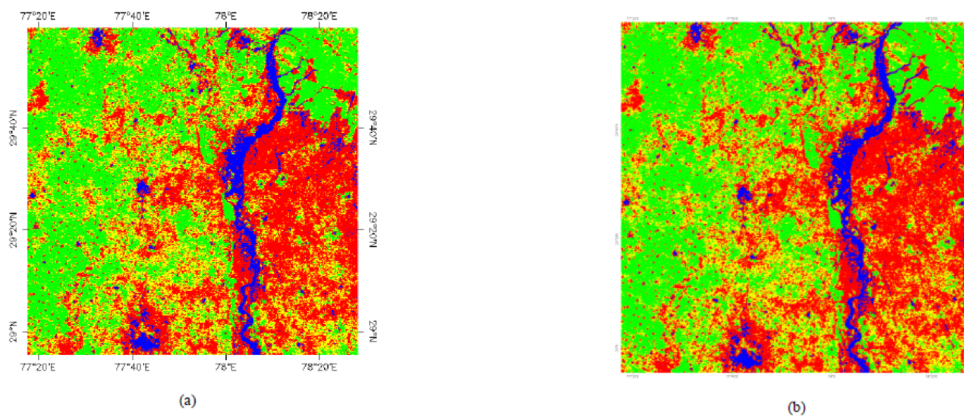
resulting in novel and powerful approaches for data fusion between different acquisitions (in temporal/spatial/spectral resolutions). This program needs both strong expertise in the physical processes beyond the acquisitions and the application of non-linear physics ideas on the behavior of the acquired physical phenomena. The proposal will focus on specific applications in Earth Observation and monitoring for which the Indian partner has developed a very strong expertise, notably in its knowledge and use of the physical processes in remote sensing acquisitions. This partnership is an extremely interesting and high potential collaboration between two teams which focus separately either on the acquisition of the physical processes or their analysis by Complex Systems and non-linear physics methodologies. The recent results obtained in super-resolution by GEOSTAT promises strong applications to a much wider range of Universe Sciences problems, notably with a strong emphasis on data fusion between the physical variables acquired on related but different acquisitions. OptiC builds on a collaboration between Inria and IIT ROORKEE teams, added with partners in Universe Sciences and earth observation (ONERA, CNRS) already involved in research actions with Geostat.

### 9.3.1.2. Summary of work done in 2015



*Figure 7. Left: nearest neighbors classification with the original 500m data, showing a cross-validated accuracy of  $0.81 \pm 0.03$ . Right: results on the superresolved 250m data, accuracy of  $0.83 \pm 0.02$ . Although the performance did not improve significantly on the reference points, the generalization capabilities are greatly enhanced: water regions (river, right, and canal, left) are well recognized, together with villages (magenta dots) and bare soil (red) adequately spotting the landscape instead of the incorrect zones on the lower-left at 500m. The other two classes are crops/small vegetation (yellow) and dense/tropical vegetation (green). The region is a MODIS sinusoidal projection around Roorkee.*

- The public availability of low-resolution MODIS data is cost-effective, but limited in precision. Some applications, such as land monitoring and anomaly detection, must not only operate on objects smaller than provided in the freely available data, but also offer a high level of confidence in the classified land occupation. We are working on both aspects:
- Augmenting numerically the resolution of the images. This can be done with different methods, out of which two are currently explored in our team. The first relies on wavelet decompositions, with an attempt at preserving the spatial structure around each pixel (e.g. edges). This is typically done by propagating the high-frequency components to higher wavelet decomposition level through some interpolation mechanism, plus artifact-reduction steps. The second method considers a sub-pixel mixing model which is fit from all multispectral bands. The assumption is that, irrespectively of the reflectance of natural elements at each wavelength, the proportion of these elements is a physical property shared through all spectral bands. Then, unmixing is performed in order to estimate the best sub-pixels. See figure 7 .
- Resolution-augmented images are then exploited for classification. We use by field measurements, in

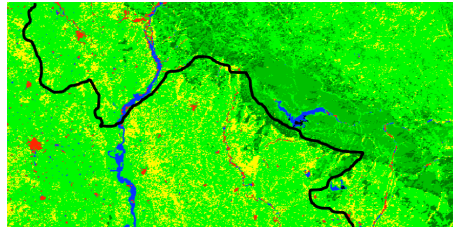


*Figure 8. Classified MODIS image (a) Low resolution (b) after resolution enhancement.*

order to provide the ground truth for a corpus of well-registered locations, which together encompass a wide variety of objects (e.g. urban, crops, etc). We then train our super-resolution algorithms, and quantitatively assess our super-resolved maps on how well they improve the performance of land classification. As the final accuracy results from the interplay between the considered feature space and the classification method itself, we quantify both aspects with cross-validated data sets. We have tested state of art classification methods (SVM, decision trees, probabilistic models, nearest neighbors, etc...). Classification accuracy is improved by the used of superresolved images but, more importantly, so are the generalization ability of the classifiers. This is shown in the following two images, demonstrating the improvement in land recognition between the use of the original 500m MODIS data and the superresolved 250m data.

- A wavelet based resolution enhancement technique has been critically analyzed to see the effect of it on resolution enhancement modified discrete wavelet transform and interpolation based technique is proposed for enhancing the resolution of satellite images having low resolution in such a way that a highly resolved satellite image can be obtained without losing any image information. The advent of DWT has given a major impetus to many techniques based on achieving super resolution starting with a single low resolution image. In the proposed method, DWT is employed on the input satellite image to decompose it into sub-bands then the high frequency subbands and the input low resolution satellite image have been interpolated to obtain four interpolated images which are later combined after minor alterations to the interpolated input image using IDWT. The quantitative peak signal-to-noise ratio (PSNR) and classification results show that the resolution has been enhanced to a good scale without losing any information content present in the satellite image. The quality assessment parameters also illustrate the supremacy of the proposed technique over the conventional techniques. Results are shown in fig 8 .
- A technique based on feature extraction has been attempted to apply in the low resolution satellite data by which a land cover monitoring system can be developed. Moderate resolution imaging spectroradiometer (MODIS) data is a good resource for land cover monitoring as it is freely available data, having high temporal frequency and spatial resolutions 250 m, 500m and 1000m. MODIS being optical satellite data suffers from various atmospheric and cloud disturbances due to which, feature extraction and land cover interpretation using MODIS data is a significant and challenging task. In the past various features like spectral indices (EVI, SAVI, GEMI, PAVI etc), fourier based features, wavelet based features were extracted for land cover classification from MODIS data but the role of





*Figure 9. Classification MODIS image by developed approach.*

texture descriptors and color features in land cover analysis has not been focussed, which has the potential to provide a new stage of land cover discrimination. Therefore, the objective of this work was to explore the applicability of MODIS composite data for land cover monitoring by texture and color features extraction. Various texture features and descriptors like GLCM (Gray Level Co-occurrence Matrix) measures, LBP (Local Binary Pattern), EHD (Edge Histogram Descriptor), gabor wavelets and color features like Red-Green-Blue (RGB) color space, Hue-Saturation-Value (HSV) color space, Hue-Min-Max-Difference (HMMD) color space, MPEG-7 Dominant Color Descriptor (DCD), MPEG-7 Color Structure Descriptor (CSD) and MPEG-7 Scalable Color Descriptor (SCD) were extracted. These color features were extracted over the artificial-color image obtained by mapping band2 (infrared band), NDVI (Normalized Vegetation Index) and band1 (red band) to the red, green and blue (RGB) color channels, respectively. It is observed that the extracted features are giving quite good results for land cover identification and classification. This infers that in near future these features could play a major role in the development of the land monitoring system using MODIS data. A classified result of Roorkee region of India is shown in fig 9 which has the overall classification accuracy approx. 82%.

- An another approach based on KLT (Kanade-Lucas-Tomasi) tracker has also been explored to apply on the Phased Array L-Band Synthetic Aperture Radar (PALSAR) satellite image for adaptive monitoring the land cover changes. It is observed that KLT tracking algorithm has good potential to be used as monitoring of vegetation in less time without applying time consuming image registration technique.

Related publications: link to [list of publications on OPTIC web site](#).

## MEMPHIS Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

The project members are actively participating to the CPU cluster of excellence of Idex Bordeaux (<http://cpu.labex.u-bordeaux.fr/>).

## 9.2. National Initiatives

We belong to the GDR AMORE on ROMs.

### 9.2.1. Starting grants

A PEPS project ("Programme Exploratoire Premier Soutien"), initiated by Afaf Bouharguane, about Optimal Transport Theory. Angelo Iollo and Lisl Weynans are also involved in this project.

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

EU research projects were and will be a privileged instrument of diffusion and transfer of our results. The AEROGUST H2020 project involves aeronautical industry (Airbus, Dassault, Piaggio..) and research labs (University of Bristol, DLR, NLR, University of Cape Town) and is dedicated to modeling of aerodynamic gust response for applications. We take part in this project by developing simulation models for unsteady aeroelastic problems and data-driven reduced-order models. We played a similar role for the past in the FP7 project FFAST with the same partners.

#### 9.3.1.1. AEROGUST

Title: Aeroelastic Gust Modelling

Programm: H2020

Duration: May 2015 - May 2018

Coordinator: University of Bristol

Partners:

Airbus Defence and Space (Germany)

Dassault Aviation (France)

Deutsches Zentrum für Luft - und Raumfahrt Ev (Germany)

Stichting Nationaal Lucht- en Ruimtevaartlaboratorium (Netherlands)

Numerical Mechanics Applications International (Belgium)

Optimad Engineering S.R.L. (Italy)

Piaggio Aero Industries Spa (Italy)

The University of Liverpool (United Kingdom)

University of Cape Town (South Africa)

University of Bristol (United Kingdom)

Valeols (France)

Inria contact: Angelo IOLLO



Encounters with atmospheric turbulence are a vitally important in the design and certification of many manmade structures such as aircraft and wind turbines. Gusts cause rapid changes in the flow about the structures which leads to rigid and flexible unsteady responses. Knowledge of aircraft/gust interactions is therefore vital for loads estimation during aircraft design as it impacts on control systems and often defines the maximum loads that these structures will experience in service. At present industry typically uses the linear doublet lattice method with static loads corrections from expensive wind tunnel data. The wind tunnel data is created using the final aerodynamic surface in the predicted cruise shape. This means that gust loads come relatively late when the design options have been narrowed. Increased competition and environmental concerns are likely to lead to the adoption of more flexible materials and the consideration of novel configurations, in which case the linear assumptions of the current gust loads process will become unacceptable. To introduce non-linearity into the gust loads process without significantly increasing the cost and time, this project has three main objectives: to carry out investigations using CFD so that the non-linearities in gust interactions are understood; to create a gust loads process that does not require wind tunnel data and hence reduces the need for wind tunnel testing; to develop updated reduced order models for gust prediction that account for non-linearity at an acceptable cost. These investigations will reduce the need for expensive wind tunnel testing and hence lead to time and cost savings at the design stage therefore ensuring that the European aerospace and defence industry remain competitive in the future. The wind turbine industry has similar concerns, with gusts and wind shear restricting the locations available for wind farms. The project will also address these issues using common methodology.

### 9.3.2. Collaborations with Major European Organizations

Partner 1: Chalmers University (Sweden)

This activity is complemented by several international interactions, in particular with Chalmers University in order to converge towards the real implementation of new control technologies on cars, buses and trucks.

Partner 2: Optimad Engineering , Torino (Italy)

We have a crucial partnership with Optimad Engineering, a spin-off of the Politecnico di Torino. This society has implemented in industrial codes several schemes that we have developed for the past. In exchange, we have access to these codes. One example is Pablo, an octree managing parallel library (<http://www.optimad.it/products/pablo/>). Three former PhD students at Inria are presently employed in Optimad and several others have spent or will spend a research period in this company in order to get acquainted with code architecture and massive parallelism. This company represents for us an ideal partner for the actual industrial feedback on our methods. As mentioned, we plan to create a local start-up in close collaboration with Optimad. This start-up will respond to actual industrial needs by specific software packages built starting from open source tools that are made available to the applied research community via a consortium. Florian Bernard has been recruited in Memphis for two years with the objective of bringing to a higher maturity level a set of modules developed within the team. He plans to fully invest himself in the creation of the start-up. As for the consortium, we are discussing with several partners including Cineca (Italy HPC center) and Optimad about how to structure such a mutual effort. The Storm Inria team is included in the discussions as a possible partner.

Partner 3: W4E (Wave for Energy) (Italy)

One project is the design of an ISWEC (Inertial Sea Wave Energy Converter) in collaboration with W4E (Wave for Energy), Optimad and others. The ISWEC is a floater prototype that can extract energy from the sea waves. The mechanism is based on a gyroscope that is rotating due to the passive motion of the floater. This prototype is actually tested in the Mediterranean sea in Italy. We will develop the numerical simulation as well as the shape optimization of the ISWEC.

Partner 4: MRGM (Maladies Rares : Génétique et Métabolisme), Bordeaux University (France)

We develop a collaboration with the MRGM lab. They are interesting in the swimming of a zebrafish larvae under genetic modifications. One aim is to quantify the power spent by such fishes to swim after a stimuli reaction. The numerical simulation we develop can help computing integral quantities such the power. This simulation is challenging coupling several methods like image treatment (from movies given by MRGM), optimal transport and numerical simulations.

Partner 5: CRPP (Centre de recherche Paul Pascal), LOF (Laboratoire du Futur) and LOMA (Laboratoire Ondes et Matière d'Aquitaine) labs, Bordeaux University, France.

We established collaborations with physics and chemistry labs in Bordeaux, namely the CRPP, the LOF and the LOMA. They are concerned with the behavior of many passive (CRPP and LOF) and active (LOMA) particles in an incompressible flow. With these partners we intend to use a combined experimental and computational approach to calibrate models in the case of dilute and concentrated suspensions. The numerical simulations of such particles can help to understand some underlying phenomena at the particles scale and thus to develop mesoscopic models for the whole system (PhD of Baptiste Lambert, oct. 2015).

## 9.4. International Initiatives

### 9.4.1. Inria International Partners

#### 9.4.1.1. Informal International Partners

With Rajat Mittal, of Johns Hopkins University, we collaborate on the simulation of complex biological flows that involve fluid-structure interactions with large deformations like foamation, heart beating, freely moving elastic capsules in blood vessels, fish-like swimming or flapping wings. A common journal paper in *Bioinspiration & Biomimetics* has been issued so far. This collaboration will continue in the future.

## 9.5. International Research Visitors

### 9.5.1. Visits of International Scientists

Frédéric Gibou, from UC Santa Barbara, visited us in 2015. With the team of Frédéric Gibou we collaborate to develop general enough numerical models that allow a simplified geometrical and computational set up by the systematic use of hierarchical Cartesian meshes and monolithic models: multi-resolution schemes based on octree grid structures, refined grid patches, numerical zooms, overset.

Giovanni Russo, of the University of Catania, shares many of our scientific objectives: one of his past PhD students, Armando Cocco, has spent one year in Bordeaux dedicated to the parallelization of a multigrid cartesian solver. G. Russo has spent several weeks in Bordeaux as a visiting scientist at the Memphis team in 2015. This visit was dedicated to the study of new all-Mach schemes for conservative equations, guaranteeing accuracy and efficiency of the schemes used to solve problems where the time scales are those of the material velocities as opposed to acoustic wave time scales.

Gabriella Puppo, initially at the Politecnico di Torino and now at the university of Insubria, also visited us in 2015. We have an established collaboration with her to extend our approaches to rarefied gas dynamics, i.e., problems governed by the BGK equation. We have co-directed the PhD of Florian Bernard and we have now another co-direction, that of Emanuela Abbate, who will be studying relaxation equations for stiff problems of compressible non-linear elasticity.

Conglin Liu (univ. Harbin China), visited Charles-Henri Bruneau during the whole academic year 2014-2015. She had a grant from the Chinese Government.

#### 9.5.1.1. Internships

Nadia Loy is an international internship from the university of Florence.

### ***9.5.2. Visits to International Teams***

With the team of Frédéric Gibou we collaborate to develop general enough numerical models that allow a simplified geometrical and computational set up by the systematic use of hierarchical Cartesian meshes and monolithic models: multi-resolution schemes based on octree grid structures, refined grid patches, numerical zooms, overset.

In this framework we have recently organized a commun workshop in Santa Barbara funded by the Idex initiative in Bordeaux.

## REALOPT Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

We have received support from the regional authorities (Region Aquitaine) for a research project on the planning under uncertainty. A postdoc, Agnès Leroux, has been recruited on this project. She currently develops dynamic programming approaches for scheduling problems and their application to building planning for phytosanitary treatments.

## 9.2. National Initiatives

### 9.2.1. ANR

#### 9.2.1.1. ANR Solhar (ANR-13-MONU-0007)

This project aims at studying and designing algorithms and parallel programming models for implementing direct methods for the solution of sparse linear systems on emerging computing platforms equipped with accelerators. This project proposes an innovative approach which relies on the efficiency and portability of runtime systems, such as the StarPU tool. The focus of RealOpt in this project is on the scheduling aspect. Indeed, executing a heterogeneous workload with complex dependencies on a heterogeneous architecture is a very challenging problem that demands the development of effective scheduling algorithms. These will be confronted with possibly limited views of dependencies among tasks and multiple, and potentially conflicting objectives, such as minimizing the makespan, maximizing the locality of data or, where it applies, minimizing the memory consumption.

See also: <http://solhar.gforge.inria.fr/>

#### 9.2.1.2. ANR SONGS (ANR 11 INFRA 13)

The goal of the SONGS project is to extend the applicability of the SimGrid simulation framework from Grids and Peer-to-Peer systems to Clouds and High Performance Computation systems. Any sound study of such systems through simulations relies on the following pillars of simulation methodology: Efficient simulation kernel; Sound and validated models; Simulation analysis tools; Campaign simulation management. The contribution of RealOpt in this project revolves around enabling peer-to-peer simulation, and providing use cases for Cloud Computing simulations.

See also: <http://infra-songs.gforge.inria.fr/>

## 9.3. International Initiatives

### 9.3.1. Inria Associate Team

#### 9.3.1.1. SAMBA

Title: Synergies for Ameliorations and Mastering of Branch-and-Price Algorithms

International Partner (Institution - Laboratory - Researcher):

Universidade Federal Fluminense (Brazil) & Universidad Adolfo Ibanez (Chile)

Start year: 2011-13 and 2014-16

See also: [https://realopt.bordeaux.inria.fr/?page\\_id=573](https://realopt.bordeaux.inria.fr/?page_id=573)

SAMBA is a research project between the Inria project team ReAlOpt (Bordeaux, France), the ADT-Lab Pontifícia Universidade Católica do Rio de Janeiro, and the LOGIS at the Universidade Federal Fluminense. The project is supported by Inria under the “associate team” framework for an initial period of three years (2011-2013) and was renewed for another three years period (2014-2016) with additional partners at the Operations Research and Complex Systems Group School of Business, Universidad Adolfo Ibanez, Chile, and the LIRMM at the University of Montpellier.

Quantitative models are important tools for strategic, tactical, and operational decision-making. Many underlying optimization problems are discrete in nature. They are modeled as linear programs with integer variables, so called Mixed Integer Programs (MIP). Their solution is essentially based on enumeration techniques, which is notoriously difficult given the huge size of the solution set. Powerful generic commercial solvers for MIP are available, but despite continuous progress, the existing tools can be overwhelmed when problem complexity or size increases.

Decomposition approaches are primary tools to expand the capabilities of MIP solution techniques. When the application presents a decomposable constraint system, the so-called “Dantzig-Wolfe decomposition” consists in reformulating the problem as a selection of a specific solution for each individual subsystems that together satisfy the linking constraints. In practice, the individual subsystem solutions are brought in the formulation in the course of the optimization if they can lead to improvement in the objective value. On the other hand, “Benders’ decomposition applies when the the application presents a decomposable system of variables, as traditional in stochastic two-stage optimization models where main decisions are taken prior to knowing the realization of random data, while second stage decision are adjustments that can be done once the true value of data is revealed. In this context, one solves the first stage model and check a posteriori the feasibility of the second stage. In case the second stage is infeasible, a constraint on the first stage variables is induced that aim to account for the cause of second stage infeasibility, and the processus reiterates.

Both of these decomposition approaches are perceived as requiring an application specific implementation for tractability in scaling-up to real-life applications. Our research aim at developing generic methods for these and algorithmic enhancements to can yield significant speed-ups in practice and have sound theoretical basis. Such research includes methodological developments (such as stabilization techniques for improved convergence, preprocessing rules, dynamic aggregation-and-disaggregation), algorithms strategies (such as mutli-column/cut generation strategies, pre-evaluation of enumerated subproblem strategies – so-called strong branching), and efficient implementations (code re-engineering of our software platform BaPCod).

Beyond the methodological developments, our motivations are to set new benchmarks on standard combinatorial problems and industrial applications. In particular, we proceed to extend our techniques to the context of dynamic optimization. In a stochastic environment, the aim is to build a planning that are robust to perturbations in the sense that it can be adapted dynamically in reaction to the observed changes in the predicted data.

The project builds on the accumulated experience of both the Brazilian, the Chilean and the French teams that have done pioneering work in tackling complex applications and deriving generic solution strategies using this decomposition approach.

## 9.4. International Research Visitors

### 9.4.1. Visits of International Scientists

- Alexander Lazarev (Russia) visited us in Bordeaux in January 2015.
- Eduardo Uchoa (Brasil) visited us in Bordeaux on the second week of January 2015.
- Michael Poss visited us in Bordeaux on the first week of May 2015.
- Eduardo Moreno (Chile) visited us in Bordeaux for 10 days in November 2015.

## **9.4.2. Visits to International Teams**

### *9.4.2.1. Sabbatical programme*

Sadykov Ruslan

Date: Aug 2015 - Jul 2016

Institution: **Universidade Federal Fluminense** (Brazil)

## CARMEN Team

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

### 8.1.1. IHU LIRYC

Our work is partially funded by the LIRYC project (ANR 10-IAHU 04).

- For 2015: the salary of M. Potse, member of Carmen, is paid by LIRYC..
- For 2012-2015: 1/2 PhD thesis associated to the project *Modélisation pour les données multimodales* (see section Regional Initiatives).

### 8.1.2. ANR HR-CEM

In 2014, we are supported for the project “High Resolution Cardiac Electrophysiology Models: HR-CEM” within the call for project « Modèles Numériques » of the ANR.

The scientific start of the project was on November 4th, 2013.

It is an international project that involves three partners: Inria (coordinator), IHU LIRYC, and UMI-CRM at Montréal (Canada). The project has some external collaborators in Univ. Bordeaux and Univ. Pau.

Based on these collaborations and new developments in structural and functional imaging of the heart available at LIRYC, we plan to reconsider the concepts behind the models in order to improve the accuracy and efficiency of simulations. Cardiac simulation software and high-resolution numerical models will be derived from experimental data from animal models. Validation will be performed by comparing of simulation output with experimentally recorded functional data. The validated numerical models will be made available to the community of researchers who take advantage of in-silico cardiac simulation and, hopefully, become references. In particular we shall provide the first exhaustive model of an animal heart including the four chambers coupled through the special conduction network, with highly detailed microstructure of both the atria and the ventricles. Such a model embedded in high-performance computational software will provide stronger medical foundations for in-silico experimentation, and elucidate mechanisms of cardiac arrhythmias.

### 8.1.3. AMIES – Medic Activ

We were granted by the Agency AMIES a financial support to complete the one obtained from the Région Aquitaine for the Medic Activ project (see above). The objective of this support is to develop reduced order models of cardiac electrophysiology that might enter the MedicActiv framework. The difficulty is to define qualitatively realistic but fast numerical simulations of the ECG and cardiac function, for educational purpose.

### 8.1.4. ANR Labcom CardioXcomp

We are participant in the ANR Labcom project between Inria and the society Notocord ([www.notocord.com](http://www.notocord.com)). At Inria, the project is led by J.-F. Gerbeau from the Reo team and we participate to the study and development of cardiac electrophysiology models suited to the context of the project.

The aim of CardioXcomp is to code human induced pluripotent cardiomyocyte cells and drug/hiPS-CMs interaction. N. Zemzemi works on this project with E. Abbate (PhD thesis until October 2015) for the coupling between human induced pluripotent cardiomyocyte cells and the measurement tool multi-electrode array (MEA). In this project, some different tests on drug models and selection of the most suitable for the hiPS-CMs. In the same time, N. Zemzemi with collaborators N. Fikal, R. Aboulaich and EL.M. El Guarmah worked on the quantification of the effect of uncertainty in the conductivity values on the Electrocardiography imaging (ECGI) inverse solution. N. Zemzemi and J. Lassoued C. Corrado and M. Mahjoub worked on the stability analysis of the reduced order model for the bidomain equation using proper orthogonal decomposition and on the estimation of the location of cardiac ischemia in a 3D geometry with inverse problem tools with C. Chavez F. Alonso-Atienz, D. Alvarez and Y. Coudière.

### 8.1.5. REO

The CARMEN team is a partner with the REO team at Inria Paris Rocquencourt and the NOTOCORD company in the CardioXcomp project.

### 8.1.6. MedicActiv

The CARMEN team cooperates in interaction with the MedicActiv project.

### 8.1.7. GENCI

GENCI – grand équipement national de calcul intensif – is the agency that grants access to national high-performance resources for scientific purposes in France. GENCI projects have to be renewed yearly. Our project renewal *Interaction between tissue structure and ion-channel function in cardiac arrhythmia*, submitted in October 2015, has been granted 9.4 million core-hours on the three major systems Curie, Occigen, and Turing. This compute time, to be used in the calendar year 2016, is primarily destined for our research into the interaction between ionic and structural heart disease in atrial fibrillation, Brugada syndrome, and early repolarisation syndrome [37].

## 8.2. International Initiatives

### 8.2.1. Inria International Labs

**LIRIMA:** Associate Team involved in the International Lab:

#### 8.2.1.1. EPICARD (<https://team.inria.fr/carmen/epicard>)

Title: inverse Problems In CARDiac electrophysiology

International Partner (Institution - Laboratory - Researcher):

ENIT (Tunisia) Department of Intelligence Science and Technology - Nabil Gmati

- Start year: 2015
- See also: <https://team.inria.fr/carmen/epicard/>
- Improving the information that we can extract from electrical signals measured on patients with heart diseases is a major priority for the IHU LIRYC in Bordeaux headed by Professor Michel Haissaguerre. We would like to non-invasively construct the electrical potential on the heart surface only from measurements of the electrical potential on the chest of the patient. This helps the medical doctor to visualise an image of the electrical potential of the heart of the patient. It is known that have been used in the literature for solving this electrocardiography imaging (ECGI) problem, including those used in commercial medical devices have several limitations. This problem could be mathematically seen as a boundary data completion problem for elliptic equations. Many works in the literature have been carried \* out in order to solve this Cauchy problem, but have never been used for solving the ECGI problem. Our goal from the associate team is to develop an experimental platform allowing to test various methods and compare their performance on real life experimental data.

### 8.2.2. Inria International Partners

#### 8.2.2.1. Informal International Partners

Applied work on atrial fibrillation is performed in collaboration with the experimental and clinical groups of professors U. Schotten and H. Crijns at Maastricht University [36].

M. Potse collaborates on several projects with the Institute of Computational Science at the *Università della Svizzera italiana* in Lugano, Switzerland, and the Department of electronics, informatics, and bioengineering of the *Politecnico di Milano*, Milan, Italy.



## **8.3. International Research Visitors**

### ***8.3.1. Visits of International Scientists***

#### *8.3.1.1. Internships*

- B. Mostafa
  - The Faculty of Mathematics and Natural Sciences, University of Oslo, Norway
  - Johann Radon Institute for Computational and Applied Mathematics (RICAM) Austrian Academy of Sciences, Linz, Austria.
  - CI<sup>2</sup>MA y Departamento de Ingenieria Matemática, Universidad de Concepcion, Concepcion, Chile.
  - Departamento de Matemática Aplicada e Estatística, Instituto de Ciências Matemáticas e de Computação – USP, São Carlos, Brazil

## MAGIQUE-3D Project-Team

# 8. Partnerships and Cooperations

## 8.1. Regional Initiatives

### 8.1.1. Partnership with I2M in Bordeaux supported by Conseil Régional d'Aquitaine

title: Imaging complex materials.

Coordinator: H el ene Barucq

Other partners: I2M CNRS Universit e Bordeaux I

The detection, localization and monitoring of the defect evolution in composite materials, concrete and more generally heterogeneous materials is a challenging problem for Aeronautics and energy production. It is already possible to localize defects in homogeneous materials by using methods based on ultrasonic inspection and sometimes, they are usable in particular heterogeneous materials, most of the time in 2D. Classical methods rely on the correspondence between the distance and the propagation time of the wave traveling between the defect and the receivers. In complex media, such a correspondence may be lapsed, for instance when the velocity depends on the frequency (dispersion) or of the propagation direction (anisotropy). The defect signature can also be embedded in the acoustic field sent by the structure (multiple reflections). The complexity of the propagation in heterogeneous materials makes then difficult the accurate localization of the defect, in particular in 3D.

Topological imaging techniques can be applied to heterogeneous media. They can find the positions of defects from two simulations performed in a safe experimental medium. They have been developed at I2M laboratory to carry on 2D single/multi mode inspection in isotropic and anisotropic waveguides. They have also been applied to a highly reflecting medium observed with a single sensor. The objective of this work is to extend the technique to 3D problems. In particular, we are going to handle detection in composite plates and in highly heterogeneous media including a collection of small scatterers.

This project is supported by the Conseil R egional d'Aquitaine, for a duration of 2 years.

## 8.2. National Initiatives

### 8.2.1. Depth Imaging Partnership

Magique-3D maintains active collaborations with Total. In the context of Depth Imaging, Magique-3D coordinates research activities dealing with the development of high-performance numerical methods for solving wave equations in complex media. This project involves 2 other Inria Team-Projects (Hiepac and Nachos) which have complementary skills in mathematics, computing and in geophysics. DIP is fully funded by Total by the way of an outline agreement with Inria .

Since its beginning (2009), eight PhD students have been funded and Magique 3D has hired six of them, one being shared with the project team Nachos (<http://www-sop.inria.fr/nachos/>). Moreover, several internships have been realized. In 2014 the second phase of DIP has begun. Lionel Boillot has been hired as engineer to work on the DIP platform.

### 8.2.2. Micro-local analysis of wave equations

The numerical solution of wave equations most often requires to truncate the propagation domain to define a computational domain limited by an artificial boundary. Magique-3D is very involved in the construction and mathematical validation of boundary conditions which are set on the artificial boundary. Different techniques can be used for the design of such conditions and Magique-3D maintains a collaboration with Prof. Olivier Lafitte from the University of Paris 13 on the mathematical analysis of the Dirichlet-to-Neumann (DtN) operator for acoustic waves. This issue is addressed by applying micro-local analysis which enables us to consider the full DtN operator in the whole space of frequencies.

### **8.2.3. Partnership with the department DMAE of ONERA**

title: Modeling of multiperforated plates

Coordinator: Sébastien Tordeux

Other partners: Department DMAE of ONERA

Abstract: In the aeronautic industry, there is a need of numerical models for the design of turboreactors of new generation. Magique-3D is cooperating with the department DMAE of ONERA to develop acoustic models of multiperforated plates which is an important component of the turboreactors.

This project is interdisciplinary, since it involves the experimental expertise of Estelle Piot (acoustician engineer of ONERA working on acoustic bench), the competences in mathematical modeling of Magique 3D. In parallel to the obtention of new theoretical results we are jointly developing a new numerical library based on the discontinuous Galerkin approximation which aims in interpreting experimental data.

This cooperation is formalized thanks to the common supervision of the PhD of Vincent Popie funded by ONERA and DGA and is a follow-up of the ANR APAM (2008-2011).

## **8.3. European Initiatives**

### **8.3.1. FP7 & H2020 Projects**

#### *8.3.1.1. GEAGAM*

Title: Geophysical Exploration using Advanced GALerkin Methods

Programm: H2020

Duration: January 2015 - January 2018

Coordinator: Universidad Del Pais Vasco (EHU UPV)

Partners:

Bcam - Basque Center for Applied Mathematics Asociacion (Spain)

Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)

Total S.A. (France)

Universidad Del Pais Vasco/ Euskal Herriko Unibertsitatea (Spain)

Inria contact: H el ene BARUCQ

The main objective of this Marie Curie RISE action is to improve and exchange interdisciplinary knowledge on applied mathematics, high performance computing, and geophysics to be able to better simulate and understand the materials composing the Earth's subsurface. This is essential for a variety of applications such as CO<sub>2</sub> storage, hydrocarbon extraction, mining, and geothermal energy production, among others. All these problems have in common the need to obtain an accurate characterization of the Earth's subsurface, and to achieve this goal, several complementary areas will be studied, including the mathematical foundations of various high-order Galerkin multiphysics simulation methods, the efficient computer implementation of these methods in large parallel machines and GPUs, and some crucial geophysical aspects such as the design of measurement acquisition systems in different scenarios. Results will be widely disseminated through publications, workshops, post-graduate courses to train new researchers, a dedicated webpage, and visits to companies working in the area. In that way, we will perform an important role in technology transfer between the most advanced numerical methods and mathematics of the moment and the area of applied geophysics.

#### *8.3.1.2. HPC4E*

Title: HPC for Energy

Programm: H2020

Duration: December 2015 - December 2017

Coordinator: Barcelona Supercomputing Center

Inria contact: Stephane Lanteri

During the last years, High Performance Computing (HPC) resources have undergone a dramatic transformation, with an explosion on the available parallelism and the use of special purpose processors. There are international initiatives focusing on redesigning hardware and software in order to achieve the Exaflop ( $10^{18}$  flops) capability. This project aims at applying the new exascale HPC techniques to energy industry simulations, customizing them if necessary, and going beyond the state-of-the-art in the required HPC exascale simulations for different energy sources that are the present and the future of energy: wind energy production and design, efficient combustion systems for biomass-derived fuels (biogas), and exploration geophysics for hydrocarbon reservoirs.

## 8.4. International Initiatives

### 8.4.1. Inria International Partners

#### 8.4.1.1. Declared Inria International Partners

##### 8.4.1.1.1. MAGIC2

Title: Advance Modeling in Geophysics

International Partner (Institution - Laboratory - Researcher):

California State University at Northridge (United States) - Department of Mathematics -  
Djellouli Rabia

The Associated Team MAGIC was created in January 2006 and renewed in January 2009. At the end of the program in December 2011, the two partners, MAGIQUE-3D and the California State University at Northridge (CSUN) decided to continue their collaboration and obtained the “Inria International Partner” label in 2013.

See also: <https://project.inria.fr/magic/>

The ultimate objective of this research collaboration is to develop efficient solution methodologies for solving inverse problems arising in various applications such as geophysical exploration, underwater acoustics, and electromagnetics. To this end, the research program will be based upon the following three pillars that are the key ingredients for successfully solving inverse obstacle problems. 1) The design of efficient methods for solving high-frequency wave problems. 2) The sensitivity analysis of the scattered field to the shape and parameters of heterogeneities/scatterers. 3) The construction of higher-order Absorbing Boundary Conditions.

## 8.5. International Research Visitors

### 8.5.1. Visits of International Scientists

#### 8.5.1.1. Internships

Andrew Wang, graduate student from the Massachusetts Institute of Technology, visited MAGIQUE-3D for a two months internship in June and July 2015.

## MNEMOSYNE Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. *PsyPhINe: Cogito Ergo Es*

**Participant:** Nicolas Rougier.

PEPS site Mirabelle (CNRS & University of Lorraine) gathering researchers from the following institutes: MSH Lorraine (USR3261), InterPsy (EA 4432), APEMAC, EPSaM (EA4360), Archives Henri-Poincaré (UMR7117), Loria (UMR7503).

PsyPhiNe is an interdisciplinary and exploratory project between philosophers, psychologists and computer scientists. The goal of the project is related to cognition and behavior. Cognition is a set of processes that are difficult to unite in a general definition. The project aims to explore the idea of assignments of intelligence or intentionality, assuming that our intersubjectivity and our natural tendency to anthropomorphize play a central role: we project onto others parts of our own cognition. To test these hypotheses, our aim is to design a "non-verbal" Turing Test, which satisfies the definitions of our various fields (psychology, philosophy, neuroscience and computer science), using a robotic prototype. Some of the questions that we aim to answer are: is it possible to give the illusion of cognition and of intelligence through such a technical device? How elaborate must be the control algorithms or "behaviors" of such a device to fool test subjects? How many degrees of freedom must it have?

### 9.1.2. *Project PEPS of the Idex: Dopamine control of a novel basal ganglia cell-type*

**Participants:** André Garenne, Nicolas Rougier.

The neurotransmitter dopamine (DA) plays a key role in basal ganglia (BG) circuits. However, despite the fundamental importance of DA in those circuits, the electrophysiological effects of dopamine on target neurons are largely unknown. Furthermore, contrary to classical models that only view the globus pallidus (GP) as a relay station of the indirect pathway, our neuroscientist colleagues at IMN have discovered a novel GP cell-type called the Arkypallidal (Arky-GP) neurons that only project to striatum in a very dense way. We thus have been modeling the structure of the striatum ( $\approx 3$  millions neurons) and the globus pallidus ( $\approx 50,000$  neurons) in the mouse using down-scaled models. Two models have been made, the first one utilized the neural field theory while the other one utilized integrate-and-fire neurons. The goal was to study the activity around the electrode contact point in order to give account on recorded activity in vivo. Unfortunately, electrophysiological recording were not precise enough to conclude on these models.

### 9.1.3. *Project of the Aquitaine Regional Council: Decision making, from motor primitives to action*

**Participants:** Nicolas Rougier, Meropi Topalidou.

The aim of this project (partly funding the PhD of Meropi Topalidou) is to investigate decision making at intermediate level in order to establish the link between motor primitives and higher level actions. The question is to understand how continuous complex motor sequences can be dynamically represented as actions such that they can be manipulated to resolve conflict when several actions are possible. In tight collaboration with Thomas Boraud from the Institute of Neurodegenerative Diseases, we have been modeling the basal ganglia such as to explain the formation of habits in the monkey. This fruitful collaboration lead to the joint publication of several articles [4], [43], [42], [5] and the model enabled us to make very precise prediction on the behavior of the monkeys (dissociation of goal-directed and habitual behavior). Early experiments on two female macaques tend to confirm the prediction.

#### **9.1.4. Collaboration with the Neurocentre Magendie on parameter optimization: Neurobees**

**Participant:** André Garenne.

The development of computational models of neurons and networks typically involves tuning the numerical parameters to fit experimental results. Parameter tuning can sometimes be manually completed, it is more convenient to use automated optimization algorithms at least for two reasons: (i) to apply an homogeneous processing to all the calculation and parameter space exploration which alleviates operator influence and (ii) to avoid a tedious and uncertain result from human operators when the dimensionality increases. A multi-agent algorithm in line with ABC (Artificial Bee Colony) paradigm has been applied to new benchmark tests in order to ensure its robustness and better performances, especially when compared to evolutionary and swarm algorithms and this has recently been confirmed, thanks to the local Plafrim computation facilities. A draft paper is then currently modified before submission to take into account these last results.

#### **9.1.5. Thematic Transverse Action of the University of Bordeaux: Project MISTERE**

**Participant:** André Garenne.

The MISTERE (Etude du Mécanisme d'Interaction des Signaux de Téléphonie mobile sur des Réseaux de neurones in vitro) project has been recently accepted and we have obtained financial support and 1 year of post-doctoral contract by the Science and Technology department of the University of Bordeaux. The main topic of this project lies in the elucidation of the cellular mechanisms of the effects of the GSM radio frequencies (GSM-RF) on the neuronal activity. The approach will consist both in computational modeling studies and in pharmacological tests of neuronal cultures activity when submitted to GSM-RF.

## **9.2. National Initiatives**

#### **9.2.1. GDR3672 - BioComp - Material Implementation of natural computation**

**Participant:** Nicolas Rougier [member of the steering committee].

The **GDR BIOCAMP** has been officially created on January 2015 and gathers the INP, INSIS, INS2I, INSB, INC institutes of the CNRS. The goal of this GDR is to facilitate interdisciplinary exchanges in France around a common goal: the realization of bio-inspired hardware systems. More precisely, this GDR seeks to understand the mechanisms at work in biological systems to create chips based on natural computation, but also vice versa, building hardware architectures as test systems to better understand biology. In France there is a wealth of expertise in all disciplines concerned with hardware implementations of natural computation: biology, computational neuroscience, mathematics, computer architecture and computer systems, microelectronics, nanotechnology and physics. Making bio-inspired chips is extremely complex and requires advanced skills in all these disciplines. By organizing interdisciplinary meetings and conferences, the goal is hence to bring together different communities so that they can understand each other and work together.

#### **9.2.2. Project Motus of the ANSES**

**Participant:** André Garenne.

The MOTUS project (MOdulaTion dU Signal RF et effets sur le cerveau : approche in vivo et in vitro) has been recently accepted and will be financed by the ANSES (the french national agency for health security). This 3 years project includes substantial financial support as well as 2 years of post-doctoral contracts with our partner IMS regarding the effects of GSM-RF on living matter and especially neuronal activity and development. It is designed to be synergistic with the MISTERE project previously obtained (cf section 9.1.5 ). Our main involvement will concern electrophysiological data and spike trains analysis as well as the development of pharmacological protocols to test GSM-RF effects hypotheses.

#### **9.2.3. Project Mimacore of the CNRS Challenge Imag'In**

**Participants:** Frédéric Alexandre, Nicolas Rougier.

Better understanding the resting states (regional interactions and corresponding functional networks in the brain when the subject is at rest) is of central interest for a systemic approach of brain understanding. As we think that this domain is not mature enough for a direct functional modeling approach, we try to get familiar with it, through this imaging study. In this exploratory study funded by the CNRS, we are associated with three teams in neuroscience developing three imaging techniques (MRS, MRI, Clarity), to explore resting states in rodents and learn more about their genesis.

## 9.3. International Initiatives

### 9.3.1. Inria Associate Teams not involved in an Inria International Labs

#### 9.3.1.1. Braincraft

Title: Braincraft

International Partner (Institution - Laboratory - Researcher):

University of Colorado, Boulder (United States) - Computational Cognitive Neuroscience  
- Randall O'Reilly

Start year: 2015

We develop with this team a computationally-based understanding of the neural circuits involved in decision making, namely basal ganglia and prefrontal cortex. More precisely, we want to understand what are the processes by which animals and humans select their actions based on their motivations and on the consequences of past actions. This is a fundamental question in neurosciences, with implications to ethology, psychology, economics, sociology and computer science. Through a unique combination of expertise in cognitive psychology, neurosciences and computer science, this associate team will foster a collaboration for developing a computationally-based understanding of the neural circuits involved in decision making, namely basal ganglia and prefrontal cortex. One of the key question is to know the overall contribution of these structures and their function in the decision process.

#### 9.3.2. Project BGaL with India

In the 3-years project “Basal Ganglia at Large (BGaL)”, funded by the CNRS and the CEFIPRA, we collaborate with the computer science department of IIIT Hyderabad and the biomedical department of IIT Madras, for the design of models of basal ganglia and for their implementation at large scale (*cf.* § 7.4 ) as well as for their relation with other brain structures (*cf.* § 7.2 ).

#### 9.3.3. Project ECOS-Sud with Chile

In the 3-years project “A network for computational neuroscience, from vision to robotics”, funded by ECOS-Sud and Conicyt, we collaborate with University Santa Maria and University of Valparaiso in Chile, and also with another Inria EPI, NeuroMathComp. The goal of the project is to rely on our experience of previous collaborations with these teams, to develop original tools and experimental frameworks to open our scientific domains of investigation to new fields of valorization, including medical (neurodegeneration) and technological aspects (robotics).

## 9.4. International Research Visitors

### 9.4.1. Visits of International Scientists

#### 9.4.1.1. Internships

Nallapu Bhargav Teja

Date: June 2015 - Dec 2015

Institution: University of Hyderabad (India)

## Monc Team

# 8. Partnerships and Cooperations

## 8.1. Regional Initiatives

### 8.1.1. *BIS-Japan Idex Université de Bordeaux*

- Project acronym - BIS-Japan Idex
- Duration - 2015
- Coordinator - C. Poignard
- Abstract - The project proposes to gather the skills of the Japanese partner on cell migration modeling, molecular pathways in cancer and theoretical aspects of partial differential equations with the experience of the Bordeaux team MONC (Modeling in ONCology), which involves researchers from University of Bordeaux, IPB, CNRS and Inria, in cancer modeling. More particularly, the team MONC is involved in the derivation of tumor growth models and of accurate finite volume numerical schemes to solve the partial differential equations in order to provide a deep multiscale knowledge of the tumor development at the cell scale. The overall aim of this project is to propose a comprehensive study of the metastatic processes at the cell scale, by highlighting the molecular pathways and the main chemical processes involved in cancer cell migration and division.

## 8.2. National Initiatives

### 8.2.1. *Plan cancer DYNAMO*

- Project acronym - Plan Cancer DYNAMO
- Partners - Lab Ampère-Lyon, Lab. Vectorologie et thérapies anticancéreuses- Villejuif and Equipe Inria MONC-Talence
- Duration - from sep. 2015 to sep 2018
- Coordinator - R. Scorretti, Lab. Ampère / Local coordinator - C. Poignard
- Team participants - C. Poignard
- Abstract - Electroporation (EPN) is a method which allows either killing the cells in a target region (tumors) by a nonthermal mechanism (irreversible EPN, or IRE) or allowing non permeant molecules (drugs, DNA) to penetrate the cells. EPN opens new perspectives for cancer treatment (electrochemotherapy, or ECT) and for gene therapy. In spite of its advantages, applications of EPN are still limited because of the scarcity of quantitative data concerning the reaction of tissues following electric pulses. Moreover, due to the lack of reliable tools for treatment planning, most clinical applications deal with superficial tumors in patients treated in more than 130 EU cancer centers using validated standard operating procedures. However the more difficult treatment of deep-seated tumors is still at the stage of academic research and a crucial challenge for forthcoming cancer therapies. This project aims at investigating how EPN can be effectively modeled, from the scale of cell up to the scale of tissue, and how molecular uptake holds and is enhanced by electric field delivery. To develop a dynamic model of tissue EPN, two approaches will be followed: one derived from the macroscopic scale (ad hoc tissue model) and the other from the microscopic scale using homogenization techniques. In order to enable accurate elaboration of the models, experiments will be carried out on raw potato tubers, HEK-293 (Human Embryonic Kidney) cell aggregates and on mice liver and muscle. The transport of molecules through the tissue, which is also a bottleneck, will be overcome thanks to a porous medium approach, which will provide qualitative and quantitative behaviour of the transport in the tissue.



### 8.2.2. *Plan Cancer METASIS*

- Project acronym - Plan Cancer METASIS
- Partner - Laboratory of Biology, Bordeaux University
- Duration - from 2013 to 2015
- Coordinator - A. Bikfalvi
- Team participants - S. Benzekry, Th. Colin, C. Poignard, O. Saut
- Title - Modeling the Interaction of the (Metastasis) Vascular/Tumor Niche Using a Systems Biology Approach

### 8.2.3. *Plan Cancer MIMOSA*

- Project acronym - Plan Cancer MIMOSA (Physique, Mathématiques et Sciences de l'ingénieur appliqués au Cancer)
- Partner - Laboratory of Biology, Bordeaux University
- Duration - from 2014 to 2017
- Coordinator - Th. Colin
- Team participants - S. Benzekry, Th. Colin, C. Poignard, O. Saut
- Title - Mathematical modeling for exploration of the impact of mechanical constraints on tumor growth

### 8.2.4. *A\*Midex MARS*

- Project acronym - A\*Midex MARS
- Partner - Service d'Oncologie Multidisciplinaire & Innovations Thérapeutiques, Hopitaux de Marseille
- Duration - from 2014 to 2016
- Coordinator - F. Barlesi
- Team participant - S. Benzekry
- Title - Modeling Anticancer Research & Simulation

### 8.2.5. *PEPS CNRS*

- Project acronym - PEPS Electroporation
- Partners - Lab Ampère-Lyon and Equipe Inria MONC-Talence
- Duration - June-Dec 2015
- Leader - D. Voyer, Lab. Ampère / Local leader - C. Poignard

## 8.3. International Initiatives

### 8.3.1. *Inria International Partners*

#### 8.3.1.1. *Informal International Partners*

##### **LIA EBAM**

- Title - LIA EBAM
- Partners - University of Ljubljana, IPBS, Institut Gustave Roussy, XLim, Institute of Oncologie, Ljubljana and Equipe Inria MONC-Talence
- Duration - 2015-2019 (renewal)
- Leader - L.M. Mir / Local leader - C. Poignard

- The main aim of the LIA EBAM is to use an interdisciplinary approach, integrating biology, chemistry, physics, biophysics, mathematics, computational modelling and engineering, through the expertise of its members in order to 1- Enhance our understanding on the mechanisms of classical electroporation and of the new nanoelectroporation (electroporation using nanosecond electric pulses), as well as on the mechanisms of transmembrane transport of molecules into electroporated cells and tissues on a microscopic and macroscopic scale. 2- Contribute to a better and safer implementation of the electroporation-based applications, and to the development of new applications. 3- Develop new devices and new equipment for the nanoelectroporation at cell and tissue levels. 4- Develop new approaches like treatment planning in existing applications, such as antitumor electrochemotherapy and in vivo gene transfer for therapeutic purposes. 5- Disseminate the knowledge and the applications in the scientific community and in the society, through publications, a one-week course (already implemented) co-directed by the LEA directors, internal and external training, and through other means that the LEA will develop and/or will apply for (to the EC programs for example). Partners participating in the project possess complementary knowledge and skills, which only if brought together will allow for successful accomplishments of the above objectives.

#### **JSPS Core-to-Core Program on Establishing International Research Network of Mathematical Oncology**

- Title - JSPS Core-to-Core Program on Establishing International Research Network of Mathematical Oncology
- Partners - Osaka University, Vanderbilt University, Dundee university and Equipe Inria MONC-Talence
- Duration - 2015-2019 (renewal)
- Leader - T. Suzuki, Osaka University / Local leader - C. Poinard
- Establishing International Research Network of Mathematical Oncology

**Collaboration with John Ebos**, Roswell Park Cancer Institute, Buffalo, NY, USA. Quantification of metastatic potential and differential effect of anti-angiogenic therapies on primary tumor and metastasis, in a preclinical setting.

## **8.4. International Research Visitors**

### **8.4.1. Visits of International Scientists**

- Tadeja Forjanic (PhD Student Ljubljana), 2 weeks in jan. 2015. *Tumor growth modeling after electroporation* (Local supervisor: C. Poinard)
- Ariff Admon (PhD Student Osaka University), 1month June 2015. *Free boundary problem for invadopodia*. (Local supervisor: C. Poinard)

## PLEIADE Team

# 7. Partnerships and Cooperations

## 7.1. National Initiatives

### 7.1.1. CAER – Alternative Fuels for Aeronautics

CAER is a 6 M-Euro contract with the Civil Aviation Directorate (Direction Générale de l'Aviation Civile, DGAC), coordinated by the French Petroleum Institute (Institut français de pétrole-énergies nouvelles, IFPEN) on behalf of a large consortium of industrial (EADS, Dassault, Snecma, Turbomeca, Airbus, Air France, Total) and academic (CNRS, INRA, Inria) partners to explore different technologies for alternative fuels for aviation. PLEIADE's role concerns the genomics of highly-performant oleaginous microorganisms.

## 7.2. International Initiatives

### 7.2.1. Inria International Partners

#### 7.2.1.1. Informal International Partners

PLEIADE collaborates with Rodrigo Assar of the Universidad Andrés Bello, and Nicolás Loira and Alessandro Maass of the Center for Genomic Regulation, in Santiago de Chile (Chile).

## 7.3. International Research Visitors

### 7.3.1. Visits of International Scientists

Rodrigo Assar, assistant professor in the ICBM Human Genetics Program of the School of Medicine of the University of Chile, was invited by PLEIADE in the context of an ongoing collaboration on hybrid, stochastic modeling of complex biological systems.

#### 7.3.1.1. Internships

Leyla Mirvakhabova, student at the National research University Higher School of Economics, Moscow, was invited by PLEIADE for an internship to work on faster mathematical methods for nonlinear mapping, to be applied to very large distance matrices.

Ulysse Guyet, Masters student in Bioinformatique-Biostatistique at the University of Nantes, was invited by PLEIADE for an intership to work on software components for transferring DNA sequence annotations from reference genomes to newly sequenced strains.

## **SISTM Project-Team**

# **8. Partnerships and Cooperations**

## **8.1. Regional Initiatives**

The team have strong links with Bordeaux CHU ("Centre Hospitalier Universitaire").

## **8.2. National Initiatives**

### **8.2.1. *Labex Vaccine Research Institute (VRI)***

There are strong collaborations with immunologists involved in the Labex Vaccine Research Institute (VRI) as RT is leading the Biostatistics/Bioinformatics division.

### **8.2.2. *Expert Appraisals***

Expertise of a project for Institut de Recherche en Santé Publique IRESP (MA)

RT is a member of the scientific advisory board of the Ebola VSV ring trial (published in New England Journal of Medicine in August 2015) and of the Pierre Louis Institute of Epidemiology and Public Health (Paris)

RT is a member of the Systems biology and cancer comity (Plan Cancer)

### **8.2.3. *Partnership with the french swimming federation***

Convention between the "Fédération française de natation" and Inria (18950 euros) for the R&D project "Quels schémas de périodisation pour la préparation des Jeux Olympiques à Rio ?"

### **8.2.4. *Partnership with ANSM***

DRUGS-SAFE platform funded by ANSM.

## **8.3. European Initiatives**

### **8.3.1. *Collaborations in European Programs, except FP7 & H2020***

Program: The EBOVAC2 project is one of 8 projects funded under IMI Ebola+ programme that was launched in response to the Ebola virus disease outbreak. The project aims to assess the safety and efficacy of a novel prime boost preventive vaccine regimen against Ebola Virus Disease (EVD).

Project acronym: EBOVAC2

Project title: EBOVAC2

Coordinator: Rdolphe Thiébaud

Other partners: Inserm (France), Labex VRI (France), Janssen Pharmaceutical Companies of Johnson & Johnson, London School of Hygiene & Tropical Medicine (United Kingdom), The Chancellor, Masters and Scholars of the University of Oxford (United Kingdom), Le Centre Muraz (Burkina Faso), Inserm Transfert (France)

Abstract: Given the urgent need for an preventive Ebola vaccine strategy in the context of the current epidemic, the clinical development plan follows an expedited scheme, aiming at starting a Phase 2B large scale safety and immunogenicity study as soon as possible while assuring the safety of the trial participants.

Phase 1 trials to assess the safety and immunogenicity data of the candidate prime-boost regimen in healthy volunteers are ongoing in the UK, the US and Kenya and Uganda. A further study site has been approved to start in Tanzania. Both prime-boost combinations (Ad26.ZEBOV prime + MVA-BN-Filo boost; and MVA-BN-Filo prime + Ad26.ZEBOV boost) administered at different intervals are being tested in these trials.

Phase 2 trials (this project) are planned to start as soon as the post-prime safety and immunogenicity data from the UK Phase I are available. Phase 2 trials will be conducted in healthy volunteers in Europe (France and UK) and non-epidemic African countries (to be determined). HIV positive adults will also be vaccinated in African countries. The rationale for inclusion of European volunteers in Phase 2, in addition to the trials in Africa, is to allow for higher sensitivity in safety signal detection in populations with low incidence of febrile illnesses, to generate negative control specimens for assay development, to allow for inclusion of health care workers or military personnel that may be deployed to Ebola-endemic regions.

## 8.4. International Initiatives

### 8.4.1. Participation In International Programs

RT is participating to the EUROCOORD network on HIV cohort collaborations as :  
 a member of the scientific committee of IWHOD International Workshop on HIV Observational Databases from 2013,  
 a project leader on defining references for the CD4 count response to antiretrovirals.

## 8.5. International Research Visitors

### 8.5.1. Visits of International Scientists

David Conesa (Associate Professor of Biostatistics, "Spatial and Temporal Statistics in Epidemiology and Environment" Research Group, Universitat de Val encia, Spain) visited the team through the Erasmus+ program.

Following the RHOME0 project (ANR-BBSRC Systems biology 2007 call, 2007-2011) steered by RT, a strong collaboration has been established with Pr Robin Callard (UCL Immunology) who is visiting the team in Bordeaux one month each year, Andy Yates (Physicists, Glasgow Univ) and Ben Seddon (NIMR, UCL Immunology).

Also, several other international collaboration have been initiated through the Labex:

Raphael Gottardo, Zoe Moodie, Steve Self in Seattle (HVTN HIV vaccine Trial Network, Fred Hutchinson cancer centre)

Marcus Altfeld (Immunologists, Hambourg & Harvard).

### 8.5.2. Visits to International Teams

#### 8.5.2.1. Sabbatical programme

BL was on sabbatical in Queensland University, Australia until Sep 2015.

#### 8.5.2.2. Research stays abroad

Chloé Pasin visited (from 11/10/14 to 10/04/15) Steve Self at HVTN, Seattle.

Chariff Alkhasim (from 07/04/15 to 10/04/15) visited François Caron at Oxford University, United-Kingdom. MA (from 24/02/15 to 10/03/15) and Perrine Soret (from 26/12/15 to 28/01/16) visited Cristian Meza and Karine Bertin (Inria Chili) at CIMFAV (Centre for Research and Modeling of Random Phenomena – Valparaiso), Univ Valparaiso, Chili, concerning the project "New challenges in mixed-effects models".

## HIEPACS Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. Innovative simulation methods for large scale numeric prototypes on emerging architectures computers

**Participants:** Emmanuel Agullo, Olivier Coulaud, Aurélien Esnard, Mathieu Faverge, Luc Giraud, Abdou Guermouche, Pierre Ramet, Jean Roman.

**Grant:** Regional council

**Dates:** 2013 – 2015

**Partners:** EPIs **REALOPT**, **STORM** from Inria Bordeaux Sud-Ouest, CEA-CESTA and l'Institut pluridisciplinaire de recherche sur l'environnement et les matériaux (IPREM) .

**Overview:** Numerical simulation is now integrated into all the design levels and the scientific studies for both academic and industrial contexts. Given the increasing size and sophistication of the simulations carried out, the use of parallel computing is inescapable. The complexity of such achievements requires collaboration of multidisciplinary teams capable of mastering all the necessary scientific skills for each component constituting the chain of expertise. In this project we consider each of these elements as well as efficient methods for parallel codes coupling. All these works are intended to contribute to the design of large scale parallel multi-physics simulations. In addition to this research human activities the regional council also support some innovative computing equipment that will be embedded in the PlaFRIM experimental platform, project led by O. Coulaud.

## 9.2. National Initiatives

### 9.2.1. Inria Project Lab

#### 9.2.1.1. C2S@Exa - Computer and Computational Sciences at Exascale

Since January 2013, the team is participating to the **C2S@EXA** Inria Project Lab (IPL). This national initiative aims at the development of numerical modeling methodologies that fully exploit the processing capabilities of modern massively parallel architectures in the context of a number of selected applications related to important scientific and technological challenges for the quality and the security of life in our society. At the current state of the art in technologies and methodologies, a multidisciplinary approach is required to overcome the challenges raised by the development of highly scalable numerical simulation software that can exploit computing platforms offering several hundreds of thousands of cores. Hence, the main objective of **C2S@EXA** is the establishment of a continuum of expertise in the computer science and numerical mathematics domains, by gathering researchers from Inria project-teams whose research and development activities are tightly linked to high performance computing issues in these domains. More precisely, this collaborative effort involves computer scientists that are experts of programming models, environments and tools for harnessing massively parallel systems, algorithmists that propose algorithms and contribute to generic libraries and core solvers in order to take benefit from all the parallelism levels with the main goal of optimal scaling on very large numbers of computing entities and, numerical mathematicians that are studying numerical schemes and scalable solvers for systems of partial differential equations in view of the simulation of very large-scale problems.

### 9.2.2. ANR

#### 9.2.2.1. SOLHAR: SOLvers for Heterogeneous Architectures over Runtime systems

**Participants:** Emmanuel Agullo, Mathieu Faverge, Abdou Guermouche, Xavier Lacoste, Pierre Ramet, Jean Roman, Guillaume Sylvand.

**Grant:** ANR-MONU

**Dates:** 2013 – 2017

**Partners:** Inria (**REALOPT**, **STORM** Bordeaux Sud-Ouest et **ROMA** Rhone-Alpes), IRIT/INPT, CEA-CESTA et Airbus Group Innovations.

**Overview:**

During the last five years, the interest of the scientific computing community towards accelerating devices has been rapidly growing. The reason for this interest lies in the massive computational power delivered by these devices. Several software libraries for dense linear algebra have been produced; the related algorithms are extremely rich in computation and exhibit a very regular pattern of access to data which makes them extremely good candidates for GPU execution. On the contrary, methods for the direct solution of sparse linear systems have irregular, indirect memory access patterns that adversely interact with typical GPU throughput optimizations.

This project aims at studying and designing algorithms and parallel programming models for implementing direct methods for the solution of sparse linear systems on emerging computer equipped with accelerators. The ultimate aim of this project is to achieve the implementation of a software package providing a solver based on direct methods for sparse linear systems of equations. To date, the approaches proposed to achieve this objective are mostly based on a simple offloading of some computational tasks to the accelerators and rely on fine hand-tuning of the code and accurate performance modeling to achieve efficiency. This project proposes an innovative approach which relies on the efficiency and portability of runtime systems. The development of a production-quality, sparse direct solver requires a considerable research effort along three distinct axes:

- linear algebra: algorithms have to be adapted or redesigned in order to exhibit properties that make their implementation and execution on heterogeneous computing platforms efficient and reliable. This may require the development of novel methods for defining data access patterns that are more suitable for the dynamic scheduling of computational tasks on processing units with considerably different capabilities as well as techniques for guaranteeing a reliable and robust behavior and accurate solutions. In addition, it will be necessary to develop novel and efficient accelerator implementations of the specific dense linear algebra kernels that are used within sparse, direct solvers;
- runtime systems: tools such as the **StarPU** runtime system proved to be extremely efficient and robust for the implementation of dense linear algebra algorithms. Sparse linear algebra algorithms, however, are commonly characterized by complicated data access patterns, computational tasks with extremely variable granularity and complex dependencies. Therefore, a substantial research effort is necessary to design and implement features as well as interfaces to comply with the needs formalized by the research activity on direct methods;
- scheduling: executing a heterogeneous workload with complex dependencies on a heterogeneous architecture is a very challenging problem that demands the development of effective scheduling algorithms. These will be confronted with possibly limited views of dependencies among tasks and multiple, and potentially conflicting objectives, such as minimizing the makespan, maximizing the locality of data or, where it applies, minimizing the memory consumption.

Given the wide availability of computing platforms equipped with accelerators and the numerical robustness of direct solution methods for sparse linear systems, it is reasonable to expect that the outcome of this project will have a considerable impact on both academic and industrial scientific computing. This project will moreover provide a substantial contribution to the computational science and high-performance computing communities, as it will deliver an unprecedented example of a complex numerical code whose parallelization completely relies on runtime scheduling systems and which is, therefore, extremely portable, maintainable and evolvable towards future computing architectures.

#### 9.2.2.2. *SONGS: Simulation Of Next Generation Systems*

**Participant:** Abdou Guermouche.

**Grant:** ANR 11 INFRA 13

**Dates:** 2011 – 2015

**Partners:** Inria (Bordeaux Sud-Ouest, Nancy - Grand Est, Rhone-Alpes, Sophia Antipolis - Méditerranée), I3S, LSIIT

**Overview:**

The last decade has brought tremendous changes to the characteristics of large scale distributed computing platforms. Large grids processing terabytes of information a day and the peer-to-peer technology have become common even though understanding how to efficiently exploit such platforms still raises many challenges. As demonstrated by the USS SimGrid project funded by the ANR in 2008, simulation has proved to be a very effective approach for studying such platforms. Although even more challenging, we think the issues raised by petaflop/exaflop computers and emerging cloud infrastructures can be addressed using similar simulation methodology.

The goal of the **SONGS** project is to extend the applicability of the SimGrid simulation framework from Grids and Peer-to-Peer systems to Clouds and High Performance Computation systems. Each type of large-scale computing system will be addressed through a set of use cases and lead by researchers recognized as experts in this area.

Any sound study of such systems through simulations relies on the following pillars of simulation methodology: Efficient simulation kernel; Sound and validated models; Simulation analysis tools; Campaign simulation management.

9.2.2.3. *ANEMOS: Advanced Numeric for ELMs : Modeling and Optimized Schemes*

**Participants:** Xavier Lacoste, Guillaume Latu, Pierre Ramet.

**Grant:** ANR-MN

**Dates:** 2012 – 2016

**Partners:** Univ. Nice, CEA/IRFM, CNRS/MDS.

**Overview:** The main goal of the project is to make a significant progress in understanding of active control methods of plasma edge MHD instabilities Edge Localized Modes (ELMs) which represent particular danger with respect to heat and particle loads for Plasma Facing Components (PFC) in ITER. The project is focused in particular on the numerical modelling study of such ELM control methods as Resonant Magnetic Perturbations (RMPs) and pellet ELM pacing both foreseen in ITER. The goals of the project are to improve understanding of the related physics and propose possible new strategies to improve effectiveness of ELM control techniques. The tool for the non-linear MHD modeling is the **JOEK** code which was essentially developed within previous ANR **ASTER**. **JOEK** will be largely developed within the present project to include corresponding new physical models in conjunction with new developments in mathematics and computer science strategy. The present project will put the non-linear MHD modeling of ELMs and ELM control on the solid ground theoretically, computationally, and applications-wise in order to progress in urgently needed solutions for ITER.

Regarding our contributions, the **JOEK** code is mainly composed of numerical computations on 3D data. The toroidal dimension of the tokamak is treated in Fourier space, while the poloidal plane is decomposed in Bezier patches. The numerical scheme used involves a direct solver on a large sparse matrix as a main computation of one time step. Two main costs are clearly identified: the assembly of the sparse matrix, and the direct factorization and solve of the system that includes communications between all processors. The efficient parallelization of **JOEK** is one of our main goals, to do so we will reconsider: data distribution, computation distribution or GMRES implementation. The quality of the sparse solver is also crucial, both in term of performance and accuracy. In the current release of **JOEK**, the memory scaling is not satisfactory to solve problems listed above, since at present as one increases the number of processes for a given problem size, the memory footprint on each process does not reduce as much as one can expect. In order to access finer meshes on available supercomputers, memory savings have to be done in the whole code. Another key point for improving parallelization is to carefully profile the application to understand the regions of the code that do not scale well. Depending on the timings obtained, strategies to diminish communication overheads will be evaluated and schemes that improve load balancing will be initiated. **JOEK** uses **PaStiX** sparse matrix library for matrix inversion. However, large number of toroidal harmonics and particular thin structures to resolve for realistic plasma parameters and ITER machine size still require more aggressive optimisation in numeric



dealing with numerical stability, adaptive meshes etc. However many possible applications of **JOEK** code we proposed here which represent urgent ITER relevant issues related to ELM control by RMPs and pellets remain to be solved.

#### 9.2.2.4. *RESCUE: Résilience des applications SCientifiqUEs*

**Participants:** Emmanuel Agullo, Luc Giraud, Abdou Guermouche, Jean Roman, Mawussi Zounon.

**Grant:** ANR-Blanc (computer science theme)

**Dates:** 2010 – 2015

**Partners:** Inria EPI **ROMA** (leader) and GRAND LARGE.

**Overview:** The advent of exascale machines will help solve new scientific challenges only if the resilience of large scientific applications deployed on these machines can be guaranteed. With 10,000,000 core processors, or more, the time interval between two consecutive failures is anticipated to be smaller than the typical duration of a checkpoint, i.e., the time needed to save all necessary application and system data. No actual progress can then be expected for a large-scale parallel application. Current fault-tolerant techniques and tools can no longer be used. The main objective of the **RESCUE** project is to develop new algorithmic techniques and software tools to solve the exascale resilience problem. Solving this problem implies a departure from current approaches, and calls for yet-to-be-discovered algorithms, protocols and software tools.

This proposed research follows three main research thrusts. The first thrust deals with novel checkpoint protocols. This thrust will include the classification of relevant fault categories and the development of a software package for fault injection into application execution at runtime. The main research activity will be the design and development of scalable and light-weight checkpoint and migration protocols, with on-the-fly storing of key data, distributed but coordinated decisions, etc. These protocols will be validated via a prototype implementation integrated with the public-domain MPICH project. The second thrust entails the development of novel execution models, i.e., accurate stochastic models to predict (and, in turn, optimize) the expected performance (execution time or throughput) of large-scale parallel scientific applications. In the third thrust, we will develop novel parallel algorithms for scientific numerical kernels. We will profile a representative set of key large-scale applications to assess their resilience characteristics (e.g., identify specific patterns to reduce checkpoint overhead). We will also analyze execution trade-offs based on the replication of crucial kernels and on decentralized ABFT (Algorithm-Based Fault Tolerant) techniques. Finally, we will develop new numerical methods and robust algorithms that still converge in the presence of multiple failures. These algorithms will be implemented as part of a software prototype, which will be evaluated when confronted with realistic faults generated via our fault injection techniques.

We firmly believe that only the combination of these three thrusts (new checkpoint protocols, new execution models, and new parallel algorithms) can solve the exascale resilience problem. We hope to contribute to the solution of this critical problem by providing the community with new protocols, models and algorithms, as well as with a set of freely available public-domain software prototypes.

#### 9.2.2.5. *DEDALES: Algebraic and Geometric Domain Decomposition for Subsurface/Groundwater Flows*

**Participants:** Emmanuel Agullo, Luc Giraud, Mathieu Faverge, Louis Poirel.

**Grant:** ANR-14-CE23-0005

**Dates:** 2014 – 2018

**Partners:** Inria EPI POMDAPI (leader); Université Paris 13 - Laboratoire Analyse, Géométrie et Applications; Maison de la Simulation; Andra.

**Overview:** Project **DEDALES** aims at developing high performance software for the simulation of two phase flow in porous media. The project will specifically target parallel computers where each node is itself composed of a large number of processing cores, such as are found in new generation many-core architectures. The project will be driven by an application to radioactive waste deep geological disposal. Its main feature is phenomenological complexity: water-gas flow in highly heterogeneous medium, with widely varying space and time scales. The assessment of large scale model is of major importance and issue for this application, and realistic geological models have several million grid cells. Few, if at all, software codes provide the necessary physical features with massively parallel simulation capabilities. The aim of the **DEDALES** project is to study, and experiment with, new approaches to develop effective simulation tools with the capability to take advantage of modern computer architectures and their hierarchical structure. To achieve this goal, we will explore two complementary software approaches that both match the hierarchical hardware architecture: on the one hand, we will integrate a hybrid parallel linear solver into an existing flow and transport code, and on the other hand, we will explore a two level approach with the outer level using (space time) domain decomposition, parallelized with a distributed memory approach, and the inner level as a subdomain solver that will exploit thread level parallelism. Linear solvers have always been, and will continue to be, at the center of simulation codes. However, parallelizing implicit methods on unstructured meshes, such as are required to accurately represent the fine geological details of the heterogeneous media considered, is notoriously difficult. It has also been suggested that time level parallelism could be a useful avenue to provide an extra degree of parallelism, so as to exploit the very large number of computing elements that will be part of these next generation computers. Project **DEDALES** will show that space-time DD methods can provide this extra level, and can usefully be combined with parallel linear solvers at the subdomain level. For all tasks, realistic test cases will be used to show the validity and the parallel scalability of the chosen approach. The most demanding models will be at the frontier of what is currently feasible for the size of models.

#### 9.2.2.6. *TECSER: Novel high performance numerical solution techniques for RCS computations*

**Participants:** Emmanuel Agullo, Luc Giraud, Matthieu Kuhn.

**Grant:** ANR-14-ASTRID

**Dates:** 2014 – 2017

**Partners:** Inria EPI NACHOS (leader), Corida, HiePACS; Airbus Group Innovations, Nucléutudes.

**Overview:** the objective of the TECSER projet is to develop an innovative high performance numerical methodology for frequency-domain electromagnetics with applications to RCS (Radar Cross Section) calculation of complicated structures. This numerical methodology combines a high order hybridized DG method for the discretization of the frequency-domain Maxwell in heterogeneous media with a BEM (Boundary Element Method) discretization of an integral representation of Maxwell's equations in order to obtain the most accurate treatment of boundary truncation in the case of theoretically unbounded propagation domain. Beside, scalable hybrid iterative/direct domain decomposition based algorithms are used for the solution of the resulting algebraic system of equations.

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

#### 9.3.1.1. HPC4E

Title: HPC for Energy

Programm: H2020

Duration: 2015 - 2018

Coordinator: Barcelona Supercomputing Center

Inria contact: Stephane Lanteri

Objectives: This project has three general objectives and a large list of specific technical objectives related with research in each technology:

1. The main objective is to develop beyond the state of the art high performance simulation tools that can help the energy industry to respond future energy demands and also to carbon related environmental issues using the state of the art HPC systems.
2. Improve the cooperation between energy industries from EU and Brazil. The project includes relevant energy industrial partners from Brazil and EU, which will benefit from the project's results. They guarantee that TRL of the project technologies will be very high
3. Improve the cooperation between the leading research centres in EU and Brazil in HPC applied to energy industry. This includes sharing supercomputing infrastructures between Brazil and EU. The cross fertilization between energy related problems and other scientific fields will be beneficial at both sides of the Atlantic.

#### 9.3.1.2. EXA2CT

Type: FP7

Defi: Special action

Instrument: Specific Targeted Research Project

Objectif: Exascale computing platforms, software and applications

Duration: September 2013 - August 2016

Coordinator: IMEC, Belgium

Partner: Particular specializations and experience of the partners are:

- Applications:
  - NAG - long experience in consultancy for HPC applications
  - Intel France - collaboration with industry on the migration of software for future HPC systems
  - TS-SFR - long experience in consultancy for HPC applications in Aerospace and Oil & Gas
- Algorithms – primarily numerical:
  - UA - broad experience in numerical solvers, with some taken up by the PETSc numerical library and other work published in high-ranking journals such as Science.
  - USI - expertise in parallel many-core algorithms for real-world applications on emerging architectures
  - Inria - expertise on large scale parallel numerical algorithms
  - IT4I - experience in the development of scalable solvers for large HPC systems (e.g. PRACE)
- Programming Models & Runtime Environments:
  - Imec - leads the programming model research within the Flanders ExaScience Lab
  - UVSQ - specialized in code optimization and performance evaluation in the area of HPC
  - TS-SFR - leading the BMBF funded GASPI project
  - Fraunhofer - developed a GASPI runtime environment used in industrial applications
- Hardware Optimization:
  - Intel France - investigates workloads for new hardware architectures within the context of the Exascale Computing Research centre

Inria contact: Luc Giraud

Abstract: The EXA2CT project brings together experts at the cutting edge of the development of solvers, related algorithmic techniques, and HPC software architects for programming models and communication. We will produce modular open source proto-applications that demonstrate the algorithms and programming techniques developed in the project, to help boot-strap the creation of genuine exascale codes.

Numerical simulation is a crucial part of science and industry in Europe. The advancement of simulation as a discipline relies on increasingly compute intensive models that require more computational resources to run. This is the driver for the evolution to exascale. Due to limits in the increase in single processor performance, exascale machines will rely on massive parallelism on and off chip, with a complex hierarchy of resources. The large number of components and the machine complexity introduce severe problems for reliability and programmability.

## 9.4. International Initiatives

We are involved in the Inria@SiliconValley initiative through the associate team FASTLA described below.

### 9.4.1. Inria Associate Teams not involved in an Inria International Labs

#### 9.4.1.1. MORSE

Title: Matrices Over Runtime Systems @ Exascale

International Partner (Institution - Laboratory - Researcher):

KAUST Supercomputing Laboratory (USA)

Duration: 2014 - 2016

See also: <http://icl.cs.utk.edu/projectsdev/morse/index.html>

The goal of Matrices Over Runtime Systems at Exascale (MORSE) project is to design dense and sparse linear algebra methods that achieve the fastest possible time to an accurate solution on large-scale multicore systems with GPU accelerators, using all the processing power that future high end systems can make available. To develop software that will perform well on petascale and exascale systems with thousands of nodes and millions of cores, several daunting challenges have to be overcome, both by the numerical linear algebra and the runtime system communities. By designing a research framework for describing linear algebra algorithms at a high level of abstraction, the MORSE team will enable the strong collaboration between research groups in linear algebra, runtime systems and scheduling needed to develop methods and libraries that fully benefit from the potential of future large-scale machines. Our project will take a pioneering step in the effort to bridge the immense software gap that has opened up in front of the High-Performance Computing (HPC) community.

#### 9.4.1.2. FASTLA

Title: Fast and Scalable Hierarchical Algorithms for Computational Linear Algebra

International Partner (Institution - Laboratory - Researcher):

Stanford University (USA)

Lawrence Berkeley National Laboratory (USA)

Duration: 2014 - 2016

See also: [http://people.bordeaux.inria.fr/coulaud/projets/FastLA\\_Website/](http://people.bordeaux.inria.fr/coulaud/projets/FastLA_Website/)

In this project, we propose to study fast and scalable hierarchical numerical kernels and their implementations on heterogeneous manycore platforms for two major computational kernels in intensive challenging applications. Namely, fast multipole methods (FMM) and sparse hybrid linear solvers, that appear in many intensive numerical simulations in computational sciences. Regarding the FMM we plan to study novel generic formulations based on  $\mathcal{H}$ -matrices techniques, that will be eventually validated in the field of material physics: the dislocation dynamics. For the hybrid solvers, new parallel preconditioning approaches will be designed and the use of  $\mathcal{H}$ -matrices techniques will be first investigated in the framework of fast and monitored approximations on central components. Finally, the innovative algorithmic design will be essentially focused on heterogeneous manycore platforms. The partners, Inria HiePACS, Lawrence Berkeley Nat. Lab and Stanford University, have strong, complementary and recognized experiences and backgrounds in these fields.

#### **9.4.2. Participation In other International Programs**

##### *9.4.2.1. HOSCAR*

We are involved in the Inria-CNPq **HOSCAR** project led by Stéphane Lanteri.

The general objective of the project is to setup a multidisciplinary Brazil-France collaborative effort for taking full benefits of future high-performance massively parallel architectures. The targets are the very large-scale datasets and numerical simulations relevant to a selected set of applications in natural sciences: (i) resource prospection, (ii) reservoir simulation, (iii) ecological modeling, (iv) astronomy data management, and (v) simulation data management. The project involves computer scientists and numerical mathematicians divided in 3 fundamental research groups: (i) numerical schemes for PDE models (Group 1), (ii) scientific data management (Group 2), and (iii) high-performance software systems (Group 3).

The final annual meeting has been organized in Inria Sophia, on September 21-24, 2015, while a follow-up of the project will exist as a H2020 project entitles HPC4E (HPC for Energy) to be started in 2016 with an enlarged partnership.

### **9.5. International Research Visitors**

#### **9.5.1. Visits to International Teams**

##### *9.5.1.1. Research stays abroad*

Mathieu Faverge has been invited to KAUST University from October to December 2015 in the context of the associate team **MORSE**.

Pierre Blanchard participated to the Gene Golub SIAM Summer school on Randomized Numerical Linear Algebra held in Delphi, Greece in June 2015.

## PHOENIX Project-Team

# 8. Partnerships and Cooperations

## 8.1. Regional Initiatives

### 8.1.1. HomeAssist: Platform for Assisted Living

The objective of this project is to provide an open platform of digital assistance dedicated to aging in place. This project is in collaboration with researchers in Cognitive Science (Bordeaux University) and the UDCCAS Gironde (Union Départementale des Centres Communaux d'Action Sociale) managing elderly care. This project includes a need analysis, the development of assistive applications and their experimental validation.

This work is funded by CARSAT Aquitaine (“Caisse d'Assurance Retraite et de la Santé au Travail”), Aquitaine Region and Conseil Général de la Gironde.

### 8.1.2. HomeAssist 500 – Populational Study

HomeAssist is an assisted living platform developed by the Phoenix research group at Inria. This platform has been applied to the domain of assisted living for the past two years. From the start, computer scientists and researchers in Ageing and Occupational Therapy have conducted this research effort in close collaboration with the stakeholders of aging in place. An initial set of applications has been developed, relying on a basic set of entities (sensors, actuators and web services). HomeAssist has been deployed in the homes of 24 older adults (matched with 24 control counterparts not equipped) and is currently being assessed. Although ongoing, the preliminary results of this field study show that the platform is well adopted (highly accepted and usable) by the older adults and their families or caregivers. Additionally, benefits from HomeAssist intervention have been demonstrated in terms of well-being, autonomy as well as quality of life (psychological health).

#### 8.1.2.1. A Randomized Controlled Trial (RCT) of HomeAssist

This RTC will be conducted with older adults, ranging from autonomous to mildly cognitively impaired (e.g., cognitive or physical frailty) Alzheimer disease (AD) in its early stage). The RCT is considered as the gold standard of a true experimental design. Furthermore, it provides strong evidence for causal relationships, as well as the ability to generalize the results to people outside the study's sample. The study design will thus be a single-blinded RCT. It will include up to 500 participants, matched with non-equipped participants. The HomeAssist intervention will involve monitoring as well as compensation services to support independent living in place. The duration of the HomeAssist intervention is of 12 months.

#### 8.1.2.2. Expected Impact on Elderly Care

**Prolonging ageing in place.** Our 12-month field study of a large group of participants, combined with a control group, will give a statistical basis to assess the efficacy of our platform to prolong ageing in place for a range of older adults, including participants with mild cognitive impairment. Functional status and nursing needs will be assessed through statistical analyses over the duration of the field study. Subjective and objective measures will be done using such tools as the Multilevel Assessment Instrument or Lawton Scale and the Time-Based IADL. These traditional assessments will be completed by longitudinal in situ actimetric data recorded at home via HomeAssist, for measuring the actual IADL performance.

Secondary criteria of technology efficacy will also be studied, including general cognitive status, memory and executive functioning.

**Improving well-being.** Socialization activities have proven to be a key factor in well-being. To promote socialization activities, our platform offers a variety of services ranging from the main tablet, running a digital picture frame connected to online albums, to a simplified email client, allowing responses to be voice-recorded, instead of typed on a keyboard. Our platform also supports autonomous realization of daily tasks, which is known to be related to older adult well-being. Additionally, to improve well-being, applications support self-regulation and self-determination in helping the users to conform to their own daily routines via sensor-based activity monitoring and assistive supports (e.g., activity reminders or prompts). Specific assessment tools will be used to measure the well-being and the self-efficacy of the participants over the duration of the study.

**Improving the efficiency of the caregiving environment.** The actions of the caregiving environment are often limited or impeded by the lack of a proxy at the older adult's home. Such a proxy is needed for a number of actions, including mutualizing the planning of care services, gathering information on older adult activities, reminding of activities and appointments, monitoring potentially unsafe activities and situations. Our online catalog already offers applications materializing a caregiving proxy; the HomeAssist project will expand this catalog with an emphasis on older adults with cognitive impairment. Questionnaires will be administered to caregivers to assess the reassurance impact of our platform in their daily delivery of services (e.g., feeling of burden assessment, Psychological health of caregivers).

#### 8.1.2.3. *Expected Impact on Pervasive Computing*

**Robustness.** The DiaSuiteBox platform will be deployed at a large scale, serving 500 users. This deployment will allow to further test the robustness of DiaSuiteBox beyond the current 24 users in Bordeaux. Various runtime logs will be collected to measure the performance and the behavior of DiaSuiteBox.

**Development of assistive applications.** Our existing experience in developing assistive applications will be significantly expanded by considering users with cognitive impairment. This situation will result in taking into account additional parameters in the user interactions. We will formalize and report on a methodology to assess users' need and develop assistive applications, leveraging our current experience and the one of HomeAssist.

**A validated assistive platform.** An outcome of the HomeAssist project is the validation of the DiaSuiteBox technology as a platform for assisted living. The project will provide a solid basis on which a technology transfer can be achieved. In particular, the following factors will be key measures of the readiness and potential of DiaSuiteBox: diversity of users participating in our field study, the range of applications developed, the variety of devices utilized. The questionnaires administered to the participants will be valuable information for elaborating marketing strategies of the DiaSuiteBox technology.

#### 8.1.2.4. *Technology Transfer*

An outcome of the HomeAssist-500 project is the validation of the DiaSuiteBox technology as a platform for assisted living. The project will provide a solid basis for the creation of a startup to market the technology. In particular, the following factors will be key measures of the readiness and potential of DiaSuiteBox: diversity of users participating in our field study, range of applications developed, variety of devices utilized, deployment in 500 homes for a period of 12 months. The questionnaires administered to the participants will be valuable information for elaborating marketing strategies for the DiaSuiteBox technology. Inria, which owns the intellectual property of DiaSuiteBox, is committed to providing the Inria Phoenix group with support to turn this technology into a marketable product.

This work is funded by European Regional Development Funds, CARSAT Aquitaine, (ERDF), Aquitaine Region, Réunica, Conseil Département de Gironde, RPDAD / UDCCAS Gironde, CNSA.

### 8.1.3. **ANDDI**

Five percent of the population have Intellectual Disabilities (ID). Individuals with ID have significant socio-adaptive limitations in a variety of daily activities, at home (task planification and execution, medication, home safety, etc.) as well as outside (route planning, itinerary in public transportation, etc.). Individuals with ID, their families, health institutions, caregiving services, and dedicated organizations strive to find ways in which these individuals can live as independently as possible, while promoting their social inclusion in every respect of their life (housing, professional training, employment, leisure, culture, etc.).

The research project ANDDI leverages the abilities of individuals with ID and the recent technological advances to develop a variety of assistive services addressing their daily needs. These services draw on our expertise in cognitive science and computer science, dedicated to assisting users with technologies. In particular, we use our platform, named HomeAssist, dedicated to the independently living of older adults. This platform relies on DiaSuite, our suite of tools for developing applications that orchestrate networked objects, and DiaSuiteBox, our platform that runs an open-ended set of applications, sensors, actuators and web services.



ANDDI addresses users with Down syndrome aiming to live independently; it pursues the following goals:

1. determining the key obstacles to perform daily activities autonomously and collecting the needs in assistive support expressed by individuals with ID and their family and caregivers;
2. developing and adapting assistive services available in HomeAssist across an iterative assessment (period of 6 months) of experiences of each individual;
3. evaluating the efficacy of our developed assistive services across the stages experienced by individuals progressively becoming independent in their daily life (pre-post comparison after 12 months of HomAssist intervention).

This project is the outcome of the OPALI project, described in Section 8.3.1.1, and is funded by the Aquitaine Region and “Trisomie 21 France”.

#### **8.1.4. Certification of an open platform**

The purpose of this project is to define concepts and tools for developing certifying open platforms. This certification process must ensure a set of critical properties (e.g., safety, confidentiality, security) by certifying each tier application. These guarantees are essential to ensure that openness does not come at the expense of the user’s well-being. To preserve the innovation model of open platforms, this certification process should also be as automatic as possible. Indeed, the success of open platforms is mainly due to the low development cost of a new application. The case study of this thesis will be the domain of home automation. The results of this thesis will be put into practice in the DiaSuiteBox open platform.

This project is funded by Aquitaine Region.

## **8.2. National Initiatives**

### **8.2.1. Objects’ World: design-driven development of large-scale smart spaces**

There are an abundance of research and industry initiatives that have been undertaken with the aim of promoting the emergence of Internet of Things. In line with this goal, the Object’s World project brings together stakeholders from different domains to build and support the emergence of an IoT sector in France and beyond. The project is lead by SIGFOX, the world’s first cellular network operator dedicated to low-bandwidth wireless objects. The cooperation between industry and research partners (e.g., sensor manufacturers, computer science and electrical engineering research labs) is of uttermost importance in overcoming technological barriers. This issue is currently hindering the development of an IoT sector. The main objectives of this project are the development of

- expertise in the low-bandwidth network sector,
- low-cost transmitter/receiver chips,
- low-energy autonomous sensors, and
- software frameworks which cover the entire lifecycle of IoT applications.

Network infrastructures that support huge numbers of objects open up a range of opportunities for innovative services. Critically, these new opportunities rely on the ability to address the software engineering challenges of this new sector. We promote an approach that revolves around software frameworks. In areas such as mobile and web development, this approach has already been shown to facilitate software development by abstracting over implementation details and guiding the programmer.

Our objective is to propose concepts and tools for developing reliable applications orchestrating large-scale smart spaces of networked entities. The industrial partners of the Objects’ World project will provide us with real-size case studies in various application domains (e.g., smart cities, tracking of vehicles, healthcare, energy management).

This work is funded by the OSEO national agency.



### **8.2.2. School Inclusion for Children with Autism**

The objective of this project is to provide children with assistive technologies dedicated to the school routines. This project is in collaboration with the “Handicap et Système Nerveux” research group (EA 4136, Bordeaux University), the PsyCLÉ research center (EA 3273, Provence Aix-Marseille University) and the “Parole et Langage” research laboratory (CNRS, Provence Aix-Marseille University).

This work is funded by the French Ministry of National Education and Orange Foundation.

## **8.3. International Initiatives**

### **8.3.1. Inria Associate Teams not involved in an Inria International Labs**

#### **8.3.1.1. OPALI**

Title: OPen Assistive-technology platform for independent LIving

International Partner (Institution - Laboratory - Researcher):

Université du Québec à Trois Rivières (Canada) - Self-Determination Assistive Technologies Research Chair (TSA Chair) - Dany Lussier-Desrochers

Start year: 2013

See also: <http://phoenix.inria.fr/opali>

The goal of the OPALI project is to develop an Open Platform for Assisted Living targeting users with cognitive disabilities. It is a cross-disciplinary project combining expertise in (1) Computer Science focusing in development of applications orchestrating networked devices and (2) Psychology focusing in assistive technologies for users with cognitive disabilities. Furthermore, this project will leverage a unique research vehicle created by the University of Trois-Rivières consisting of a full-fledged apartment equipped with a range of networked devices and dedicated to experimental studies. The outcome of the project will include a large catalog of assistive applications allowing to match each user’s project life.

## **8.4. International Research Visitors**

### **8.4.1. Visits of International Scientists**

Faustina HWang visited in June 2015. She is a professor at Reading University (UK). Her research interests concern assistive technologies, mainly for older adults and people with learning disabilities.

Matthew Goodwin visited in July 2015. He is a founding and key faculty member of a new doctoral program in Personal Health Informatics (PHI) and Director of the Computational Behavioral Science Laboratory (CBSL) at Northeastern University.

Myra Fernandes visited in September 2015. She is a professor at Waterloo University. Her research interests include memory, aging, Parkinson disorder, and virtual reality.

## STORM Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

**REGION AQUITAINE - CEA** The Aquitaine Region Council together with CEA is funding PhD thesis of Marc Sergent (2013-2016) on Scalability for Task-based Runtimes

**Labex CPU** The Labex CPU local cluster from the University of Bordeaux is funding the engineer position of Adrien Cassagne (2015-2016) to explore the optimization Error Correction Code (ECC) algorithms and simulation chains from IMS Laboratory using STORM software and expertise, for designing the upcoming 5G mobile phone communication technology.

## 9.2. National Initiatives

### 9.2.1. PIA

**ELCI** The ELCI project (Software Environment for HPC) aims to develop a new generation of software stack for supercomputers, numerical solvers, runtime and programming development environments for HPC simulation. The ELCI project also aims to validate this software stack by showing its capacity to offer improved scalability, resilience, security, modularity and abstraction on real applications. The coordinator is Bull, and the different partners are CEA, Inria, SAFRAN, CERFACS, CNRS CORIA, CENAERO, ONERA, UVSQ, Kitware and AlgoTech.

### 9.2.2. ANR

**ANR SOLHAR** (<http://solhar.gforge.inria.fr/doku.php?id=start>).

ANR MONU 2013 Program, 2013 - 2016 (36 months)

Identification: ANR-13-MONU-0007

Coordinator: Inria Bordeaux/LaBRI

Other partners: CNRS-IRIT, Inria-LIP Lyon, CEA/CESTA, EADS-IW

**Abstract:** This project aims at studying and designing algorithms and parallel programming models for implementing direct methods for the solution of sparse linear systems on emerging computers equipped with accelerators. The ultimate aim of this project is to achieve the implementation of a software package providing a solver based on direct methods for sparse linear systems of equations. Several attempts have been made to accomplish the porting of these methods on such architectures; the proposed approaches are mostly based on a simple offloading of some computational tasks (the coarsest grained ones) to the accelerators and rely on fine hand-tuning of the code and accurate performance modeling to achieve efficiency. This project proposes an innovative approach which relies on the efficiency and portability of runtime systems, such as the StarPU tool developed in the runtime team (Bordeaux). Although the SOLHAR project will focus on heterogeneous computers equipped with GPUs due to their wide availability and affordable cost, the research accomplished on algorithms, methods and programming models will be readily applicable to other accelerator devices such as ClearSpeed boards or Cell processors.

**ANR Songs** Simulation of next generation systems (<http://infra-songs.gforge.inria.fr/>).

ANR INFRA 2011, 01/2012 - 12/2015 (48 months)

Identification: ANR-11INFR01306

Coordinator: Martin Quinson (Inria Nancy)

Other partners: Inria Nancy, Inria Rhône-Alpes, IN2P3, LSIIT, Inria Rennes, I3S.

Abstract: The goal of the SONGS project is to extend the applicability of the SimGrid simulation framework from Grids and Peer-to-Peer systems to Clouds and High Performance Computation systems. Each type of large-scale computing system will be addressed through a set of use cases and lead by researchers recognized as experts in this area.

### 9.2.3. ADT - Inria Technological Development Actions

ADT K'Star (<http://kstar.gforge.inria.fr/#!/index.md>)

**Participants:** Olivier Aumage, Nathalie Furmento, Samuel Pitoiset, Samuel Thibault.

Inria ADT Campaign 2013, 10/2013 - 9/2015 (24 months)

Coordinator: Thierry Gautier (team AVALON, Inria Grenoble - Rhône-Alpes) and Olivier Aumage (team RUNTIME, Inria Bordeaux - Sud-Ouest)

Abstract: The Inria action ADT K'Star is a joint effort from Inria teams AVALON and RUNTIME to design the Klang-Omp source-to-source OpenMP compiler to translate OpenMP directives into calls to the API of AVALON and RUNTIME respective runtime systems (XKaaapi for AVALON, StarPU for RUNTIME).

### 9.2.4. IPL - Inria Project Lab

C2S@Exa - Computer and Computational Sciences at Exascale **Participant:** Olivier Aumage.

Inria IPL 2013 - 2017 (48 months)

Coordinator: Stéphane Lantéri (team Nachos, Inria Sophia)

Since January 2013, the team is participating to the C2S@Exa [http://www-sop.inria.fr/c2s\\_at\\_exa](http://www-sop.inria.fr/c2s_at_exa) Inria Project Lab (IPL). This national initiative aims at the development of numerical modeling methodologies that fully exploit the processing capabilities of modern massively parallel architectures in the context of a number of selected applications related to important scientific and technological challenges for the quality and the security of life in our society. This collaborative effort involves computer scientists that are experts of programming models, environments and tools for harnessing massively parallel systems, algorithmists that propose algorithms and contribute to generic libraries and core solvers in order to take benefit from all the parallelism levels with the main goal of optimal scaling on very large numbers of computing entities and, numerical mathematicians that are studying numerical schemes and scalable solvers for systems of partial differential equations in view of the simulation of very large-scale problems.

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

#### 9.3.1.1. INTERTWINE

Title: Programming Model INTERoperability ToWards Exascale

Programm: H2020

Duration: October 2015 - October 2018

Coordinator: EPCC

Partners:

Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)

Deutsches Zentrum für Luft - und Raumfahrt Ev (Germany)

Fraunhofer Gesellschaft Zur Forderung Der Angewandten Forschung Ev (Germany)

Institut National de Recherche en Informatique et en Automatique (France)

Kungliga Tekniska Hoegskolan (Sweden)

T-Systems Solutions for Research (Germany)  
The University of Edinburgh (United Kingdom)  
Universitat Jaume I de Castellon (Spain)  
The University of Manchester (United Kingdom)

Inria contact: Olivier Aumage

This project addresses the problem of programming model design and implementation for the Exascale. The first Exascale computers will be very highly parallel systems, consisting of a hierarchy of architectural levels. To program such systems effectively and portably, programming APIs with efficient and robust implementations must be ready in the appropriate timescale. A single, “silver bullet” API which addresses all the architectural levels does not exist and seems very unlikely to emerge soon enough. We must therefore expect that using combinations of different APIs at different system levels will be the only practical solution in the short to medium term. Although there remains room for improvement in individual programming models and their implementations, the main challenges lie in interoperability between APIs. It is this interoperability, both at the specification level and at the implementation level, which this project seeks to address and to further the state of the art. INTERTWinE brings together the principal European organisations driving the evolution of programming models and their implementations. The project will focus on seven key programming APIs: MPI, GASPI, OpenMP, OmpSs, StarPU, QUARK and PaRSEC, each of which has a project partner with extensive experience in API design and implementation. Interoperability requirements, and evaluation of implementations will be driven by a set of kernels and applications, each of which has a project partner with a major role in their development. The project will implement a co- design cycle, by feeding back advances in API design and implementation into the applications and kernels, thereby driving new requirements and hence further advances.

#### 9.3.1.2. *Mont-Blanc 2*

Title: Programming Model INTERoperability ToWards Exascale

Programm: H2020

Duration: Sep. 2013 - Sep. 2016

Coordinator: BSC

Partners: Atos/Bull, ARM, Jülich, LRZ, Univ. Stuttgart, CINECA, CNRS, CEA, Univ. Bristol, Allinea Software, Univ. Cantabria

Inria contact: Olivier Aumage

The Mont-Blanc project aims to develop a European Exascale approach leveraging on commodity power-efficient embedded technologies. The project has developed a HPC system software stack on ARM, and will deploy the first integrated ARM-based HPC prototype by 2014, and is also working on a set of 11 scientific applications to be ported and tuned to the prototype system.

#### 9.3.2. *Collaborations with Major European Organizations*

PRACE (Europe): Two-days training session on runtime systems, as part of the Prace Advanced Training Center Program (together with *La Maison de la Simulation*).

## 9.4. International Initiatives

### 9.4.1. *Inria Associate Teams not involved in an Inria International Labs*

MORSE Matrices Over Runtime Systems at Exascale

- Inria Associate-Teams program: 2011-2016
- Coordinator: Emmanuel Agullo (Hiepac)
- Partners: Inria (Runtime & Hiepac), University of Tennessee Knoxville, University of Colorado Denver and KAUST.

- Abstract: The Matrices Over Runtime Systems at Exascale (MORSE) associate team has vocation to design dense and sparse linear algebra methods that achieve the fastest possible time to an accurate solution on large-scale multicore systems with GPU accelerators, using all the processing power that future high end systems can make available. To develop software that will perform well on petascale and exascale systems with thousands of nodes and millions of cores, several daunting challenges have to be overcome both by the numerical linear algebra and the runtime system communities. With Inria Hiepacs, University of Tennessee, Knoxville and University of Colorado, Denver.

## TADAAM Team

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

### 8.1.1. ANR

*ANR Songs* Simulation of next generation systems (<http://infra-songs.gforge.inria.fr/>).

ANR INFRA 2011, 01/2012 - 12/2015 (48 months)

Identification: ANR-11INFR01306

Coordinator: Martin Quinson (Inria Nancy)

Other partners: Inria Nancy, Inria Rhône-Alpes, IN2P3, LSIIT, Inria Rennes, I3S.

Abstract: The goal of the SONGS project is to extend the applicability of the SimGrid simulation framework from Grids and Peer-to-Peer systems to Clouds and High Performance Computation systems. Each type of large-scale computing system will be addressed through a set of use cases and lead by researchers recognized as experts in this area.

*ANR MOEBUS* Scheduling in HPC (<http://moebus.gforge.inria.fr/doku.php>).

ANR INFRA 2013, 10/2013 - 9/2017 (48 months)

Coordinator: Denis Trystram (Inria Rhône-Alpes)

Other partners: Inria Bordeaux Sud-Ouest, Bull/ATOS

Abstract: This project focuses on the efficient execution of parallel applications submitted by various users and sharing resources in large-scale high-performance computing environments

*ANR SATAS* SAT as a Service.

AP générique 2015, 01/2016 - 12-2019 (48 months)

Coordinator: Laurent Simon (LaBRI)

Other partners: CRIL (Univ. Artois), Inria Lille (Spirals)

Abstract: The SATAS project aims to advance the state of the art in massively parallel SAT solving. The final goal of the project is to provide a “pay as you go” interface to SAT solving services and will extend the reach of SAT solving technologies, daily used in many critical and industrial applications, to new application areas, which were previously considered too hard, and lower the cost of deploying massively parallel SAT solvers on the cloud.

### 8.1.2. IPL - Inria Project Lab

MULTICORE - Large scale multicore virtualization for performance scaling and portability

**Participants:** Emmanuel Jeannot.

Multicore processors are becoming the norm in most computing systems. However supporting them in an efficient way is still a scientific challenge. This large-scale initiative introduces a novel approach based on virtualization and dynamicity, in order to mask hardware heterogeneity, and to let performance scale with the number and nature of cores. It aims to build collaborative virtualization mechanisms that achieve essential tasks related to parallel execution and data management. We want to unify the analysis and transformation processes of programs and accompanying data into one unique virtual machine. We hope delivering a solution for compute-intensive applications running on general-purpose standard computers.

## 8.2. European Initiatives

### 8.2.1. Collaborations in European Programs, except FP7 & H2020

COLOC: the Concurrency and Locality Challenge (<http://www.coloc-itea.org>).

Program: ITEA2

Project acronym: COLOC

Project title: The Concurrency and Locality Challenge

Duration: November 2014 - November 2017

Coordinator: BULL/ATOS

Other partners: BULL/ATOS (France); Dassault Aviation (France) ; Enfeild AB (Sweden); Scilab entreprise (France); Teratec (France); Inria (France); Swedish Defense Research Agency - FOI (France); UVSQ (France).

Abstract: The COLOC project aims at providing new models, mechanisms and tools for improving applications performance and supercomputer resources usage taking into account data locality and concurrency.

NESUS: Network for Ultrascale Computing (<http://www.nesus.eu>)

Program: COST

Project acronym: NESUS

Project title: Network for Ultrascale Computing

Duration: April 2014 - April 2018

Coordinator: University Carlos III de Madrid

Other partners: more than 35 countries

Abstract: Ultrascale systems are envisioned as large-scale complex systems joining parallel and distributed computing systems that will be two to three orders of magnitude larger than today's systems. The EU is already funding large scale computing systems research, but it is not coordinated across researchers, leading to duplications and inefficiencies. The goal of the NESUS Action is to establish an open European research network targeting sustainable solutions for ultrascale computing aiming at cross fertilization among HPC, large scale distributed systems, and big data management. The network will contribute to glue disparate researchers working across different areas and provide a meeting ground for researchers in these separate areas to exchange ideas, to identify synergies, and to pursue common activities in research topics such as sustainable software solutions (applications and system software stack), data management, energy efficiency, and resilience. Some of the most active research groups of the world in this area are members of this proposal. This Action will increase the value of these groups at the European-level by reducing duplication of efforts and providing a more holistic view to all researchers, it will promote the leadership of Europe, and it will increase their impact on science, economy, and society.

### 8.2.2. Collaborations with Major European Organizations

Partner 1: INESC-ID, Lisbon, (Portugal)

Subject 1: Application modeling for hierarchical memory system

Partner 2: ETH Zurich (Switzerland)

Subject 2: Topology mapping

Partner 3: BSC, Barcelona (Spain)

Subject 3: High-performance communication on new architectures; load-balancing and meshing.

## 8.3. International Initiatives

### 8.3.1. Inria International Labs

JLPC Inria joint-Lab on Extreme Scale Computing:

Coordinators: Franck Cappello and Marc Snir.

Other partners: Argonne National Lab, Inria, University of Urbanna Champaign, Tokyo Riken, Jülich Supercomputing Center, Barcelona Supercomputing Center.

Abstract: The Joint Laboratory is based at Illinois and includes researchers from Inria, and the National Center for Supercomputing Applications, ANL, Riken, Jülich, and BSC. It focuses on software challenges found in extreme scale high-performance computers.

### 8.3.2. Inria International Partners

#### 8.3.2.1. Informal International Partners

Partner 1: ICL at University of Tennessee

Subject 1: on instrumenting MPI applications and modeling platforms (works on HWLOC take place in the context of the OPEN MPI consortium) and MPI and process placement

Partner 2: Cisco Systems

Subject 2: network topologies and platform models

Partner 3: UWLAX (Wisconsin)

Subject 3: network topology modeling

Partner 4: Intel

Subject 4: modeling many-core platforms and next-generation memory architectures

Partner 5: University of Tokyo and Riken

Subject 5: Adaptation of MPI and runtime systems to MIC processors.

Partner 6: Lawrence Livermore National Laboratory

Subject 6: Testing of the mapping features of SCOTCH on very large process graphs (more than two billion vertices) and very large target architectures (more than 200,000 parts).

## 8.4. International Research Visitors

### 8.4.1. Visits of International Scientists

#### 8.4.1.1. Internships

- Ivan Cores from Universidade da Coruña, Spain, visited us for 4 months and have worked on topology-aware malleability of MPI programs.
- Guillaume Houzeaux and Mariano Vazquez from BSC visited us for several days to work on particule and mesh based applications and new architectures.



## FLOWERS Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. Poppy Education

Poppy Education

Program: Feder - Région Aquitaine

Duration: January 2014 - December 2017

Coordinator: PY Oudeyer, Inria Flowers

Partners: Inria Flowers

Funding: 1 million euros (co-funded by Feder/EU Commission, Region Aquitaine and Inria)

Poppy Education aims to create, evaluate and disseminate pedagogical kits “turnkey solutions” complete, open-source and low cost, for teaching computer science and robotics. It is designed to help young people to take ownership with concepts and technologies of the digital world, and provide the tools they need to allow them to become actors of this world, with a considerable socio-economic potential. It is carried out in collaboration with teachers and several official french structures (French National Education/Rectorat, Highschools, engineering schools, ...). It targets secondary education and higher education, scientific literacy centers, Fablabs.

Poppy robotic platform used in the project is free hardware and software, printed in 3D, and is intended primarily for:

- learning of computer science and robotics,
- introduction to digital manufacturing (3D printing ...)
- initiation to the integration of IT in physical objects in humanoid robotics, mechatronics.
- artistic activities.

Educational sectors covered by the project are mainly: Enseignement d’exploration ICN en seconde, enseignement ISN en terminale S et bientôt en 1ère, filière STI2D, MPS seconde. Web: <http://www.poppy-project.org/education>.

### 9.1.2. ENSAM

The orientation of a (high school) student, choosing a career, is often based on an imagined representation of a discipline, sector of activity or training. Moreover, higher education is sometimes for a college student or a student a self centered universe, with inaccessible teaching methodologies and level of competence.

The Arts and Métiers campus at Bordeaux-Talence in partnership with Inria contributes with its educational and scientific expertise to the development of new teaching methods and tools. The objective is to develop teaching sequences based on a project approach relying on an attractive multidisciplinary technological system: the humanoid Inria Poppy robot. These teaching sequences will be built and tailored to different levels of training, from high schools to Engineer schools.

The new formation "Bachelor of Technology", started in September 2014 at Ensam Bordeaux, is resolutely turned towards a project based pedagogy, outlining concepts from concrete situations. The humanoid Inria Poppy robot offers an open platform capable of providing an unifying thread for the different subjects covered during the 3-years of the Bachelor formation: mechanics, manufacturing (3D printing), electrical, mechatronics, computer sciences, design. . .

For the 1st and 2nd year of the ENSAM Engineer cursus, the Poppy robot is now used to support the teaching and to conduct further investigation.

### 9.1.3. KidLearn and Region Aquitaine

A Conseil Régional d'Aquitaine Project (KidLearn, 2015-) began, coordinated by Manuel Lopes entitled KidLearn. Will fund 50% of a 3 years PhD student.

We propose here a research project that aims at elaborating algorithms and software systems to help humans learn efficiently, at school, at home or at work, by adapting and personalizing sequences of learning activities to the particularities of each individual student. This project leverages recent innovative algorithmic models of human learning (curiosity in particular, developed as a result of ERC European project of the Flowers team), and combines it with state-of-the-art optimization algorithms and an original integration with existing expert knowledge (human teachers). Given a knowledge domain and a set of possible learning activities, it will be able to propose the right activity at the right time to maximize learning progress. It can be applied to many learning situations and potential users: children learning basic knowledge in schools and with the support of their teachers, older kids using educational software at home, of adults needing to acquire new skills through professional training (“formation professionnelle”). Because it combines innovations in computational sciences (machine learning and optimization) with theories of human cognition (theories of human learning and of education), this project is also implementing a strong cross-fertilization between technology and human sciences (SHS).

### 9.1.4. Comacina Capsule Creative Art/Science project and Idex/Univ. Bordeaux

The artist community is a rich source of inspiration and can provide new perspectives to scientific and technological questions. This complementarity is a great opportunity that we want to enforce in the Poppy project by making the robot accessible to non-robotic-expert users. The Comacina project, in collaboration with the Flowers team and supported by funding from Idex/Univ. Bordeaux, explored the role of movements and light in expressing emotions: <http://comacina.org>. This project was implemented through several residencies during the year, and several performances at various cultural places in Aquitaine, including at Pole Evasion in Ambares-et-Lagrave. a report is available at <https://flowers.inria.fr/RencontreAutourDuGeste.pdf>. It benefited from funding from the Art/Science Idex call for project.

## 9.2. National Initiatives

F. Stulp: Collaboration: with Olivier Sigaud of the Institut des Systèmes Intelligents (ISIR) et de Robotique of Université Pierre et Marie Curie (UPMC) [37].

F. Stulp: Collaboration: with Xavier Lamy of Laboratoire d'Intégration de Systèmes et des Technologies of the Commissariat à l'énergie atomique et aux énergies alternatives (CEA-LIST) and Pedro Rodriguez-Ayerbe and Sami Tliba of Supélec [57], [58]. Funded by Digiteo, project “PrActIx”.

PY Oudeyer and M Lopes collaborated with Aymar de Rugy, Daniel Cattaert and Florent Palet (INCIA, CNRS/Univ. Bordeaux) about the design of myoelectric robotic prostheses based on the Poppy platform, and on the design of algorithms for co-adaptation learning between the human user and the prosthesis. This was funded by a PEPS CNRS grant.

A collaboration with the national InMediats project was organized around the Poppy project. InMediats is a national project gathering 6 science museums (Bordeaux, Rennes, Grenoble, Caen, Toulouse, Paris) that aims at setting large popular science actions allowing the general public to access the latest research and development <http://inmediats.fr/le-programme/>. In this context, the collaboration with the Flowers team consisted in setting up a network of educational activities around robotics and the use of the Poppy platform in the six towns, with the target to foster the discovery of robotics technologies and their societal dimensions: <http://inmediats.fr/poppy-lhistoire-dune-collaboration-inter-centre/>. In this context several successful workshops with the general public were organized.

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

#### 9.3.1.1. 3rd HAND

Title: Semi-Autonomous 3rd Hand

Programm: FP7

Duration: October 2013 - September 2017

Coordinator: Inria

Partners:

Technische Universitaet Darmstadt (Germany)

Universitaet Innsbruck (Austria)

Universitaet Stuttgart (Germany)

Inria contact: Manuel Lopes

Robots have been essential for keeping industrial manufacturing in Europe. Most factories have large numbers of robots in a fixed setup and few programs that produce the exact same product hundreds of thousands times. The only common interaction between the robot and the human worker has become the so-called 'emergency stop button'. As a result, re-programming robots for new or personalized products has become a key bottleneck for keeping manufacturing jobs in Europe. The core requirement to date has been the production in large numbers or at a high price. Robot-based small series production requires a major breakthrough in robotics: the development of a new class of semi-autonomous robots that can decrease this cost substantially. Such robots need to be aware of the human worker, alleviating him from the monotonous repetitive tasks while keeping him in the loop where his intelligence makes a substantial difference. In this project, we pursue this breakthrough by developing a semi-autonomous robot assistant that acts as a third hand of a human worker. It will be straightforward to instruct even by an untrained layman worker, allow for efficient knowledge transfer between tasks and enable an effective collaboration between a human worker with a robot third hand. The main contributions of this project will be the scientific principles of semi-autonomous human-robot collaboration, a new semi-autonomous robotic system that is able to: i) learn cooperative tasks from demonstration; ii) learn from instruction; and iii) transfer knowledge between tasks and environments. We will demonstrate its efficiency in the collaborative assembly of an IKEA-like shelf where the robot acts as a semiautonomous 3rd-Hand. <http://www.3rdhandrobot.eu>

#### 9.3.1.2. DREAM

Title: Deferred Restructuring of Experience in Autonomous Machines

Programm: H2020

Duration: January 2015 - December 2018

Coordinator: UPMC

Partners:

Armines (ENSTA ParisTech)

Queen Mary University London (England)

University of A Coruna (Spain)

Vrije University Amsterdam (Holland)

Contact: David Filliat

Abstract: A holy grail in robotics and artificial intelligence is to design a machine that can accumulate adaptations on developmental time scales of months and years. From infancy through adulthood, such a system must continually consolidate and bootstrap its knowledge, to ensure that the learned knowledge and skills are compositional, and organized into meaningful hierarchies. Consolidation of previous experience and knowledge appears to be one of the main purposes of sleep and dreams for humans, that serve to tidy the brain by removing excess information, to recombine concepts to improve information processing, and to consolidate memory. Our approach – Deferred Restructuring of Experience in Autonomous Machines (DREAM) – incorporates sleep and dream-like processes

within a cognitive architecture. This enables an individual robot or groups of robots to consolidate their experience into more useful and generic formats, thus improving their future ability to learn and adapt. DREAM relies on Evolutionary Neurodynamic ensemble methods (Fernando et al, 2012 *Frontiers in Comp Neuro*; Bellas et al., *IEEE-TAMD*, 2010 ) as a unifying principle for discovery, optimization, re- structuring and consolidation of knowledge. This new paradigm will make the robot more autonomous in its acquisition, organization and use of knowledge and skills just as long as they comply with the satisfaction of pre-established basic motivations. DREAM will enable robots to cope with the complexity of being an information-processing entity in domains that are open-ended both in terms of space and time. It paves the way for a new generation of robots whose existence and purpose goes far beyond the mere execution of dull tasks. <http://www.robotsthatdream.eu>

### **9.3.2. Collaborations in European Programs, except FP7 & H2020**

#### **9.3.2.1. IGLU**

Title: Interactive Grounded Language Understanding (IGLU)

Programm: CHIST-ERA

Duration: October 2015 - September 2018

Coordinator: University of Sherbrooke, Canada

Partners:

University of Sherbrooke, Canada

Inria Bordeaux, France

University of Mons, Belgium

KTH Royal Institute of Technology, Sweden

University of Zaragoza, Spain

University of Lille 1 , France

University of Montreal, Canada

Inria contact: Manuel Lopes

Language is an ability that develops in young children through joint interaction with their caretakers and their physical environment. At this level, human language understanding could be referred as interpreting and expressing semantic concepts (e.g. objects, actions and relations) through what can be perceived (or inferred) from current context in the environment. Previous work in the field of artificial intelligence has failed to address the acquisition of such perceptually-grounded knowledge in virtual agents (avatars), mainly because of the lack of physical embodiment (ability to interact physically) and dialogue, communication skills (ability to interact verbally). We believe that robotic agents are more appropriate for this task, and that interaction is a so important aspect of human language learning and understanding that pragmatic knowledge (identifying or conveying intention) must be present to complement semantic knowledge. Through a developmental approach where knowledge grows in complexity while driven by multimodal experience and language interaction with a human, we propose an agent that will incorporate models of dialogues, human emotions and intentions as part of its decision-making process. This will lead anticipation and reaction not only based on its internal state (own goal and intention, perception of the environment), but also on the perceived state and intention of the human interactant. This will be possible through the development of advanced machine learning methods (combining developmental, deep and reinforcement learning) to handle large-scale multimodal inputs, besides leveraging state-of-the-art technological components involved in a language-based dialog system available within the consortium. Evaluations of learned skills and knowledge will be performed using an integrated architecture in a culinary use-case, and novel databases enabling research in grounded human language understanding will be released. IGLU will gather an interdisciplinary consortium composed of committed and experienced researchers in machine learning, neurosciences and cognitive sciences, developmental robotics, speech and language technologies, and multimodal/multimedia signal processing. We expect to have key impacts in the development of more interactive and adaptable systems sharing our environment in everyday life. <http://iglu-chistera.github.io/>

## 9.4. International Initiatives

### 9.4.1. Inria Associate Teams not involved in an Inria International Labs

#### 9.4.1.1. NEUROCURIOSITY

Title: NeuroCuriosity

International Partner (Institution - Laboratory - Researcher):

University of Columbia (United States) - Neuroscience - Jacqueline Gottlieb

Start year: 2013

See also: <https://flowers.inria.fr/curiosity-information-seeking-and-attention-in-human-adults-models-and-experiments/>

One of the most striking aspects of human behavior is our enormous curiosity, drive for exploration. From a child feverishly examining a new toy with its hands and its eyes, to a tourist exploring a new city, to a scientist studying the brain, humans incessantly want to know. This exuberant curiosity shapes our private and social lives, and is arguably a key cognitive feature that allows our species to understand, control and alter our world. We aim to develop a novel unified biological and computational theory, which explains curiosity in the domain of visual exploration and attention as a deliberate decision motivated by learning progress. This theory will build and improve upon pioneer computational models of intrinsic motivation elaborated in developmental robotics, and be empirically evaluated in the context of visual exploration in monkeys through behavioral and brain imaging techniques. This will be the first attempt at a biological-computational framework of intrinsic motivation and perceptual exploration and their underlying cognitive mechanisms.

### 9.4.2. Inria International Partners

#### 9.4.2.1. Informal International Partners

AL Vollmer and PY Oudeyer continued a major collaboration with Katharina Rohlfing (**Univ. Paderborn, Germany**) and Britta Wrede (**CITEC/Univ. Bielefeld, Germany**) on the study of how interactional structures help learners to acquire sensorimotor and linguistic skills in interaction with teachers, and based on the development of a new framework for conceptualizing pragmatic frames.

In the context of the Neurocuriosity project, a collaboration was initiated with Celeste Kidd, **Rochester Baby Lab, Univ. Rochester, US**.

In the context of the SMART-E Marie Curie Project (<http://smart-e-mariecurie.eu>), Yasmin Ansari from **SSSA, Pisa, Italy**, is visiting the Flowers team for 3 months for a collaboration involving the study of how algorithms for active learning of inverse models can be applied to learn soft robot control.

In the context of our projects on educational robotics research and applications, Didier Roy and PY Oudeyer have collaborated with Francesco Mondada, Morgane Chevallier and Gordana Gerber (**EPFL, Lausanne**), and Stéphane Magnenat and Fanny Riedo (**Mobsya association, Switzerland**).

Collaboration with Vittorio Loreto, Physics Department, Sapienza University of Rome, on statistical aspects of the Language Games. (W. Schueller and P.-Y. Oudeyer)

### 9.4.3. Participation In other International Programs

F. Stulp: Collaboration with Andrej Gams and Rok Vuga of the Josef Stefan Institute, Ljubljana, Slovenia. Funded by the “Programme Proteus 2015” for cooperations between France and Slovenia. Project “LoCoRoS”.

## **9.5. International Research Visitors**

### ***9.5.1. Visits of International Scientists***

- Marc Toussaint, University of Stuttgart, Sept 2015
- Michele Sebag, CNRS, Sept 2015
- Oliver Brock, Technical University of Berlin, Sept 2015
- Stephano Cerri, University of Montpellier, Sept 2015
- Pierre Bessi re, Univ. Paris VI and CNRS, april 2015
- Verena Hafner, Univ. Berlin, Germany, april 2015
- Jean-Baptiste Mouret, Inria, april 2015
- Yasmin Ansari, SSSA, Italy, december 2015

### ***9.5.2. Visits to International Teams***

- Pierre-Yves Oudeyer visited the SPECS Lab, Univ. Pompeu Fabra, Barcelona
- Pierre-Yves Oudeyer visited ISIR, Univ. Paris VI
- Pierre-Yves Oudeyer visited LPNC/GIPSA Lab, Grenoble

#### ***9.5.2.1. Research stays abroad***

- Manuel Lopes spent 2 weeks at the University of Columbia
- Anna-Lisa Vollmer is visiting Bielefeld University, Germany for a long-term research stay

## MANAO Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. Carer xD: "Caractérisation et restitution du réel xD"

Currently, the characterization and display of the real world are limited to techniques focusing on a subset of the necessary physical phenomena. A lot of work has been done to acquire geometric properties. However, the acquisition of a geometry on an object with complex reflection property or dynamic behavior is still a challenge. Similarly, the characterization of a material is limited to a uniform object for complex material or a diffuse material when one is interested in its spatial variations.

To reach full interaction between real and virtual worlds (augmented reality, mixed reality), it is necessary to acquire the real world in all its aspects (spatial, spectral, temporal) and to return it as in all these dimensions. To achieve this goal, a number of theoretical and practical tools will be developed around the development of mixed reality solutions and the development of some theoretical framework that supports the entire project.

## 9.2. National Initiatives

### 9.2.1. ANR

#### 9.2.1.1. "Young Researcher" RichShape (2014-2018)

MANAO

**Leader** G. Guennebaud

This project aims at the development of novel representations for the efficient rendering and manipulation of highly detailed shapes in a multi-resolution context.

#### 9.2.1.2. ALTA (2011-2016)

MAVERICK, REVES

**Leader** N. Holzschuch (MAVERICK)

The project ALTA aims at analyzing the light transport equations and at using the resulting representations and algorithms for more efficient computation. We target lighting simulations, either off-line, high-quality simulations or interactive simulations.

#### 9.2.1.3. ISAR (2014-2017)

POTIOC, MANAO, LIG-CNRS-UJF, Diotasoft

**Leader** M. Hachet (POTIOC)

The ISAR project focuses on the design, implementation and evaluation of new interaction paradigms for spatial augmented reality, and to systematically explore the design space.

#### 9.2.1.4. MATERIALS (2015-2019)

MAVERICK, LP2N-CNRS (MANAO), Musée d'Ethnographie de Bordeaux, OCÉ-Print

**Leader** N. Holzschuch (MAVERICK)

**Local Leader** R. Pacanowski (LP2N-CNRS)

Museums are operating under conflicting constraints: they have to preserve the artifacts they are storing, while making them available to the public and to researchers. Cultural artifacts are so fragile that simply exposing them to light degrades them. 3D scanning, combined with virtual reality and 3D printing has been used for the preservation and study of sculptures. The approach is limited: it acquires the geometry and the color, but not complex material properties. Current 3D printers are also limited in the range of colors they can reproduce. Our goal in this project is to address the entire chain of material acquisition and restitution. Our idea is to scan complex cultural artifacts, such as silk cloths, capturing all the geometry of their materials at the microscopic level, then reproduce them for study by public and researchers. Reproduction can be either done through 2.5D printing or virtual reality displays.

### 9.2.2. Competitiveness Clusters

#### 9.2.2.1. LabEx CPU

IMB (UPR 5251), LABRI (UMR 5800), Inria (CENTRE BORDEAUX SUD-OUEST), I2M (NEW UMR FROM 2011), IMS (UMR 5218), CEA/DAM

Some members of *MANAO* participate in the local initiative CPU. As it includes many thematics, from fluid mechanics computation to structure safety but also management of timetable, safety of networks and protocols, management of energy consumption, etc., numerical technology can impact a whole industrial sector. In order to address problems in the domain of certification or qualification, we want to develop numerical sciences at such a level that it can be used as a certification tool.

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

#### 9.3.1.1. PRISM

Title: Perceptual Representation of Illumination, Shape and Material

Programm: FP7

Duration: January 2013 - December 2016

Coordinator: JUSTUS-LIEBIG-UNIVERSITAET GIESSEN

Partners:

Justus-Liebig-Universitaet Giessen (Germany)

Katholieke Universiteit Leuven (Belgium)

Next Limit SI (Spain)

Technische Universiteit Delft (Netherlands)

the Chancellor, Masters and Scholars of The University of Cambridge (United Kingdom)

Bilkent Üniversitesi (Turkey)

Universite Paris Descartes (France)

The University of Birmingham (United Kingdom)

Local Leader: Pascal Barla

Visual perception provides us with a richly detailed representation of the surrounding world, enabling us to make subtle judgements of 1) 3D shape, 2) the material properties of objects, and 3) the flow of illumination within a scene. Together, these three factors determine the intensity of a surface in the image. Estimating scene properties is crucial for guiding action and making decisions like whether food is edible. Visual 'look and feel' also plays a key role in industrial design, computer graphics and other industries. Despite this, little is known about how we visually estimate the physical properties of objects and illumination. Previous research has mainly focussed on one or two of the three causal factors independently, and from the viewpoint of a specific discipline. By contrast, in PRISM we take an integrative approach, to understand how the brain creates a richly detailed representation of the world by looking at how all three factors interact simultaneously. PRISM is



radically interdisciplinary, uniting experts from psychology, neuroscience, computer science and physics to understand both the analysis and synthesis of shape, shading and materials. PRISM is intersectoral by uniting researchers from seven leading Universities and two industrial partners, enabling impact in basic research, technology and the creative industries. Through research projects, cross-discipline visits, and structured Course Modules delivered through local and network-wide training events, we will endow PRISM fellows with an unusually broad overview and the cross-sector skills they need to become future leaders in European research and development. Thus, by delivering early-career training embedded in a cutting-edge research programme, we aim to 1) springboard the next generation of interdisciplinary researchers on perceptual representations of 3D scenes and 2) cement long-term collaborations between sectors to enhance European perception research and its applications.

## **9.4. International Initiatives**

### **9.4.1. International Partners**

#### *9.4.1.1. Rainbow Particle Imaging Velocimetry*

**Partner :** KAUST - King Abdullah University of Science & Technology

We propose a new approach for snapshot imaging of time-resolved, non-stationary 3D fluid flows, which we term Rainbow Particle Imaging Velocimetry (RainbowPIV). Using only a single camera, RainbowPIV will be able to track a dense set of particles advected in the flow. This is achieved by illuminating the flow volume with a stack of monochromatic light planes at different wavelengths (a “rainbow”). Particles are tracked in 3D by both following their 2D spatial position and their change in color, depending on which light plane they traverse.

RainbowPIV will provide dense measurements of 3D velocity vectors, thus obtaining a dense 3D representation of a 3D velocity field. This will allow us to accurately image and understand many new types of flow, including turbulent flows within complex 3D geometries and particle trajectories, with limited optical access. After the initial exploration stage covered in this proposal, RainbowPIV could find many applications in science and engineering, for example to help understand combustion processes or flow through catalytic converters, between turbine blades, and inside inlet manifolds.

## POTIOC Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### Inria ADT Artik:

- duration: 2014-2016
- coordinator: J r my Laviol  & Martin Hachet
- The Artik projet is focused on the development of Papart (Paper Augmented Reality Toolkit). Papart is a toolkit that enables projector/cameras (ProCam) and depth camera to work together to create interactive surfaces. It works with consumer-available hardware and enables tabletop interactions, although high-end cameras and projectors are also well supported. Here are the major advances of the developments of 2015: The hardware is now managed with a dedicated application, each Papart application is now hardware agnostic. Extrinsic calibration of projector / color and depth cameras can be done with any application running, the calibration processing is now below 2 minutes. The touch detection can be tweaked to fit any surface: it has been tested on a table, wall, and floor with respectively finger, hand, and foot interaction. This project relies on open source software, we also maintain the support of Maven distribution for the Processing project.
- website: <https://team.inria.fr/potioc/scientific-subjects/papart/>

### Cap Sciences:

- Potioc has strong relationships with the Cap Sciences museum (<http://www.cap-sciences.net/>), especially through its Living Lab. In 2015, we have co-supervised a Master thesis on augmented interactive maps that was partly done at Cap Sciences and Inria-Potioc. We are currently investigating how this map prototype can be used in a smart city project with Cap Sciences.

### Immersion:

- Potioc has strong relationships with Immersion. In 2015, Immersion and Potioc notably co-supervised a Master student (Maxime Daniel) on the topic " valuation de la charge de travail, de l'attention, et de la reconnaissance d'erreur dans un environnement interactif par analyse EEG".

## 9.2. National Initiatives

### ANR Rebel:

- duration: 2016-2019
- coordinator: Fabien Lotte
- funding: ANR Jeune Chercheur Jeune Chercheuse Project
- partners: Disabilities and Nervous Systems Laboratory Bordeaux
- Brain-Computer Interfaces (BCI) are communication systems that enable their users to send commands to computers through brain activity only. While BCI are very promising for assistive technologies or human-computer interaction (HCI), they are barely used outside laboratories, due to a poor reliability. Designing a BCI requires 1) its user to learn to produce distinct brain activity patterns and 2) the machine to recognize these patterns using signal processing. Most research efforts focused on signal processing. However, BCI user training is as essential but is only scarcely studied and based on heuristics that do not satisfy human learning principles. Thus, currently poor BCI reliability is probably due to suboptimal user training. Thus, we propose to create a new generation of BCI that apply human learning principles in their design to ensure the users can learn high quality control skills, hence making BCI reliable. This could change HCI as BCI have promised but failed to do so far.

**HOBIT: Hybrid Optical Bench for Innovative Teaching:**

- duration: 2015-2017
- funding: Idex CPU & LAPHIA, and Inria ADT
- partners: Université de Bordeaux (IUT mesures physiques) & Université de Lorraine
- The goal of the Hobit project (Hybrid Optical Bench for Innovative Teaching) is to design a hybrid optical bench that benefits from both the physical and the virtual worlds to enhance teaching and training in the field of optics and photonics.

**ANR Project ISAR:**

- duration: 2014-2017
- coordinator: Martin Hachet
- partners: LIG-CNRS (Grenoble), Diotasoftware (Paris)
- acronym: Interaction en Réalité Augmentée Spatiale / Interacting with Spatial Augmented Reality
- The ISAR project (Interaction with Spatial Augmented Reality) focuses on the design, implementation, and evaluation of new paradigms to improve interaction with the digital world when digital content is directly projected onto physical objects (e.g. a ball on the figure). It opens new perspectives for exciting tomorrow's applications, beyond traditional screen-based applications.
- website: <https://team.inria.fr/potioc/scientific-subjects/papart/>

**Inria ADT OpenViBE-X:**

- duration: 2014-2016
- partners: Inria teams Hybrid and Athena
- coordinator: Maureen Clerc (Inria Sophia Antipolis)
- This is the follow-up project of OpenViBE-NT
- website: <http://openvibe.inria.fr>

**Inria Project Lab BCI-LIFT:**

- duration: 2015-2018
- partners: Inria team Athena (Inria Sophia-Antipolis), Inria team Hybrid (Inria Rennes), Inria team Neurosys (Inria Nancy), LITIS (Université de Rouen), Inria team DEMAR (Inria Sophia-Antipolis), Inria team MINT (Inria Lille), DyCOG (INSERM Lyon)
- coordinator: Maureen Clerc (Inria Sophia Antipolis)
- Project around BCI in the evaluation process, first meeting with all the partners was in October 2013
- The aim is to reach a next generation of non-invasive Brain-Computer Interfaces (BCI), more specifically BCI that are easier to appropriate, more efficient, and suit a larger number of people. With this concern of usability as our driving objective, we will build non-invasive systems that benefit from advanced signal processing and machine learning methods, from smart interface design, and where the user immediately receives supportive feedback. What drives this project is the concern that a substantial proportion of human participants is currently categorized "BCI-illiterate" because of their apparent inability to communicate through BCI. Through this project we aim at making it easier for people to learn to use the BCI, by implementing appropriate machine learning methods and developing user training scenarios.
- website: <http://bci-lift.inria.fr/>

**Helios:**

- duration: 2014-2015
- partners: Université de Lorraine
- funding: SATT Nancy Grand Est
- coordinator: Stéphanie Fleck (Université de Lorraine)
- The Helios project aims to provide a methodology and innovative media for the improvement of learning of basic astronomical phenomena for school groups (8-11 years). As part of this project, Potioc will focus on the development of the final application for augmented reality based and 3D manipulation, for providing a high-fidelity prototype.

### 9.3. European Initiatives

#### 9.3.1. Collaborations in European Programs, except FP7 & H2020

**Assessing and Optimising Human-Machine Symbiosis through Neural signals for Big Data Analytics:**

- duration: 2014-2018
- partners: Ulster University (UK)
- funding: DGA-DSTL project
- This project objective is to design new tools for Big Data analysis, and in particular visual analytics tools that tap onto human cognitive skills as well as on Brain-Computer Interfaces. The goal is to enable the user to identify and select relevant information much faster than what can be achieved by using automatic tools or traditional human-computer interfaces. More specifically, this project will aim at identifying in a passive way various mental states (e.g., different kinds of attention, mental workload, relevant stimulus perception, etc.) in order to optimize the display, the arrangement of the selection of relevant information.

#### 9.3.2. Collaborations with Major European Organizations

Collaboration with the University of Sussex, Brighton, Interact Lab, UK (Head: Pr. Sriram Subramanian)

- We have strong relationships with Sriram Subramanian. This has led to joint paper publications, numerous visits and a co-supervision of a PhD thesis (Camille Jeunet).

Bordeaux Idex project "Conception de Système d'interfaces cerveau-ordinateur prenant en compte les facteurs humains afin d'optimiser l'apprentissage de l'utilisateur" for international PhD project

- partners: Bordeaux Segalen University (Handicap & Système nerveux team), Bristol University (BIG team)
- duration: October 2013 - September 2016

## **9.4. International Initiatives**

### **9.4.1. Inria International Partners**

#### *9.4.1.1. Informal International Partners*

- Pr. Roger N’KAMBOU, department of Computer Sciences at the UQAM (Université du Québec à Montréal) who is a specialist of Intelligent Tutoring Systems (ITS). We are collaborating with him to develop such a system in order to optimise human learning in Brain-Computer Interfaces (BCI), and thus improve the performances with such systems.
- We are collaborating with Dr. Cuntai Guan (I2R, Singapore), Pr. Jonathan Bromberg (Kansas University, USA) and Pr. Gerwin Schalk (Wadsworth center, USA) on ElectroCorticoGraphic (ECoG) signal analysis.
- We are collaborating with Prof. Johannes Schoening (Univ. Hasselt, Belgium), Prof. Beat Signer (Vrije Universiteit Brussel, Belgium) and Dr. Brent Hecht (University of Minnesota, USA) on customization of geographic maps.

## **9.5. International Research Visitors**

### **9.5.1. Visits of International Scientists**

- Pr. Pierre Dillenbourg, EPFL, visited team Potioc in April, 2015
- Dr. Thorsten Zander, group leader at TU Berlin, Germany, visited team Potioc from November to December 2015 with two of his students (Lena M. Andreessen and Laurens R. Krol)
- Pr. Sriram Subramanian, University of Sussex, visited team Potioc in December 2015

### **9.5.2. Visits to International Teams**

#### *9.5.2.1. Research stays abroad*

- Jérémy Frey was working at the INRS in Montreal, Canada, in the MuSAE (Multimedia/Multimodal Signal Analysis and Enhancement) laboratory of Prof. Tiago H. Falk, from October to November 2015
- Camille Jeunet was working at the University of Sussex, Brighton, UK, in the Interact Lab of Pr. Sriram Subramanian, from November 2015 to January 2016.
- Fabien Lotte was working at the Sugiyama Laboratory, The University of Tokyo, Japan, from July to August 2015