



RESEARCH CENTER  
Sophia Antipolis - Méditerranée

FIELD

Activity Report 2016

# Section Partnerships and Cooperations

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## AOSTE Project-Team

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

### 8.1.1. ANR

#### 8.1.1.1. HOPE

**Participants:** Carlos Gomez Cardenas, Ameni Khecharem, Emilien Kofman, Robert de Simone.

The **ANR HOPE** project focused on hierarchical aspects for the high-level modeling and early estimation of power management techniques, with potential synthesis in the end if feasible. Partners were Intel, Synopsys, Magillem, UNS UMR LEAT, and ourselves.

We defined a multi-view, Model-Based design environment named MuVarch, accounting for power-level and performance of embedded hardware architectures, together with representation of abstract applications defining typical use cases fro these platforms.

Started in November 2013, the project reached its completion in February 2016, while Ameni Khecharem PhD defense took place in April 2016 [16].

#### 8.1.1.2. GeMoC

**Participants:** Matias Vara Larsen, Julien Deantoni, Frédéric Mallet.

This project was administratively handled by CNRS for our joint team, on the UMR I3S side. It ended September 2016. Partners were Inria (DiverSE EPC), ENSTA-Bretagne, IRIT, Obeo, Thales TRT and Supelec. The project focused on the executable modeling of heterogeneous systems using Models of Computation and Communication described using meta-languages. Specifically, the operational semantics of languages were equipped with precise timely constraints specified in CCSL. There were many outputs from the project but, from AOSTE perspective, we essentially developped MoCCML, an extension of CCSL with constraint automata (already integrated to TimeSquare) and BCool, a language dedicated to coordination apttern specification, which is described as part of Matias Vara-Larsen PhD thesis[19]. All the development realized in this project will end up as the first official eclipse research consortium.

#### 8.1.1.3. FUI CLISTINE

**Participants:** Robert de Simone, Amin Oueslati, Emilien Kofman.

This project was started in Oct 2013, and provides PhD funding for Amine Oueslati. Partners are SynergieCAD (coordinator), Avantis, Optis, and the two EPIs Aoste and Nachos. The goal is to study the feasibility of building a low-cost, low-power "supercomputer", reusing ideas from SoC design, but this time with out-of-chip network "on-board", and out-of-the-shelf processor elements organized as an array. The network itself should be time predictable and highly parallel (far more than PCI-e for instance). We started a thorough classification of parallel program types (known as "Dwarfs" in the literature), to provide benchmarks and evaluate the platform design options.

#### 8.1.1.4. FUI Waruna

**Participants:** Liliana Cucu, Adriana Gogonel, Walid Talaboulma, Dorin Maxim.

This recent project was started in September 2015. It targets the creation of a framework allowing to connect different existing methods while enriching the description with Waruna results. This framework allows timing analyses for different application domains like avionics, railways, medical, aerospace, automotive, etc.

## 8.1.2. Investissements d'Avenir

### 8.1.2.1. DEPARTS

**Participants:** Liliana Cucu-Grosjean, Adriana Gogonel, Walid Talaboulma.

This project is funded by the BGLE Call (*Briques Logicielles pour le Logiciel Embarqué*) of the national support programme *Investissements d'Avenir*. Formally started on October 1st, 2012 with the kick-off meeting held on April, 2013 for administrative reasons. Research will target solutions for probabilistic component-based models, and a Ph.D. thesis should start at latest on September 2015. The goal is to unify in a common framework probabilistic scheduling techniques with compositional assume/guarantee contracts that have different levels of criticality.

#### 8.1.2.2. CLARITY

**Participants:** Frédéric Mallet, Julien Deantoni, Ales Mishchenko, Robert de Simone, Marie Agnès Peraldi-Frati.

This project is funded by the LEOC Call (*Logiciel Embarqué et Objets Connectés*) of the national support programme *Investissements d'Avenir*. It was started in September 2014, and a kick-off meeting was held on October 9th. Partners are: Thales (several divisions), Airbus, Areva, Altran, All4Tec, Artal, the Eclipse Fondation, Scilab Enterprises, CESAMES, U. Rennes, and Inria. The purpose of the project is to develop and promote an open-source version of the ARCADIA Melody system design environment from Thales, renamed CAPPELLA for that purpose.

Our technical contributions to the project achievement are described in subsection 6.2.

#### 8.1.2.3. Capacites

**Participants:** Liliana Cucu-Grosjean, Dumitru Potop-Butucaru, Yves Sorel, Walid Talaboulma.

This project is funded by the LEOC Call (*Logiciel Embarqué et Objets Connectés*) of the national support programme *Investissements d'Avenir*. It has started on November 1st, 2014 with the kick-off meeting held on November, 12th 2014. The project coordinator is Kalray, and the objective of the project is to study the relevance of Kalray-style MPPA processor array for real-time computation in the avionic domain (with partners such as Airbus for instance). The post-doc of Mihail Asavae and the PhD of Walid Talaboulma are funded on this contract.

## 8.2. European Initiatives

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

#### 8.2.1.1. ASSUME

**Participants:** Dumitru Potop-Butucaru, Keryan Didier, Liliana Cucu.

This project is funded by the ITEA3 program. It has started on September 1st 2015. Project coordinator is Daimler. ASSUME has funded the (now completed) post-doc of Raul Gorcitz, and funds the PhD thesis of Keryan Didier.

Future mobility solutions will increasingly rely on smart components that continuously monitor the environment and assume more and more responsibility for a convenient, safe and reliable operation. Currently the single most important roadblock for this market is the ability to come up with an affordable, safe multi-core development methodology that allows industry to deliver trustworthy new functions at competitive prices. ASSUME will provide a seamless engineering methodology, which addresses this roadblock on the constructive and analytic side.

In this project, most our effort goes to work package "Synthesis of Predictable Concurrent Systems", which we lead. Main scientific results of our work in this project have been presented in sections 6.11 and 6.12. In addition, we closely interacted with our industrial partners to determine their needs, and developed importer tools for their internal formalisms, including Scade v4 and internal formalisms used at Airbus (all importers were developed jointly with EPI PARKAS). This work also resulted in proposals to Airbus on the specification of certain non-functional properties (e.g. the atomic groups of operations that cannot be split during allocation and scheduling). By applying our prototype tools, we have also determined that the use case has significant potential parallelism and will achieve significant speedups through execution on the chosen target architecture (the many-core Kalray MPPA256).

## 8.3. International Initiatives

### 8.3.1. FM4CPS

Title: Formal Models and tools for Cyber-Physical Systems

International Partner (Institution - Laboratory - Researcher):

ECNU (China) - Artificial Intelligence Lab - Jifeng He

Start year: 2015

See also: <https://project.inria.fr/fm4cps/>

Cyber-Physical Systems (CPS) and the connected Internet of Things (IoT) are inherently heterogeneous systems, with ("cyber") computer digital parts interacting with their physical sensible environment, under user requirements for functional and temporal correctness. Thus, design of such systems as a whole requires a diversity of models, and the behavior orchestration between such models must be carefully defined and analyzed.

FM4CPS will address several facets of Formal Model-Driven Engineering for Cyber-Physical Systems and Internet of Things. The design of such large heterogeneous systems calls for hybrid modeling, and the combination of classes of models, most previously well-established in their own restricted area: Formal Models of Computations drawn from Concurrency Theory for the "cyber" discrete processors, timed extension and continuous behaviors for physical environments, requirement models and user constraints extended to non-functional aspects, new challenges for designing and analyzing large and highly dynamic communicating software entities. Orchestration and comparison of models, with their expressive power vs. their decidable aspects, shall be considered with the point of view of hybrid/heterogeneous modeling here. Main aspects are the various timing or quantitative structure extensions relying for instance on a hybrid logical clock model for the orchestration of underlying components.

The associated team aims at various level of research, from formal models, semantics, or complexity, to experimental tools development. This will start for example on one side with building a formal orchestration model for CPSs, based on an hybrid clock model that combine discrete and physical time, synchronous and asynchronous computations or communications. Another goal will be the study of expressiveness and decidability for CPS, based on dedicated sub-families of well-structured push-down systems, addressing both unbounded communication and time-sensitive models.

Beyond their own expertise in this field, the partners will build on the results of previous cooperations in the context of the Liama projects Hades and Tempo, and the associated team DAESD. The current proposal widely broadens the domain of collaboration, and with the inclusion, for the first time, of Jiao Tong University. We expect this is the first step towards the extension of LIAMA in Shanghai with the strengthening of the involvement of E.C.N.U., and the contribution of new top notch universities such as Jiaotong.

### 8.3.2. Inria International Partners

#### 8.3.2.1. Declared Inria International Partners

We have signed an agreement with the University of Verona, which covers joint activities (see section 6.7, together with the housing of interns.

## 8.4. International Research Visitors

### 8.4.1. Visits of International Scientists

#### 8.4.1.1. Internships

Nieto Luis Agustin

Date: Sep 2015 - Feb 2016

Institution: Universidad de Buenos Aires (Argentina)

## AROMATH Project-Team

# 7. Partnerships and Cooperations

## 7.1. Regional Initiatives

### 7.1.1. Inria SAM Action Transverse

**Participants:** Paul Görlach, Evelyne Hubert.

Finding biomarkers of abnormalities of the white matter is one important problem in dMRI processing. As these biomarkers need to be independent of the orientation of the head, they are functions of the rotational invariants of the shapes that characterize the diffusion probabilities in the white matter. While the situation is well understood for second order tensors, these are not powerful enough to represent crossings in the white matter. Acquisitions made with the HARDI scheme allow for a richer description of probabilities. In particular, the project-team ATHENA has modelled them as (positive) ternary quartics (symmetric tensors of order 4). But invariants of these quartics are not well known. For a long period, only six were known, when there should be at least 12. Strategies were developed in the project-team ATHENA to compute more invariants, either algebraic [25] or polynomial [21]. The former suffered some instability issues in their evaluations, the latter did not form a minimal set. The goal of this "Transverse action" was to team up with expertise in algebraic computation and leverage the methods [23], [24], [22] [19], [7] developed in the project team AROMATH to gain more insight in this problem of rotational invariants of ternary quartics.

This action is done in collaboration with Théodore Papadopoulo (ATHENA team).

### 7.1.2. CIMI thematic project

**Participant:** Evelyne Hubert.

Labex CIMI Toulouse supports the project *Joint Implicit and Parametric Representation based on Skeleton* where the PI are Géraldine Morin (IRIT, Vortex team) and Evelyne Hubert. This project aims at developing a mathematical model and software for surfaces, based on a joint parametric and implicit representation, with a skeleton.

## 7.2. European Initiatives

### 7.2.1. FP7 & H2020 Projects

Program: Marie Skłodowska-Curie ITN

Project acronym: ARCADES

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

Duration: January 2016 - December 2019

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

Scientist-in-charge at Inria: L. Busé

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

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

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

## 7.3. International Initiatives

### 7.3.1. Participation in Other International Programs

#### 7.3.1.1. PICS project

**Participant:** Laurent Busé.

We participate to a bilateral collaboration between France and Spain which is supported as a PICS from CNRS. This project, titled *Diophantine Geometry and Computer Algebra*, aims at exploring interactions between diophantine geometry and computer algebra by stimulating collaborations between experts in both domains. The research program focuses on five particular topics : toric varieties and height, equidistribution, Diophantine geometry and complexity, factorization of multivariate polynomials by means of toric geometry and study of singularities of toric parameterizations.

The Spanish partner is the University of Barcelona, with participants J. Burgos, C. D'Andrea, Martin Sombra, and the French partners are the university of Caen, with participants F. Amoroso and M. Weimann, the University of Paris 6, with participants M. Chardin and P. Philippon and the Inria project-team AROMATH, with participant L. Busé.

#### 7.3.1.2. SYRAM project

**Participants:** Laurent Busé, Bernard Mourrain, André Galligo.

**Title:** Geometry of SYzygies of RAtional Maps with applications to geometric modeling (SYRAM)

We coordinate a research project which is funded by the regional program Math-AmSud for two years : 2015-2016. This project is composed by research teams from Argentina, Universidad de Buenos Aires (Nicolás Botbol, Alicia Dickenstein), Brazil, Universidade Federal de Rio de Janeiro, de Pernambuco e de Sergipe (Sayed Hamid Hassanzadeh, Aron Simis) and France, Institut de Mathématiques de Jussieu (Marc Chardin) and the Inria project-team AROMATH.

The study of rational maps is of theoretical interest in algebraic geometry and commutative algebra, and of practical importance in geometric modeling. This research proposal focuses on rational maps in low dimension, typically parameterizations of curves and surfaces embedded in the projective space of dimension three, but also dominant rational maps in dimension two and three. The two main objectives amount to unravel geometric properties of these rational maps from the syzygies of their projective coordinates. The first one aims at extending and generalizing the determination of the closed image of a rational map, as well as its geometric features, whereas the second one will focus on the study of dominant rational maps, in particular on the characterization of those that are generically one-to-one.



## **7.4. International Research Visitors**

### **7.4.1. Visits of International Scientists**

Cordian Riener (University of Konstanz, Germany) visited from September 4-9th, 2016 to collaborate on symmetry, orthogonal polynomials and cubature with Evelyne Hubert and Bernard Mourrain.

Lan Nguyen (University of Vietnam at Hanoi) visited to collaborate on implicitization of rational maps with Laurent Busé. His visits received the financial support of LIAFV (International Laboratory for France-Vietnam collaborations in mathematics).

Aron Simis (University of Pernambuco, Brazil) visited to collaborate on syzygies of rational maps with Laurent Busé.

Nicolas Botbol (Universidad de Buenos Aires, Argentina) visited to collaborate on distance function to rational curves and surfaces with Laurent Busé.

#### *7.4.1.1. Internships*

Paul Görlach (University of Bonn) came to work on the *CRISAM - Transverse action* between the project teams AROMATH and ATHENA (August-December).

Akshit Goyal and Deepak Bhatt (IIT Dehli) worked during their internship on “Meshing Singular Isosurfaces” and “Isosurface of the distance function” (May-July).

Antoine Deharveng, student at the engineer school of the University of Nice Sophia Antipolis, came since June 15 to work on the extraction of geometric primitives in a 3D point cloud under the supervision of Laurent Busé.

### **7.4.2. Visits to International Teams**

#### *7.4.2.1. Sabbatical programme*

Evelyne Hubert was in Ontario from September 1st 2015 to February 29th 2016, with the sabbatical programme of Inria DPEI. For the period of January and February 2016 she was hosted and supported by University of Waterloo, visiting the Symbolic Computation Lab, and more particularly Pr. George Labahn.

Bernard Mourrain was invited at Univ. of Texas, Austin, for a collaboration with Pr. Chandajit Bajaj (7th-19th May).

## DATASHAPE Team

# 9. Partnerships and Cooperations

## 9.1. National Initiatives

### 9.1.1. ANR

#### 9.1.1.1. ANR TOPDATA

**Participants:** Jean-Daniel Boissonnat, Frédéric Chazal, David Cohen-Steiner, Mariette Yvinec, Steve Oudot, Marc Glisse.

- Acronym : TopData.
- Type : ANR blanc.
- Title : Topological Data Analysis: Statistical Methods and Inference.
- Coordinator : Frédéric Chazal (DATASHAPE).
- Duration : 4 years starting October 2013.
- Others Partners: Département de Mathématiques (Université Paris Sud), Institut de Mathématiques (Université de Bourgogne), LPMA (Université Paris Diderot), LSTA (Université Pierre et Marie Curie).
- Abstract: TopData aims at designing new mathematical frameworks, models and algorithmic tools to infer and analyze the topological and geometric structure of data in different statistical settings. Its goal is to set up the mathematical and algorithmic foundations of Statistical Topological and Geometric Data Analysis and to provide robust and efficient tools to explore, infer and exploit the underlying geometric structure of various data.

Our conviction, at the root of this project, is that there is a real need to combine statistical and topological/geometric approaches in a common framework, in order to face the challenges raised by the inference and the study of topological and geometric properties of the wide variety of larger and larger available data. We are also convinced that these challenges need to be addressed both from the mathematical side and the algorithmic and application sides. Our project brings together in a unique way experts in Statistics, Geometric Inference and Computational Topology and Geometry. Our common objective is to design new theoretical frameworks and algorithmic tools and thus to contribute to the emergence of a new field at the crossroads of these domains. Beyond the purely scientific aspects we hope this project will help to give birth to an active interdisciplinary community. With these goals in mind we intend to promote, disseminate and make our tools available and useful for a broad audience, including people from other fields.

- See also: <http://geometrica.saclay.inria.fr/collaborations/TopData/Home.html>

## 9.2. European Initiatives

### 9.2.1. FP7 & H2020 Projects

#### 9.2.1.1. ERC GUDHI

Title: Algorithmic Foundations of Geometry Understanding in Higher Dimensions.

Program: FP7.

Type: ERC.

Duration: February 2014 - January 2019.

Coordinator: Inria.

PI: Jean-Daniel Boissonnat.

The central goal of this proposal is to settle the algorithmic foundations of geometry understanding in dimensions higher than 3. We coin the term geometry understanding to encompass a collection of tasks including the computer representation and the approximation of geometric structures, and the inference of geometric or topological properties of sampled shapes. The need to understand geometric structures is ubiquitous in science and has become an essential part of scientific computing and data analysis. Geometry understanding is by no means limited to three dimensions. Many applications in physics, biology, and engineering require a keen understanding of the geometry of a variety of higher dimensional spaces to capture concise information from the underlying often highly nonlinear structure of data. Our approach is complementary to manifold learning techniques and aims at developing an effective theory for geometric and topological data analysis. To reach these objectives, the guiding principle will be to foster a symbiotic relationship between theory and practice, and to address fundamental research issues along three parallel advancing fronts. We will simultaneously develop mathematical approaches providing theoretical guarantees, effective algorithms that are amenable to theoretical analysis and rigorous experimental validation, and perennial software development. We will undertake the development of a high-quality open source software platform to implement the most important geometric data structures and algorithms at the heart of geometry understanding in higher dimensions. The platform will be a unique vehicle towards researchers from other fields and will serve as a basis for groundbreaking advances in scientific computing and data analysis.

## 9.3. International Initiatives

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

#### 9.3.1.1. CATS

Title: Computations And Topological Statistics

International Partner (Institution - Laboratory - Researcher):

Carnegie Mellon University (United States) - Department of Statistics - Larry Wasserman

Start year: 2015

See also: <http://geometrica.saclay.inria.fr/collaborations/CATS/CATS.html>

Topological Data Analysis (TDA) is an emergent field attracting interest from various communities, that has recently known academic and industrial successes. Its aim is to identify and infer geometric and topological features of data to develop new methods and tools for data exploration and data analysis. TDA results mostly rely on deterministic assumptions which are not satisfactory from a statistical viewpoint and which lead to a heuristic use of TDA tools in practice. Bringing together the strong expertise of two groups in Statistics (L. Wasserman's group at CMU) and Computational Topology and Geometry (Inria Geometrica), the main objective of CATS is to set-up the mathematical foundations of Statistical TDA to design new TDA methods and to develop efficient and easy-to-use software tools for TDA.

## 9.4. International Research Visitors

### 9.4.1. Visits of International Scientists

Ramsay Dyer (April and November 2016)

Arijit Ghosh, Indian Statistical Institute, Kolkata (April and November 2016)

Jose Carlos Gomez Larranaga, CIMAT, Guanajuato, Mexico (September 2016)

Kim Jisu, CMU, Pittsburgh, USA (May and December 2016).

Antony Bak, Palantir company, USA (October 2016)

#### 9.4.1.1. Internships

Uday Kusupati, Indian Institute of Technology, Bombay (May-July 2016)

Sandip Banerjee (bourse Charpak), Indian Statistical Institute, Kolkata (March-August 2016)

Sameer Desai, Indian Statistical Institute, Kolkata (October-December 2016)

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

##### *9.4.2.1. Research Stays Abroad*

Steve Oudot and Jérémy Cochoy spent 3 months (Sept.-Nov.) at the Institute for Computational and Experimental Research in Mathematics (ICERM) at Brown University. They were invited there for the semester program entitled *Topology in Motion* (see <https://icerm.brown.edu/programs/sp-f16/>).

## MARELLE Project-Team

# 6. Partnerships and Cooperations

## 6.1. National Initiatives

### 6.1.1. ANR

We are currently members of two projects funded by the French national agency for research funding.

- BRUTUS "Chiffrements authentifiés et résistants aux attaques par canaux auxiliaires", started on October 1st, 2014, for 60 months, with a grant of 41 kEuros for Marelle. Other partners are Université de Rennes 1, CNRS, secrétariat Général de la défense et de la sécurité nationale, and Université des Sciences et Technologies de Lille 1. The corresponding researcher for this contract is Benjamin Grégoire.
- FastRelax, "Fast and Reliable Approximations", started on October 1st, 2014, for 60 months, with a grant of 75 kEuros for Marelle. Other partners are Inria Grenoble (ARIC project-team), LAAS-CNRS (Toulouse), Inria Saclay (Toccata and Specfun project-teams), and LIP6-CNRS (Paris). The corresponding researcher for this contract is Laurence Rideau.

## 6.2. International Initiatives

### 6.2.1. Inria International Partners

#### 6.2.1.1. Informal International Partners

We work with the team of Adam Chlipala at MIT, in particular the engineer Paul Steckler, with whom we have regular meetings concerning the optimization of parts of the Coq system with respect to use cases provided by the MIT team, and the design of user-interface tools. This engineer had a visit of 6 weeks in France in April, three weeks in the pi.r2 team (mostly hosted by Matthieu Sozeau) and three weeks in the Marelle team, mostly hosted by Enrico Tassi and Maxime Dénès. The collaboration continues since that visit with a weekly phone conference.

## 6.3. International Research Visitors

### 6.3.1. Visits of International Scientists

We had visits by Gilles Barthe (IMDEA, Madrid, Spain) for 2 weeks, Benedikt Schmidt (IMDEA), for 2 weeks, François-Xavier Standaert (Université Catholique de Louvain, Crypto Group, Belgium), for 1 week, Sebastian Faust (Ruhr-University Bochum, Germany) for 1 week, François Dupressoir (IMDEA) for 1 week, Pierre-Yves Strub (IMDEA), for 1 week, and Peter Schwabe (Radboud University, Nijmegen, the Netherlands) for 3 days.

### 6.3.2. Visits to International Teams

Benjamin Grégoire visited IMDEA (Madrid, Spain) for two one-week trips.

Yves Bertot, Maxime Dénès, and Enrico Tassi visited Princeton University in June for the kick-off meeting of the *Expedition in Computing* entitled "the science of deep specification" funded by the NSF foundation.

Enrico Tassi visited the team of Jesper Bengtson at the IT-University of Copenhagen, Denmark.

Anders Mörtberg visited the team of Thierry Coquand at Chalmers and University of Göteborg in Sweden.

## ACUMES Project-Team

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

### 8.1.1. Project BOUM

G. Costeseque holds a BOUM (SMAI) project on “*Mathematical homogenization techniques for traffic flow models*” with W. Salazar and M. Zaydan (LMI, INSA Rouen) and J.A. Firozaly (CERMICS, Ecole des Ponts ParisTech and LAMA, Université Paris-Est Créteil).

## 8.2. European Initiatives

### 8.2.1. FP7 & H2020 Projects

#### 8.2.1.1. TraM3

Type: FP7

Defi: NC

Instrument: ERC Starting Grant

Objectif: NC

Duration: October 2010 - March 2016

Coordinator: Inria

Inria contact: Paola Goatin

Abstract: The project intends to investigate traffic phenomena from the macroscopic point of view, using models derived from fluid-dynamics consisting in hyperbolic conservation laws. The scope is to develop a rigorous analytical framework and fast and efficient numerical tools for solving optimization and control problems, such as queues lengths control or buildings exits design. See also: <http://www-sop.inria.fr/members/Paola.Goatin/tram3.html>

## 8.3. International Initiatives

### 8.3.1. Inria International Labs

#### Inria@SiliconValley

Associate Team involved in the International Lab:

#### 8.3.1.1. ORESTE

Title: Optimal RERoute Strategies for Traffic management

International Partner (Institution - Laboratory - Researcher):

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

Start year: 2015

See also: <http://www-sop.inria.fr/members/Paola.Goatin/ORESTE/index.html>

This project focuses on traffic flow modeling and optimal management on road networks. Based on the results obtained during the first three years, we aim at further develop a unified macroscopic approach for traffic monitoring, prediction and control. In particular, we aim at investigating user equilibrium inference and Lagrangian controls actuations using macroscopic models consisting of conservation laws or Hamilton-Jacobi equations.

## **8.4. International Research Visitors**

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

- L.M. Villada-Osorio (February-July 2016, University of Bio-Bio, Chile): high order Discontinuous Galerkin and WENO finite volume schemes for non-local scalar conservation laws in one space-dimension.
- A. Borzì (June and October 2016, University of Wuerzburg): Stochastic differential games and Fokker-Planck equations.
- A. Keimer (November 2016, UC Berkeley): modeling and well-posedness study for Dynamic Traffic Assignment.

#### *8.4.1.1. Internships*

- C. De Filippis (April-August 2016, University of Milan - Bicocca): well-posedness of initial-boundary value problems for non-local scalar conservation laws in one space-dimension.

## **APICS Project-Team**

# **7. Partnerships and Cooperations**

## **7.1. Regional Initiatives**

- Contract Provence Alpes Côte d’Azur (PACA) Region - Inria, BDO (no. 2014-05764) funding the research grant of C. Papageorgakis, see Sections 5.1.5 , 6.3 .
- The team participates in the project WIMAG (Wave IMAGing) funded by the IDEX UCA-Jedi. It aims at identifying and gathering the research and development by partners of UCA involved in wave imaging systems. Other partners are UNS and CNRS (GéoAzur, I3S, LEAT, LJAD), together with Orange Labs.
- The team participates in the transversal action C4PO funded by the IDEX UCA-Jedi. This “Center for Planetary Origin” brings together scientists from various fields to advance and organize Planetary Science at the the University of Nice, and supports research and teaching initiatives within its framework.

## **7.2. National Initiatives**

### **7.2.1. ANR COCORAM**

The ANR (Astrid) project COCORAM (Co-design et co-intégration de réseaux d’antennes actives multi-bandes pour systèmes de radionavigation par satellite) started January 2014. We are associated with three other teams from XLIM (Limoges University), geared respectively towards filters, antennas and amplifiers design. The core idea of the project is to realize dual band reception an emission chains by co-conceiving the antenna, the filters, and the amplifier. We are specifically in charge of the theoretical design of the filters, matching the impedance of a bi-polarized dual band antenna. This is a perfect training ground to test, apply and adapt our work on matching problems (see Section 5.2 ).

### **7.2.2. ANR MagLune**

The ANR project MagLune (Magnétisme de la Lune) has been approved July 2014. It involves the Cerege (Centre de Recherche et d’Enseignement de Géosciences de l’Environnement, joint laboratory between Université Aix-Marseille, CNRS and IRD), the IGP (Institut de Physique du Globe de Paris) and ISTerre (Institut des Sciences de la Terre). Associated with Cerege are Inria (Apics team) and Irphe (Institut de Recherche sur les Phénomènes Hors Équilibre, joint laboratory between Université Aix-Marseille, CNRS and École Centrale de Marseille). The goal of this project (led by geologists) is to understand the past magnetic activity of the Moon, especially to answer the question whether it had a dynamo in the past and which mechanisms were at work to generate it. Apics participates in the project by providing mathematical tools and algorithms to recover the remanent magnetization of rock samples from the moon on the basis of measurements of the magnetic field it generates. The techniques described in Section 5.1 are instrumental for this purpose.

## **7.3. European Initiatives**

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

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

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



## 7.4. International Initiatives

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

#### 7.4.1.1. IMPINGE

Title: Inverse Magnetization Problems IN GEosciences.

International Partner (Institution - Laboratory - Researcher):

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

Start year: 2016

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

The associate team IMPINGE is concerned with the inverse problem of recovering a magnetization distribution from measurements of the magnetic field above rock slabs using a SQUID microscope (developed at MIT). The application domain is to Earth and planetary sciences. Indeed, the remanent magnetization of rocks provides valuable information on their history. This is a renewal of the previous Associate Team IMPINGE that ended 2015. The US team also involves a group of Mathematicians (D. Hardin, M. Northington, E.B. Saff) at Vanderbilt University.

### 7.4.2. Inria International Partners

#### 7.4.2.1. Declared Inria International Partners

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

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

## 7.5. International Research Visitors

### 7.5.1. Visits of International Scientists

- Christian Gerhards (Universität Wien, Vienna, Austria, September 5-9).
- Douglas Hardin (Vanderbilt University, Nashville, Tennessee, USA, June 11-21).
- Nuutti Hyvonen (Aalto University, Finland, June 13-14).
- Benjamin Lanfer (BESA, Munich, Germany, February 4-5).
- Eduardo Lima (MIT, Boston, Massachusetts, USA, June 13-17).
- Michael Northington (Vanderbilt University, Nashville, Tennessee, USA, June 11-22).
- Vladimir Peller (University of Michigan at East Lansing, June 10-24).
- Cristobal Villalobos (Vanderbilt University, Nashville, Tennessee, USA, June 8-21).

## 7.6. List of international and industrial partners

- Collaboration under contract with Thales Alenia Space (Toulouse, Cannes, and Paris), CNES (Toulouse), XLIM (Limoges), University of Bilbao (Universidad del País Vasco / Euskal Herriko Unibertsitatea, Spain), BESA company (Munich), Flextronics.

- Regular contacts with research groups at UST (Villeneuve d'Asq), Universities of Bordeaux-I (Talence), Orléans (MAPMO), Aix-Marseille (CMI-LATP), Nice Sophia Antipolis (Lab. JAD), Grenoble (IJF and LJK), Paris 6 (P. et M. Curie, Lab. JLL), Inria Saclay (Lab. Poems), Cerege-CNRS (Aix-en-Provence), CWI (the Netherlands), MIT (Boston, USA), Vanderbilt University (Nashville USA), Steklov Institute (Moscow), Michigan State University (East-Lansing, USA), Texas A&M University (College Station USA), Indiana University-Purdue University at Indianapolis, Politecnico di Milano (Milan, Italy), University of Trieste (Italy), RMC (Kingston, Canada), University of Leeds (UK), of Maastricht (the Netherlands), of Cork (Ireland), Vrije Universiteit Brussel (Belgium), TU-Wien and Universität Wien (Austria), TFH-Berlin (Germany), ENIT (Tunis), KTH (Stockholm), University of Cyprus (Nicosia, Cyprus), University of Macau (Macau, China), SIAE Microelettronica (Milano).
- The project is involved in the GDR-project AFHP (CNRS), in the ANR (Astrid program) project COCORAM (with XLIM, Limoges, and DGA), in the ANR (Défis de tous les savoirs program) project MagLune (with Cerege, IPGP, ISTerre, Irphe), in a MIT-France collaborative seed funding, in the Associate Inria Team IMPINGE (with MIT, Boston), and in a NSF grant (with Vanderbilt University and MIT).

## ECUADOR Project-Team

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

### 8.1.1. ANR

#### 8.1.1.1. MAIDESC

Ecuador is coordinator of the ANR project MAIDESC, with Inria team Gamma3, University of Montpellier II, CEMEF-Ecole des Mines, Inria-Bordeaux, Lemma and Transvalor. MAIDESC concentrates on mesh adaptation and in particular meshes for interfaces, third-order accuracy, meshes for boundary layers, and curved meshes.

## 8.2. European Initiatives

### 8.2.1. FP7 & H2020 Projects

#### 8.2.1.1. AboutFlow

Type: PEOPLE

Instrument: Initial Training Network

Duration: 2012-2016

Coordinator: Jens-Dominik Mueller

Partner: Queen Mary University of London (UK)

Inria contact: Laurent Hascoët

Abstract: The aim of AboutFlow is to develop robust gradient-based optimisation methods using adjoint sensitivities for numerical optimisation of flows. <http://aboutflow.sems.qmul.ac.uk/>

#### 8.2.1.2. UMRIDA

Type:AAT

Instrument:Aeronautics and Air Transport

Duration: 2013-2016

Coordinator: Charles Hirsch

Partner: Numeca S.A. (Belgium)

Inria contact: Alain Dervieux

Abstract: UMRIDA addresses major research challenges in Uncertainty Quantification and Robust Design: develop new methods that handle large numbers of simultaneous uncertainties and generalized geometrical uncertainties. Apply these methods to representative industrial configurations.

## 8.3. International Initiatives

### 8.3.1. Inria International Labs

Ecuador participates in the Joint Laboratory for Exascale Computing (JLESC) together with colleagues at Argonne National Laboratory. Laurent Hascoët attended the JLESC meeting in Lyon, France, june 27-29.

## 8.4. International Research Visitors

### 8.4.1. Visits of International Scientists

- Krishna Narayanan from Argonne National Laboratory, june 29-july 1.

### 8.4.2. Internships

- Georgios Ntanakas from Rolls-Royce, Germany, january 18-30.
- Ala Taftaf to Rolls-Royce, Germany, may 6-27.

### 8.4.3. Visits to International Teams

- Laurent Hascoët visited Argonne National Laboratory, november 14-22.

## **MCTAO Project-Team**

# **8. Partnerships and Cooperations**

## **8.1. Regional Initiatives**

The PhD thesis of Jeremy Rouot [2] has been co-funded by Région PACA.

## **8.2. National Initiatives**

### **8.2.1. ANR**

**Weak KAM beyond Hamilton-Jacobi (WKBHJ)**. Started 2013 (decision ANR-12-BS01-0020 of December 19, 2012), duration: 4 years. L. Rifford is in the scientific committee.

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

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

### **8.2.2. Others**

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

PEPS project of **AMIES** Labex, "Dealing with exclusion constraints in orbital transfer" with Thalès Alenia Space (PI J.-B. Caillau). This project funded two master internships during summer 2016 (M. Brunengo and Y. El Alaoui Faris, co-supervised with T. Dargent from Thalès).

**PGMO** grant (2016-2017) on "Metric approximation of minimizing trajectories and applications" (PI J.-B. Caillau). This project involves colleagues from Université Paris Dauphine and has funding for one year, including one internship (M2 level).

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

## **8.3. European Initiatives**

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

#### *8.3.1.1. Bilateral program with Portugal*

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

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

Project title: "Extremal spectral quantities and related problems"

Duration: 05/2016-05/2019

Coordinator: P. Freitas (Univ. Lisbon)

Team member involved: J.-B. Caillau

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

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

#### *8.3.1.2. Bilateral program with Germany*

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

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

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

Duration: 11/2014-10/2018

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

Team member involved: Bernard Bonnard is in the (scientific committee).

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

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

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

## NACHOS Project-Team

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

### 8.1.1. Inria Project Lab

#### 8.1.1.1. C2S@Exa (*Computer and Computational Sciences at Exascale*)

**Participants:** Olivier Aumage [STORM project-team, Inria Bordeaux - Sud-Ouest], Philippe Helluy [TONUS project-team, Inria Nancy - Grand-Est], Luc Giraud [HIEPACS project-team, Inria Bordeaux - Sud-Ouest], Stéphane Lanteri [Coordinator of the project], Jean-François Méhaut [CORSE project-team, Inria Grenoble - Rhône-Alpes], Christian Perez [AVALON project-team, Inria Grenoble - Rhône-Alpes].

Since January 2013, the team is coordinating 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. 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.

### 8.1.2. ANR project

#### 8.1.2.1. TECSER

**Participants:** Emmanuel Agullo [HIEPACS project-team, Inria Bordeaux - Sud-Ouest], Xavier Antoine [CORIDA project-team, Inria Nancy - Grand-Est], Patrick Breuil [Nuclétudes, Les Ulis], Thomas Frachon, Luc Giraud [HIEPACS project-team, Inria Bordeaux - Sud-Ouest], Stéphane Lanteri, Ludovic Moya, Guillaume Sylvand [Airbus Group Innovations].

Type: ANR ASTRID

Duration: May 2014 - April 2017

Coordinator: Inria

Partner: Airbus Group Innovations, Inria, Nuclétudes

Inria contact: Stéphane Lanteri

Abstract: the objective of the TECSER project 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.

## 8.2. European Initiatives

### 8.2.1. FP7 & H2020 Projects

#### 8.2.1.1. DEEP-ER

Title: Dynamic Exascale Entry Platform - Extended Reach

Program: FP7

Duration: October 2013 - September 2016

Coordinator: Forschungszentrum Juelich GmbH (Germany)

Partner: Intel GmbH (Germany), Bayerische Akademie der Wissenschaften (Germany), Ruprecht-Karls-Universität Heidelberg (Germany), Universität Regensburg (Germany), Fraunhofer-Gesellschaft zur Förderung der Angewandten Forschung E.V (Germany), Eurotech Spa (Italy), Consorzio Interuniversitario Cineca (Italy), Barcelona Supercomputing Center - Centro Nacional de Supercomputación (Spain), Xyratex Technology Limited (United Kingdom), Katholieke Universiteit Leuven (Belgium), Stichting Astronomisch Onderzoek in Nederland (The Netherlands) and Inria (France).

Inria contact: Stéphane Lanteri

Abstract: the DEEP-ER project aims at extending the Cluster-Booster Architecture that has been developed within the DEEP project with a highly scalable, efficient, easy-to-use parallel I/O system and resiliency mechanisms. A Prototype will be constructed leveraging advances in hardware components and integrate new storage technologies. They will be the basis to develop a highly scalable, efficient and user-friendly parallel I/O system tailored to HPC applications. Building on this I/O functionality a unified user-level checkpointing system with reduced overhead will be developed, exploiting multiple levels of storage. The DEEP programming model will be extended to introduce easy-to-use annotations to control checkpointing, and to combine automatic re-execution of failed tasks and recovery of long-running tasks from multi-level checkpoint. The requirements of HPC codes with regards to I/O and resiliency will guide the design of the DEEP-ER hardware and software components. Seven applications will be optimised for the DEEP-ER Prototype to demonstrate and validate the benefits of the DEEP-ER extensions to the Cluster-Booster Architecture.

#### 8.2.1.2. HPC4E

Title: HPC for Energy

Programm: H2020

Duration: December 2015 - November 2017

Coordinator: Barcelona Supercomputing Center

Partner: Barcelona Supercomputing Center (Spain), Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas - CIEMAT (Spain), REPSOL SA (Spain), Iberdrola Renovables Energía SA (Spain), Lancaster University (United Kingdom), COPPE/UFRJ - Universidade Federal do Rio de Janeiro (Brazil), LNCC (Brazil), INF/UFRGS - Universidade Federal do Rio Grande do Sul (Brazil), CER/UFPE - Universidade Federal de Pernambuco (Brazil), PETROBRAS (Brazil), TOTAL SA (France), and Inria (France).

Inria contact: Stéphane Lanteri

Abstract: This project aims to apply the new exascale HPC techniques to energy industry simulations, customizing them, and going beyond the state-of-the-art in the required HPC exascale simulations for different energy sources: wind energy production and design, efficient combustion systems for biomass-derived fuels (biogas), and exploration geophysics for hydrocarbon reservoirs. For wind energy industry HPC is a must. The competitiveness of wind farms can be guaranteed only with accurate wind resource assessment, farm design and short-term micro-scale wind simulations to forecast the daily power production. The use of CFD LES models to analyse atmospheric flow in a wind farm capturing turbine wakes and array effects requires exascale HPC systems. Biogas, i.e.

biomass-derived fuels by anaerobic digestion of organic wastes, is attractive because of its wide availability, renewability and reduction of CO<sub>2</sub> emissions, contribution to diversification of energy supply, rural development, and it does not compete with feed and food feedstock. However, its use in practical systems is still limited since the complex fuel composition might lead to unpredictable combustion performance and instabilities in industrial combustors. The next generation of exascale HPC systems will be able to run combustion simulations in parameter regimes relevant to industrial applications using alternative fuels, which is required to design efficient furnaces, engines, clean burning vehicles and power plants. One of the main HPC consumers is the oil & gas (O&G) industry. The computational requirements arising from full wave-form modelling and inversion of seismic and electromagnetic data is ensuring that the O&G industry will be an early adopter of exascale computing technologies. By taking into account the complete physics of waves in the subsurface, imaging tools are able to reveal information about the Earth's interior with unprecedented quality.

### **8.3. International Initiatives**

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

##### **8.3.1.1. HOMAR**

Title: High performance Multiscale Algorithms for wave pRopagation problems

International Partner (Institution - Laboratory - Researcher):

Laboratório Nacional de Computação Científica (Brazil) - Coordenação de Matemática Aplicada e Computacional - Frédéric Valentin

Start year: 2015

See also: <http://www-sop.inria.fr/nachos/index.php/Main/HOMAR>

The general scientific context of the collaboration proposed in the HOMAR project is the study of time dependent wave propagation problems presenting multiscale features (in space and time). The general goal is the design, analysis and implementation of a family of innovative high performance numerical methods particularly well suited to the simulation of such multiscale wave propagation problems. Mathematical models based on partial differential equations (PDE) embedding multiscale features occur in a wide range of scientific and technological applications involving wave propagation in heterogeneous media. Electromagnetic wave propagation and seismic wave propagation are two relevant physical settings that will be considered in the project. Indeed, the present collaborative project will focus on two particular application contexts: the interaction of light (i.e. optical wave) with nanometer scale structure (i.e. nanophotonics) and, the interaction of seismic wave propagation with geological media for quantitative and non destructive evaluation of imperfect interfaces.

#### **8.3.2. Inria International Partners**

##### **8.3.2.1. Informal International Partners**

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

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

Dr. Maciej Klemm, University of Bristol, Communication Systems & Networks Laboratory, Centre for Communications Research (United Kingdom)

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

### **8.4. International Research Visitors**

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



Prof. Liang Li, School of Mathematical Sciences, University of Electronic Science and Technology of China, Chengdu. From March 2016 to February 2017.

Dr. Antonio Tadeu Gomez and Dr. Frédéric Valentin, LNCC, Petropolis, Brazil. From December 15, 2016 to February 15, 2017.

Prof. Bin Li and Prof. Li Xu, School of Physical Electronics, University of Electronic Science and Technology of China, Chengdu. From August 1st to August 12, 2016.

## **TOSCA Project-Team**

# **8. Partnerships and Cooperations**

## **8.1. National Initiatives**

### **8.1.1. ANR**

- N. Champagnat is member of the ANR NONLOCAL (Phénomènes de propagation et équations non locales, 2014–2018) coordinated by F. Hamel (Univ. Aix-Marseille).
- E. Tanré is member of the ANR SloFaDyBio (Slow Fast Dynamics in Biology, ANR-14-CE25-0019, 2015-2017) coordinated by M. Desroches (EPI MATHNEURO, Inria Sophia Antipolis).

## **8.2. International Initiatives**

### **8.2.1. Inria International Labs**

#### **Inria Chile**

Associate Team involved in the International Lab:

#### **8.2.1.1. ANESTOC-TOSCA**

Title: Stochastic modelling of biology and renewable energies

International Partner (Institution - Laboratory - Researcher):

Pontificia Universidad Católica de Chile (Chile) - ANESTOC Center (ANESTOC) - Rebolledo Rolando

Start year: 2014

See also: <http://www.incidechile.cl/anestoc/teams-involved/>

This French-Chilean Associated Team deals with stochastic modeling and simulation issues for renewable energies (wind and waves) and neurosciences. It is a follow-up of a long collaboration in which each of the side takes benefit from the other side know-how and structures. In particular, this Associated Team is strongly related to the CIRIC project “Stochastic Analysis of Renewable Energy”. This project aims at transferring and valuing to Chilean companies the results of researches on renewable energies, mainly wind prediction at the windfarm’s scale and waves energy potential of a site using video.

### **8.2.2. Participation in Other International Programs**

#### **8.2.2.1. International Initiatives**

##### **ECOS Discretelongmem**

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

International Partner (Institution - Laboratory - Researcher):

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

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

Duration: 2016 - 2018

Start year: 2016

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

## 8.3. International Research Visitors

### 8.3.1. Visits of International Scientists

- L. Beznea (Simion Stoilow Institute of Mathematics of the Romanian Academy, Bucarest) has been visiting TOSCA Nancy for 11 days in July.
- O. Lupaşcu (Simion Stoilow Institute of Mathematics of the Romanian Academy, Bucarest) has been visiting TOSCA Nancy for one week in October.
- The TOSCA seminar organized by A. Richard in Sophia Antipolis has received the following speakers: Pierre-Emmanuel Jabin (University of Maryland), Christophe Henry (Institute of Fluid Flow Machinery, Polish Academy of Sciences), Tony Lelièvre (ENPC), D. Alberici (University of Bologna), Nicolas Fournier (Université Pierre et Marie Curie), Philip Protter (Columbia University), Jean-François Jabir (CIMFAV – Valparaiso, Chile), Roberto Cortez Milan (CIMFAV – Valparaiso, Chile), Areski Cousin (ISFA, Lyon).

#### 8.3.1.1. Internships

BICHAT Antoine

Subject: Modélisation de populations de cellules irradiées: une approche par processus de branchement

Date: Sep. 2015 - June 2016 (projet recherche)

Institution: Écoles des Mines de Nancy.

CORMIER Quentin

Subject: Study of invariants associated to the dynamic of a neuron network subject to STDP

Date: Oct. 2015 - Feb. 2016

Institution: ENS Lyon

DUPRE Aurore

Subject: Analyse et évaluation de l'adjonction de la modélisation de phénomènes convectifs dans un modèle numérique lagrangien de la couche limite atmosphérique

Date: April 2016 - Oct. 2016

Institution: Université de Reims Champagne-Ardenne

GEORGES Thomas

Subject: Single Particle Tracking Techniques

Date: Sept. 2016 - June 2017 (research project)

Institution: Écoles des Mines de Nancy.

GUERBAB Ismail

Subject: Sums of Pareto distributions

Date: June 2016 - Aug. 2016

Institution: Écoles des Mines de Nancy.

HELSON Pascal

Subject: Spiking Neurons in interaction with Plasticity

Date: April 2016 - Aug. 2016

Institution: Ecole des Ponts et chaussées.

KANTASSI Ameni

Subject: Processus du plus récent ancêtre commun dans des arbres de Galton-Watson

Date: April 2015 - Aug. 2015

Institution: Univ. Lorraine et École Supérieure des Sciences et Technologies d'Hamam Sousse (Tunisie).

PAPIC Alexis

Subject: States Reduction on Markov Processes

Date: Mai 2016 - Aug. 2016

Institution: Univ. Pierre et Marie Curie.

### **8.3.2. Visits to International Teams**

#### *8.3.2.1. Research Stays Abroad*

- N. Champagnat and D. Villemonais spent one week in Neuchâtel (Switzerland) in September, to work with Michel Benaïm.
- P. Pigato has spent two weeks in Valparaiso and Santiago (Chile) in March, working with R. Rebolledo and S. Torres.
- P. Pigato has spent one week in Padova (Italy), in June, for a collaboration with P. Dai Pra.
- A. Richard and E. Tanré have spent one week in Valparaíso and one week in Santiago (Chile) in December within the ECOS program (PIs: E. Tanré, S. Torres, C. Tudor), working with S. Torres (Univ. of Valparaiso).
- D. Talay spent ten days at Columbia University in October.

**ABS Project-Team (section vide)**

## ASCLEPIOS Project-Team

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

### 8.1.1. Consulting for Industry

Nicholas Ayache is a scientific consultant for the company Mauna Kea Technologies (Paris).

### 8.1.2. Collaboration with national hospitals

The Asclepios-project team collaborates with the following 3 French IHU (University Hospital Institute): the IHU-Strasbourg (Pr J. Marescaux and L. Soler) on image-guided surgery, the IHU-Bordeaux (Pr M. Haïssaguere and Pr P. Jaïs) on cardiac imaging and modeling and the IHU-Pitié Salpêtrière (Dr. O. Colliot and S. Durrleman) on neuroimaging.

We also have long term collaborations with the CHU Nice and Centre Antoine Lacassagne in Nice.

The Asclepios-project team is part of the EQUIPEX MUSIC consortium with Bordeaux University Hospital, which aim is to exploit an XMR interventional room equipped with a MUSIC workstation.

## 8.2. European Initiatives

### 8.2.1. FP7 & H2020 Projects

#### 8.2.1.1. MD PAEDIGREE

Title: Model-Driven European Paediatric Digital Repository

Programme: FP7

Period: March 2013 - February 2017

Coordinator: Ospedale Pediatrico Bambini Gesù, Rome.

Partners:

- Athena Research and Innovation Center in Information Communication & Knowledge Technologies (Greece)
- Biomolecular Research Genomics (Italy)
- Deutsches Herzzentrum Berlin (Germany)
- Empirica Gesellschaft für Kommunikations- und Technologie Forschung Mbh (Germany)
- Fraunhofer-Gesellschaft Zur Foerderung Der Angewandten Forschung E.V (Germany)
- Haute Ecole Spécialisée de Suisse Occidentale (Switzerland)
- Istituto Giannina Gaslini (Italy)
- Katholieke Universiteit Leuven (Belgium)
- Lynkeus (Italy)
- Motek Medical B.V. (Netherlands)
- Ospedale Pediatrico Bambino Gesù (Italy)
- Siemens Aktiengesellschaft (Germany)
- Siemens Corporation (United States)
- Technische Universiteit Delft (Netherlands)
- University College London (United Kingdom)
- Universitair Medisch Centrum Utrecht (Netherlands)

Universita Degli Studi di Roma Lapienza (Italy)  
 The University of Sheffield (United Kingdom)  
 Universitatea Transilvania Din Brasov (Romania)  
 Stichting Vu-Vumc (Netherlands)  
 Maat Francerl (France)

Inria contact: Xavier Pennec

MD-Paedigree is a clinically-led VPH project that addresses both the first and the second actions of part B of Objective ICT-2011.5.2:

1. it enhances existing disease models stemming from former EC-funded research projects (Health-e-Child and Sim-e-Child) and from industry and academia, by developing robust and reusable multi-scale models for more predictive, individualised, effective and safer healthcare in several disease areas;
2. it builds on the eHealth platform already developed for Health-e-Child and Sim-e-Child to establish a worldwide advanced paediatric digital repository.

Integrating the point of care through state-of-the-art and fast response interfaces, MD-Paedigree services a broad range of off-the-shelf models and simulations to support physicians and clinical researchers in their daily work. MD-Paedigree vertically integrates data, information and knowledge of incoming patients, in participating hospitals from across Europe and the USA, and provides innovative tools to define new workflows of models towards personalised predictive medicine. Conceived as a part of the 'VPH Infostructure' described in the ARGOS, MD-Paedigree encompasses a set of services for storage, sharing, similarity search, outcome analysis, risk stratification, and personalised decision support in paediatrics within its innovative model-driven data and workflow-based digital repository. As a specific implementation of the VPH-Share project, MD-Paedigree fully interoperates with it. It has the ambition to be the dominant tool within its purview. MD-Paedigree integrates methodological approaches from the targeted specialties and consequently analyzes biomedical data derived from a multitude of heterogeneous sources (from clinical, genetic and metagenomic analysis, to MRI and US image analytics, to haemodynamics, to real-time processing of musculoskeletal parameters and fibres biomechanical data, etc.), as well as specialised biomechanical and imaging VPH simulation models.

#### 8.2.1.2. VP2HF

Title: Computer model derived indices for optimal patient-specific treatment selection and planning in Heart Failure

Programme: FP7

Period: October 2013 - September 2016

Coordinator: King's College, London.

Partners:

Centron Diagnostics Ltd (United Kingdom)  
 CHU Côte de Nacre, Caen (France)  
 King's College London (United Kingdom)  
 Philips Technologie (Germany)  
 Philips France (France)  
 Simula Research Laboratory As (Norway)  
 Université Catholique de Louvain (Belgium)  
 Universitat Pompeu Fabra (Spain)

Inria contact: Dominique Chapelle / Maxime Sermesant

Heart failure (HF) is one of the major health issues in Europe affecting 6 million patients and growing substantially because of the ageing population and improving survival following myocardial infarction. The poor short to medium term prognosis of these patients means that treatments, such as cardiac re-synchronisation therapy and mitral valve repair, can have substantial impact. However, these therapies, are ineffective in up to 50% of treated patients and involve significant morbidity and substantial cost. The primary aim of VP2HF is to bring together image and data processing tools with statistical and integrated biophysical models mainly developed in previous VPH projects, into a single clinical workflow to improve therapy selection and treatment optimisation in HF. The tools will be tested and validated on 200 patients (including 50 historical datasets) across 3 clinical sites, including a prospective clinical study on 50 patients in the last year of the project. The key innovations in VP2HF, which make it likely that the project results will be commercially exploited and have major clinical impact, are:

1. all tools to process images and signals, and to obtain the statistical and biophysical models will be integrated into one clinical software platform that can be easily and intuitively used by clinicians and tried out in the prospective clinical study;
2. to select only the appropriate parts of the tool chain, we use a decision tree stratification approach, which will add maximum value to the predictions that will be used in individual patients, so that the more resource intensive parts will be used when they will add real value.

We expect that the study will result in substantially improved efficacy of the decision making process compared with current guidelines, and that an integrated package that is used as part of clinical workflow will ensure the industrial project partners, in particular Philips, will develop project outputs into dedicated products that will have significant clinical impact.

#### 8.2.1.3. *MedYMA*

Title: Biophysical Modeling and Analysis of Dynamic Medical Images

Programme: FP7

Type: ERC

Period: April 2012 - March 2017

Coordinator: Inria

Inria contact: Nicholas Ayache

During the past decades, exceptional progress was made with *in vivo* medical imaging technologies to capture the anatomical, structural and physiological properties of tissues and organs in patients, with an ever increasing spatial and temporal resolution. Physicians are now faced with a formidable overflow of information, especially when a time dimension is added to the already hard to integrate 3-D spatial, multimodal and multiscale dimensions of modern medical images. This increasingly hampers the early detection and understanding of subtle image modifications, which can have a vital impact on the patient's health. To change this situation, a new generation of computational models for the simulation and analysis of dynamic medical images is introduced. Thanks to their generative nature, they will allow the construction of databases of synthetic and realistic medical image sequences simulating various evolving diseases, producing an invaluable new resource for training and benchmarking. Leveraging on their principled biophysical and statistical foundations, these new models will bring an added clinical value once they have been personalized with innovative methods to fit the medical images of any specific patient. By explicitly revealing the underlying evolving biophysical processes observable in the images, this approach will yield new groundbreaking image processing tools to correctly interpret the patient's condition (computer aided diagnosis), to accurately predict the future evolution (computer aided prognosis), and to precisely simulate and monitor an optimal and personalized therapeutic strategy (computer aided therapy). First applications concern high impact diseases including brain tumors, Alzheimer's disease, heart failure and cardiac arrhythmia and will open new horizons in computational medical imaging.



## 8.3. International Initiatives

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

#### 8.3.1.1. *GeomStats*

Title: Geometric Statistics in Computational Anatomy: Non-linear Subspace Learning Beyond the Riemannian Structure

International Partner (Institution - Laboratory - Researcher):

Stanford (United States) - Department of Statistics - Susan Holmes

Start year: 2015

See also: <http://www-sop.inria.fr/asclepios/projects/GeomStats/>

The scientific goal of the associated team is to develop the field of geometric statistics with key applications in computational anatomy.

Computational anatomy is an emerging discipline at the interface of geometry, statistics, image analysis and medicine that aims at analyzing and modeling the biological variability of the organs shapes at the population level. An important application in neuroimaging is the spatial normalization of subjects which is necessary to compare anatomies and functions through images in populations with different clinical conditions.

The research directions have been broken into three axes, the first two being methodologically driven and the last one being application driven. The first axis aims at generalizing the statistical framework from Riemannian to more general geometric structures and even non-manifold spaces (e.g. stratified spaces). The goal is to understand what is gained or lost using each geometric structure. The second axis aims at developing subspace learning methods in non-linear manifolds. This objective contrasts with most manifold learning methods which assumes that subspaces are embedded in a large enough Euclidean space. The third scientific direction is application driven with cross-sectional and longitudinal brain neuroimaging studies. The goal will be to extract reduced models of the brain anatomy that best describe and discriminate the populations under study. One intend for instance to show where is impact of a treatment for traumatic brain injuries.

### 8.3.2. Inria International Partners

#### 8.3.2.1. *Informal International Partners*

##### 8.3.2.1.1. St Thomas' Hospital, King's College London, United Kingdom

Maxime Sermesant is a visiting lecturer in the Division of Imaging Sciences and Biomedical Engineering, St Thomas' Hospital, King's College London lead by Pr Reza Razavi. The XMR facility within this hospital is a unique opportunity to validate and exploit the cardiovascular modelling work.

##### 8.3.2.1.2. Massachusetts General Hospital, Boston

A collaboration with Dr Jan Unklebach, Assistant Professor of Radiation Oncology and Dr Jayashree Kalpathy-Cramer, radiology instructor was initiated in 2013 around the topics of tumor growth modeling, radiotherapy planning and edema characterization from MRI.

##### 8.3.2.1.3. University College London (UCL), London, UK

Marco Lorenzi holds an honorary position with the Translational Imaging Group of UCL, led by Prof. Sebastien Ourselin. His collaboration is around the topic of spatio-temporal analysis of medical images, with special focus on brain imaging analysis and biomarker development in Alzheimer disease. He is also collaborating with the "Progression Over Neurodegenerative Disorders" (POND) group (Prof. Daniel Alexander) for developing new computational models and techniques for learning characteristic patterns of disease progression using large longitudinal clinical data sets, with special focus on dementias.

#### 8.3.2.1.4. Imaging Genetics Center (IGC), University of Southern California (USC), CA, USA

Marco Lorenzi is currently collaborator with the IGC for the investigation of the very complex relationship between brain atrophy and genetics in Alzheimer's disease, in particular for demonstrating the effectiveness of multivariate statistical models in providing a meaningful description of the relationship between genotype and brain phenotype.

#### 8.3.2.1.5. Other International Hospitals

Collaborations with several other European hospitals have been established through the European projects VP2HF and MD PAEDIGREE.

## **8.4. International Research Visitors**

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

#### *8.4.1.1. Research Stays Abroad*

In the context of the Associated team GeomStats, part of the Inria International Lab Inria@SiliconValley, Nina Miolane spent 3 months (April to June 2016) at the Stanford Statistics Department:

## ATHENA Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. Inria SAM Action Transverse

**Participants:** Paul Görlach, Evelyne Hubert [Aromath project team], Théodore Papadopoulo, Rachid Deriche.

Finding biomarkers of abnormalities of the white matter is one important problem in dMRI processing. As these biomarkers need to be independent of the orientation of the head, they are functions of the rotational invariants of the shapes that characterize the diffusion probabilities in the white matter. While the situation is well understood for second order tensors, these are not powerful enough to represent crossings in the white matter. Acquisitions made with the HARDI scheme allow for a richer description of probabilities, which have been modelled in the literature team as (positive) ternary quartics (tensors of order 4). But invariants of these quartics are not well known. For a long period, only six (out of 12 in theory) were known. Previous work in the ATHENA team developed some new strategies to compute more invariants. But these were ever non-polynomial and had some stability problems [99]. Another strategy [85] was leading to polynomial and stable invariants, but the approach was generating a number of invariants (more than 12) for which it was impossible to extract an irreducible family. The goal of this "Transverse action" was to join forces with the team AROMATH and leverage the methods they developed [87], [88], [86] to have a better insight in this problem of rotational invariants of ternary quartics.

### 9.1.2. Inria SAM Action Marquante

**Participants:** Demian Wassermann, Maureen Clerc, Théodore Papadopoulo, Amandine Audino.

**Duration:** *october 2016 to January 2018*

Elucidating the structure-function relationship of the brain is one of the main open question in neuroscience. The capabilities of diffusion MRI-based techniques to quantify the connectivity strength between brain areas, namely structural connectivity (SC), in combination with modalities such as electro encephalography (EEG) to quantify brain function have enabled advances in this field. However, the actual relationship between these SC measures and measures of information transport between neuronal patches is still far from being determined.

In this project, we will address this problem by establishing a relationship between diffusion MRI (dMRI) SC measures and electrical conductivity on the human brain cortex. We will exploit the Athena's competences in dMRI (Deriche-Wassermann) and EEG (Clerc-Papadopoulo) and our collaboration with the neurosurgical service at CHU Nice (Fontaine-Almairac). In successfully addressing this problem, we will set the bases to solve the current open problem of non-invasively measuring cortico-cortical (CC) connectivity in the human brain. This will boost the understanding of cognitive function as well as neurosurgical planning for the treatment of pathologies such as drug-resistant epilepsy and resection of glioblastomas.

## 9.2. National Initiatives

### 9.2.1. Inria Project Lab

#### 9.2.1.1. IPL BCI-LIFT

**Participants:** Maureen Clerc, Théodore Papadopoulo, Nathanaël Foy, Nathalie Gayraud, Federica Turi.

**Duration:** *January 2015 to December 2018*

The Inria Project-Lab BCI-LIFT is an Inria-funded research consortium to foster collaborative research on Brain-Computer Interfaces on the topic of Learning, Interaction, Feedback and Training. It is coordinated by Maureen Clerc. Its members are from 6 Inria teams: Athena, Camin, Hybrid, Mjolnir, Neurosys, Potioc, and from Dycog team from CRNL Lyon, and University of Rouen. For more information, refer to the [BCI-LIFT](#) website.

## 9.2.2. ANR

### 9.2.2.1. ANR MRSEI LEMONS

**Participants:** Maureen Clerc, Théodore Papadopoulo.

**Duration:** *october 2015 to april 2017* The ANR MRSEI LEMONS aims to consolidate a European Network by organizing meetings and visits, in order to submit a proposal for a MSCA-ITN. The European consortium is led by Inria (coordinator Maureen Clerc).

### 9.2.2.2. ANR MOSIFAH

**Participants:** Rachid Deriche, Rutger Fick, Demian Wassermann, Maureen Clerc, Théodore Papadopoulo.

**Duration:** *October 2013 to September 2017*

This ANR project is about multimodal and multiscale modelling and simulation of the fiber architecture of the human heart. It started on October 2013 and involves three partners: Creatis Team, INSA, Lyon (I. Magnin, Y. Zhu); TIMC-IMAG, CNRS, Grenoble (Y. Uson) and the ATHENA project team.

It consists in modelling and simulating the ex vivo and in vivo 3D fiber architectures at various scales using multiphysical data from different imaging modalities working at different spatial resolutions. To this end, the myocardium of the human heart will be imaged using respectively Polarized Light Imaging (PLI) and dMRI.

Appropriate diffusion models will be explored including second and fourth order DTI models as well as HARDI models such as the single shell Q-Ball Imaging (QBI). These various types of images will be processed within the right Riemannian mathematical framework to provide tensor as well as Ensemble Average Propagator (EAP) and Orientation Distribution Function (ODF) fields. Virtual cardiac fiber structure (VCFS) will then be modelled using myocardial fiber information derived from each of these imaging modalities. Finally, diffusion behavior of water molecules in these VCFSs will be simulated by means of quantum spin theory, which allows computing ex vivo and in vivo virtual diffusion magnetic resonance (MR) images at various scales ranging from a few microns to a few millimeters. From the obtained virtual diffusion MR images, multiscale and probabilistic atlas describing the 3D fiber architecture of the heart ex vivo and in vivo will be constructed. Meanwhile, the simulation involving a large number of water molecules, grid computing will be used to cope with huge computation resource requirement.

We expect to construct a complete database containing a very wide range of simulated (noise and artifact-free) diffusion images that can be used as benchmarks or ground-truth for evaluating or validating diffusion image processing algorithms and create new virtual fiber models allowing mimicking and better understanding the heart muscle structures. Ultimately, the proposed research can open a completely novel way to approach the whole field of heart diseases including the fundamental understanding of heart physiology and pathology, and new diagnosis, monitoring and treatment of patients.

### 9.2.2.3. ANR VIBRATIONS

**Participants:** Théodore Papadopoulo, Maureen Clerc, Rachid Deriche, Demian Wassermann.

**Duration:** *February 2014 to January 2018*

Computational modeling, under the form of a “virtual brain” is a powerful tool to investigate the impact of different configurations of the sources on the measures, in a well-controlled environment.

The VIBRATIONS project proposes to simulate in a biologically realistic way MEG and EEG fields produced by different configurations of brain sources, which will differ in terms of spatial and dynamic characteristics. The research hypothesis is that computational and biophysical models can bring crucial information to clinically interpret the signals measured by MEG and EEG. In particular, they can help to efficiently address some complementary questions faced by epileptologists when analyzing electrophysiological data.

The project follows a three-fold strategy:

- construct virtual brain models with both dynamic aspects (reproducing both hyperexcitability and hypersynchronisation alterations observed in the epileptic brain) and a realistic geometry based on actual tractography measures performed in patients
- explore the parameter space through large-scale simulations of source configurations, using parallel computing implemented on a computer cluster.
- confront the results of these simulations to simultaneous recordings of EEG, MEG and intracerebral EEG (stereotactic EEG, SEEG). The models will be tuned on SEEG signals, and tested versus the surface signals in order to validate the ability of the models to represent real MEG and EEG signals.

The project constitutes a translational effort from theoretical neuroscience and mathematics towards clinical investigation. A first output of the project will be a database of simulations, which will permit in a given situation to assess the number of configurations that could have given rise to the observed signals in EEG, MEG and SEEG. A second – and major - output of the project will be to give the clinician access to a software platform which will allow for testing possible configurations of hyperexcitable regions in a user-friendly way. Moreover, representative examples will be made available to the community through a website, which will permit its use in future studies aimed at confronting the results of different signal processing methods on the same ‘ground truth’ data.

### 9.2.3. ADT

#### 9.2.3.1. ADT BOLIS

**Participants:** Nicolas Schnitzler, Théodore Papadopoulo, Juliette Leblond [APICS project-team], Jean-Paul Marmorat [CMA Ecole des Mines Paritech].

**Duration:** December 2014 to December 2016

ADT BOLIS aims to:

- build a software platform dedicated to inverse source localisation, building upon the elements of software found in FindSources3D. The platform will be modular, ergonomic, accessible and interactive. It will offer a detailed visualisation of the processing steps and the results. The goal is to provide a convenient graphical interface and a tool that can be easily distributed and used by professionals (target audience: clinicians and researchers).
- Upgrade medInria to use the latest libraries versions involved (this most notably encompasses VTK 6, Qt 5, and DTK 1.0). Then, these new versions will be used to implement a composer (a graphical tool to chain various actions in medInria) and to develop python scripting (for chaining actions and for adding non-regression testing).

#### 9.2.3.2. ADT OpenViBE-X

**Participants:** Théodore Papadopoulo, Maureen Clerc, Nathanaël Foy.

**Duration:** October 2014 to October 2016

The OpenViBE-X ADT addresses the OpenViBE Brain Computer Interfaces (BCI) platform, in order to:

1. make BCI easier to apprehend by end-users
2. enrich the interaction with multimodal biosignals (eye gaze, heart-rate)
3. implement methods for auto-calibration and online adaptation of the classification
4. provide support, maintenance and dissemination for this software.

The OpenViBE platform is a central element to BCI research at Inria, and in the international community.

### 9.2.4. Other Funding Programs

#### 9.2.4.1. Big Brain Theory: MAXIM'S

**Participants:** Demian Wassermann, Alexandra Petiet [ICM, CENIR, Paris], Stéphane Lehericy [ICM, CENIR, Paris], Julien Valette [Institut d’Imagerie Biomédicale, CEA, France], Virginie Callot [Center for Magnetic Resonance in Biology and Medicine - UMR 7339, Center for Magnetic Resonance in Biology and Medicine - UMR 7339].

Shedding light on the specificity of microstructural MRI biomarkers of axonal and myelin integrity using multi-modal imaging in rodents and quantitative histological correlations.

Magnetic Resonance Imaging (MRI) biomarkers (BMs) of axonal and myelin integrity suffer from lack of specificity at the microstructural level, which hinders our understanding of disease mechanisms. A better knowledge of the role of the white matter (WM) microstructure in normal and abnormal function relies on the development of MRI metrics that can provide (i) increased specificity to distinct attributes of WM such as local fiber architecture, axon morphology, myelin content, and (ii) specific markers of axonal vs. myelin pathologies. Advanced diffusion-weighted (DW) imaging techniques based on biophysical models of cerebral tissues and cellular compartments can extract for example mean axonal diameters or cellular geometry. In addition, diffusion-weighted spectroscopy (DWS) offers new insights into the diffusion properties of intracellular metabolites. More specifically, probing metabolite diffusion at different time scales allows assessing fiber diameter and length, and the specific compartmentalization of different metabolites in different cell types allows differentiating between astrocytic and neuronal microstructural parameters. Although very promising, these novel techniques still need extensive histological validation.

We propose to develop these two cutting-edge MRI techniques – DW-MRI and DWS, at 11.7T to investigate axonopathy and myelinopathy in well-established mouse models with a single lesion type, and to validate these new microstructural BMs with multivariate quantitative histological analyses.

**Duration:** March 2016 to March 2019

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

#### 9.3.1.1. ERC AdG CoBCoM

Program: H2020-EU.1.1. (ERC-ADG-2015 - ERC Advanced Grant)

Project acronym: CoBCoM - **ID:** 694665

Project title: *Computational Brain Connectivity Mapping*

Start date: 2016-09-01, End date: 2021-08-31

PI : R. Deriche

Partners: ATHENA project-team

Abstract:

One third of the burden of all the diseases in Europe is due to problems caused by diseases affecting brain. Although exceptional progress has been obtained for exploring it during the past decades, **the brain is still terra-incognita** and calls for specific research efforts to better understand its architecture and functioning.

CoBCoM is our response to this great challenge of modern science with the overall goal to **develop a joint Dynamical Structural-Functional Brain Connectivity Network (DSF-BCN)** solidly grounded on advanced and integrated methods for diffusion Magnetic Resonance Imaging (dMRI) and Electro & Magneto-Encephalography (EEG & MEG).

To take up this grand challenge and achieve new frontiers for brain connectivity mapping, we will develop a new generation of computational models and methods for identifying and characterizing the structural and functional connectivities that will be at the heart of the DSF-BCN. Our strategy is to break with the tradition to incrementally and separately contributing to structure or function and develop **a global approach involving strong interactions between structural and functional connectivities**. To solve the limited view of the brain provided just by one imaging modality, our models will be developed under a rigorous computational framework integrating complementary non invasive imaging modalities: dMRI, EEG and MEG.

CoBCOM will push far forward the state-of-the-art in these modalities, developing **innovative models and ground-breaking processing tools** to provide in-fine a joint DSF-BCN solidly grounded on a detailed mapping of the brain connectivity, both in space and time.

Capitalizing on the strengths of dMRI, MEG & EEG methodologies and building on the **bio-physical and mathematical foundations** of our new generation of computational models, CoBCOM will be applied to high-impact diseases, and its **ground-breaking computational nature and added clinical value** will open new perspectives in neuroimaging.

#### 9.3.1.2. ChildBrain ETN

ATHENA is an Associated Partner in this European Training Network: the team will participate in training workshops and receive PhD students in secondments.

Program: European Training Network

Project acronym: ChildBrain

Project title: Advancing brain research in children's developmental neurocognitive disorders

Duration: March 2015 to March 2019

Coordinator: Prof. Paavo Leppänen, University of Jyväskylä, Finland

Other partners: University of Leuven (Belgium), University of Münster (Germany), Rabboud University (The Netherlands), Aston University (United Kingdom), IcoMetrix (Belgium), Elekta (Finland), BESA (Germany)

Abstract: The purpose of the ChildBrain ETN is to train young scientists, i.e. Early Stage Researchers (ESRs), to utilise evidence-based neuroscientific knowledge for helping children, especially those at high risk for dropout due to neurocognitive disorders, to meet future educational and societal demands.

## 9.4. International Initiatives

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

#### 9.4.1.1. LargeBrainNets

Title: Characterizing Large-scale Brain Networks Using Novel Computational Methods for dMRI and fMRI-based Connectivity

International Partner (Institution - Laboratory - Researcher):

Stanford (United States) - Stanford Cognitive and Systems Neuroscience Laboratory -  
Vinod Menon

Start year: Jan. 2016

Partners: ATHENA project-team,

See also: <http://www-sop.inria.fr/members/Demian.Wassermann/large-brain-nets.html>

In the past two decades, brain imaging of neurotypical individuals and clinical populations has primarily focused on localization of function and structures in the brain, revealing activation in specific brain regions during performance of cognitive tasks through modalities such as functional MRI. In parallel, technologies to identify white matter structures have been developed using diffusion MRI. More recently, interest has shifted towards developing a deeper understanding of the brain's intrinsic architecture and its influence on cognitive and affective information processing. Using for this resting state fMRI and diffusion MRI to build the functional and structural networks of the human brain.

The human brain is a complex patchwork of interconnected regions, and graph-theoretical approaches have become increasingly useful for understanding how functionally connected systems engender, and constrain, cognitive functions. The functional nodes of the human brain and their

structural inter-connectivity, collectively the "connectome", are, however, poorly understood. Critically, there is a dearth of computational methods for reliably identifying functional nodes of the brain and their structural inter-connectivity in vivo, despite an abundance of high-quality data from the Human Connectome Project (HCP). Devising and validating methods for investigating the human connectome has therefore taken added significance.

The first major goal of this project is to develop and validate appropriate sophisticated computational and mathematical tools for identifying functional nodes at the whole-brain level and measuring structural and functional connectivity between them, using state-of-the-art human brain imaging techniques and open-source HCP data. To this end, we will first develop and validate novel computational tools for (1) identifying stable functional nodes of the human brain using resting-state functional MRI and (2) measuring structural connectivity between functional nodes of the brain using multi-shell high-angular diffusion MRI. Due to the complementarity of the two imaging techniques fMRI and dMRI, our novel computational methods methods, the synergy between the two laboratories of this associate team will allow us to reveal in unprecedented detail the structural and functional connectivity of the human brain.

The second major goal of this project is to use our newly developed computational tools to characterize normal structural and functional brain networks in neurotypical adults.

### **9.4.2. Inria International Partners**

#### *9.4.2.1. Informal International Partners*

- SCIL Laboratory, Sherbrooke University, CA (Maxime Descoteaux)
- CMRR, University of Minnesota, USA (Christophe Lenglet)
- Verona University, It (Gloria Menegaz)
- Department of CISE, the University of Florida, Gainesville, USA (Baba C. Vemuri)
- Centre for Medical Image Computing (CMIC), Dept. Computer Science, UCL, UK (D. Alexander)
- SBIA, University of Pennsylvania Medical School, USA (R. Verma).
- University Houari Boumedienne (USTHB, Algiers) (L. Boumghar) and University of Boumerdes, (D. Cherifi), Algeria.
- BESA company on EEG/MEG modeling.
- CRM, Centre de Recherche Mathématiques, Montréal, Canada.

### **9.4.3. Participation in Other International Programs**

#### *9.4.3.1. Program: Collaborative Research in Computational Neuroscience (NSF – ANR)*

Project acronym: NEUROREF

Project title: *Building MRI Reference Atlases to Analyze Brain Trauma and Post- Traumatic Stress*

Start date: 2016-10-01, End date: 2019-12-31

P.I : D. Wassermann (Athena) – S. Bouix (Harvard Medical School)

Partners: ATHENA project-team,

International Partner (Institution - Laboratory - Researcher):

Harvard Medical School (United States) - Psychiatry and Neuroimaging Lab - Sylvain Bouix



**Abstract:**

While mild traumatic brain injury (mTBI) has become the focus of many neuroimaging studies, the understanding of mTBI, particularly in patients who evince no radiological evidence of injury and yet experience clinical and cognitive symptoms, has remained a complex challenge. Sophisticated imaging tools are needed to delineate the kind of subtle brain injury that is extant in these patients, as existing tools are often ill-suited for the diagnosis of mTBI. For example, conventional magnetic resonance imaging (MRI) studies have focused on seeking a spatially consistent pattern of abnormal signal using statistical analyses that compare average differences between groups, i.e., separating mTBI from healthy controls. While these methods are successful in many diseases, they are not as useful in mTBI, where brain injuries are spatially heterogeneous. The goal of this proposal is to develop a robust framework to perform subject-specific neuroimaging analyses of Diffusion MRI (dMRI), as this modality has shown excellent sensitivity to brain injuries and can locate subtle brain abnormalities that are not detected using routine clinical neuroradiological readings. New algorithms will be developed to create Individualized Brain Abnormality (IBA) maps that will have a number of clinical and research applications. In this proposal, this technology will be used to analyze a previously acquired dataset from the INTRuST Clinical Consortium, a multi-center effort to study subjects with Post-Traumatic Stress Disorder (PTSD) and mTBI. Neuroimaging abnormality measures will be linked to clinical and neuropsychological assessments. This technique will allow us to tease apart neuroimaging differences between PTSD and mTBI and to establish baseline relationships between neuroimaging markers, and clinical and cognitive measures. Upon completion of this project, a set of tools, which have the potential to establish radiological evidence of brain injury in mTBI, will have been designed and evaluated, thereby enhancing both the diagnosis and monitoring of progression/recovery of injury, as well as assessing the efficacy of therapies on the injured brain.

## **9.5. International Research Visitors**

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

- Sadegh Masjoodi (PhD Student, Tehran University of Medical Sciences, Iran) visited ATHENA from April 2nd, 2016 to Sept, 10, 2016
- Lorenza Brusini (PhD Student, Univ. of Verona, Italy), visited ATHENA from Jan. 2016 until Apr 2016.
- Maria Carla Piastra (PhD Student, Univ. Clinic of Münster, Germany), visited ATHENA from Jul 2016 until Aug 2016.
- Mouloud Kachouane (PhD Student, Univ. USTHB, Alger) visited ATHENA from Nov. 2015 until Aug 2016.
- Thinhinane Megherbi (PhD Student, Univ. USTHB, Alger) visited ATHENA from Jan. 2016 until Feb. 2016.
- Vinod Menon (Stanford Medical School) visited ATHENA during June 2016
- John Kolchaka (Stanford Medical School) visited ATHENA during June 2016

#### **9.5.1.1. Internships**

Graeme Baker

Date: May 2016 – Sept 2016

Queen's University,

Supervisor: Rachid Deriche

Nahuel Lascano

Date: Jun 2016 – Sept 2016

University of Buenos Aires,

Supervisor: Demian Wassermann

Leonel Exequiel Gomez

Date: Jun 2016 – Sept 2016

University of Buenos Aires,

Supervisor: Demian Wassermann

Paul Gorlach

Date: Jul 2016 – Dec. 2016

University of Buenos Aires,

Supervisor: Theo Papadopoulo and Evelyne Hubert

## BIOCORE Project-Team

# 9. Partnerships and Cooperations

## 9.1. National Initiatives

### 9.1.1. National programmes

- **ANR-Purple Sun:** The objective of this project (ANR-13-BIME-004) is to study and optimize a new concept consisting in coupling the production of microalgae with photovoltaic panels. The main idea is to derive the excess of light energy to PV electricity production, in order to reduce the phenomena of photoinhibition and overwarming both reducing microalgal productivity.
- **ANR-Facteur 4:** The objective of this project to produce non OGM strain of microalgae with enhanced performance. BIOCORE is involved in the directed selection of microalgae with interesting properties from an industrial point of view. The theory of competition is used to give a competitive advantage to some species. This competitive advantage can be provided by an online closed loop controller.
- **ANR-Phycover:** The overall objective of the PHYCOVER project is to identify a modular wastewater treatment process for the production of biogas. The method combines three modules. First, a high-rate algal pond is dedicated to the treatment of municipal wastewater. Then, an anaerobic digester capable of co-digesting biomass products (and others organic matter resources ) to significantly reduce biological and chemical contaminants while producing a sustainable energy as biogas is analysed. A final module transforms the residual carbon, nitrogen and phosphorus into high-value microalgae dedicated to aquaculture and green chemistry.
- **ITE-OPALE:** The goal of the Institut de la Transition Énergétique - OPALE project is to increase the lipid content of microalgae by specific selection pressure. The project relies on the strain already selected during the facteur 4 project, whose productivity was 4 times higher than the wild type. We expect to still increase strain performances up to 10 times the productivity of the wild type.
- **ANR-FunFit:** The objective of this project (2013-2017) is to develop a trait-based approach linking individual fitness of fungal plant pathogens to ecological strategies. The idea is to derive eco-epidemiological strategies from fitness optimization in colonized environments and during colonization, as well as understanding the coexistence of sibling species. This project is co-coordinated by F. Grogard.
- **ANR-TripTic:** The objective of this project (2014-2018) is to document the biological diversity in the genus of the minute wasps *Trichogramma*, and to study the behavioral and populational traits relevant to their use in biological control programs.
- **ANR-GESTER:** “Management of crop resistances to diseases in agricultural landscapes as a response to new constraints on pesticide use”, ANR Agrobiosphère, 2011–2016. This project aims at producing allocation scenarios of resistant varieties at the scale of cultivated landscapes, that will allow to limit disease development while ensuring sustainable efficiency of genetic resistances. BIOCORE participates in this project via MaIAGE, INRA Jouy-en-Josas.
- **ANR-MIHMES:** “Multi-scale modelling, from animal Intra-Host to Metapopulation, of mechanisms of pathogen spread to Evaluate control Strategies”, ANR – Investissement d’avenir, action Bioinformatique (ANR-10-BINF-07) & Fond Européen de Développement Régional des Pays-de-la-Loire (FEDER), 2012–2017. This project aims at producing scientific knowledge and methods for the management of endemic infectious animal diseases and veterinary public health risks. BIOCORE participates in this project via MaIAGE, INRA Jouy-en-Josas. This project supports Natacha Go’s postdoctoral position.

- **ANR-ICycle:** This project (2016-2020) aims at understanding the communication pathways between the cell division cycle and the circadian clock, using mathematical modeling and control theory to construct and implement two coupled synthetic biological oscillators. Project coordinated by M. Chaves.
- **RESET:** The objective of this project is to control the growth of *E. coli* cells in a precise way, by arresting and restarting the gene expression machinery of the bacteria in an efficient manner directed at improving product yield and productivity. RESET is an “Investissements d’Avenir” project in Bioinformatics (managed by ANR) and it is coordinated by H. de Jong (Ibis, Inria)
- **SIGNALIFE:** Biocore is part of this Labex (scientific cluster of excellence) whose objective is to build a network for innovation on Signal Transduction Pathways in life Sciences, and is hosted by the University of Nice Sophia Antipolis.
- **UMT FIORIMED:** FioriMed is a Mixed Technology Unit created in January 2015 to strengthen the production and dissemination of innovation to the benefit of ornamental horticulture. Horticultural greenhouses are seen as a "laboratory" for the actual implementation of agroecology concepts with the possibility of generic outcomes being transferred to other production systems. The main partners of UMT FioriMed are ASTREDHOR (National Institute of Horticulture) and the ISA Joint Research Unit of INRA-CNRS-Univ. Nice.

### 9.1.2. Inria funding

- **Inria Project Lab, Algae *in silico*:** The Algae *in silico* Inria Project Lab, funded by Inria and coordinated by O. Bernard, focuses on the expertise and knowledge of biologists, applied mathematician and computer scientists to propose an innovative numerical model of microalgal culturing devices. The latest developments in metabolic modelling, hydrodynamic modelling and process control are joined to propose a new generation of advanced simulators in a realistic outdoor environment. The project gathers 5 Inria project teams and 3 external teams.

### 9.1.3. INRA funding

- **Take Control:** This project, “Deployment strategies of plant quantitative resistance to take control of plant pathogen evolution,” is funded by the PRESUME call of the SMaCH INRA metaprogram (Sustainable Management of Crop Health). BIOCORE is a partner together with INRA PACA (Sophia Antipolis and Avignon) and INRA Toulouse (2013-2016). This project provides the major part of the funding for the experiments held for Elsa Rousseau’s thesis.
- **K-Masstec:** “Knowledge-driven design of management strategies for stem canker specific resistance genes”, INRA Metaprogramme SMaCH, PRESUME action, 2013–2016. The project aims at developing efficient strategies for the deployment of genetic resistance in the field, based on knowledge issued from the understanding of the molecular interaction between distinct avirulence genes, and mainly the discovery of non-conventional gene-for-gene interactions.

### 9.1.4. Networks

- **GDR Invasions Biologiques:** The objectives of this GDR are to encourage multidisciplinary research approaches on invasion biology. It has five different thematic axes: 1) invasion biology scenarios, 2) biological invasions and ecosystem functioning, 3) environmental impact of invasive species, 4) modeling biological invasions, 5) socio-economics of invasion biology. L. Mailleret is a member of the scientific committee of the GDR .
- **ModStatSAP:** The objective of this INRA network is to federate researchers in applied mathematics and statistics and to promote mathematical and statistical modelling studies in crop and animal health. S. Touzeau is a member of the scientific committee.
- **Seminar:** BIOCORE organizes a regular seminar “Modeling and control of ecosystems” at the station zoologique of Villefranche-sur-Mer, at INRA-ISA or at Inria.

## 9.2. European Initiatives

### 9.2.1. FP7 & H2020 Projects

**SysBioDRez:** Marie Curie International Incoming Fellowship FP7 (EC-PEOPLE) is a multidisciplinary CNRS-Inria project for the collaboration of Jeremie Roux (researcher) with both Paul Hofman (scientist in charge) and Jean-Luc Gouzé (partner lab), with the objective of linking in vitro quantitative dynamics to primary tumor samples profiling in order to determine the resistance probability of a specific combination of anti-cancer drugs in lung cancer, using computational methods (see [91]).

### 9.2.2. Collaborations with Major European Organizations

Imperial college, Department of Chemical engineering (UK),  
 Modelling and optimization of microalgal based processes.  
 Imperial College, Centre for Synthetic Biology and Innovation, Dept. of Bioengineering (UK):  
 Study of metabolic/genetic models  
 University of Aveiro, Portugal  
 Interconnected boolean networks  
 Roslin Institute, Edinburgh, UK  
 Epidemiology  
 University of Padova, Italy.  
 Modelling and control of microalgal production at industrial scale.

## 9.3. International Initiatives

### 9.3.1. Inria International Labs

#### Inria Chile

Associate Team involved in the International Lab:

#### 9.3.1.1. GRENCORE

Title: Modelling and control for energy producing bioprocesses  
 International Partners (Institution - Laboratory - Researcher):  
 CIRIC (Chile) - Méline Gautier  
 PUCV (Chile) - Escuela de Ingeniería Bioquímica (EIB) - Gonzalo Ruiz Filippi  
 UTFSM (Chile) - Departamento de Matemática - Eduardo Cerpa  
 UFRO (Chile) - Chemical Engineering Department - David Jeison

Start year: 2014

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

The worldwide increasing energy needs together with the ongoing demand for CO<sub>2</sub> neutral fuels represent a renewed strong driving force for the production of energy derived from biological resources. In this scenario, the culture of oleaginous microalgae for biofuel and the anaerobic digestion to turn wastes into methane may offer an appealing solution. The main objective of our proposal is to join our expertise and tools, regarding these bioprocesses, in order to implement models and control strategies aiming to manage and finally optimize these key bioprocesses of industrial importance. By joining our expertise and experimental set-up, we want to demonstrate that closed loop control laws can significantly increase the productivity, ensure the bioprocess stability and decrease the environmental footprint of these systems. This project gathers experts in control theory and optimization (BIOCORE, UTFSM) together with experts in bioprocesses (PUCV and UFRO) and software development (CIRIC).

#### 9.3.1.2. Other IIL projects

BIOCORE is involved in the Bionature project from Inria Chile CIRIC (the Communication and Information Research and Innovation Center), in collaboration with four Chilean universities (Universidad de Chile, Universidad Técnica Federico Santa María, Pontificia Universidad Católica de Valparaíso, and Universidad de la Frontera). The Bionature project is devoted to natural resources management and the modeling and control of bioprocesses.

### **9.3.2. Inria International Partners**

#### *9.3.2.1. Informal International Partners*

Univ. Ben Gurion : Microalgal Biotechnology Lab (IL), Member of the ESSEM COST Action ES1408 European network for algal-bioproducts (EUALGAE). Modelling of photosynthesis.

Universidad de la Frontera (CL), Modelling of CO<sub>2</sub> transfer in a microalgal absorption column.

GRIMCAPE, Université de Douala, Cameroon. Epidemiology.

## **9.4. International Research Visitors**

### *9.4.1. Visits of International Scientists*

- Claude Aflalo (Ben Gurion University of the Negev, Israel), 1 week;
- Eduardo Sontag (Rutgers University);
- Laurent Tournier (Inra Jouy-en-Josas), 1 week;
- Bapan Ghosh (National Institute of Technology Meghalaya, India), 1 month.

## **9.5. Project-team seminar**

BIOCORE organized a 4-day seminar in September in La Colle-sur-Loup. On this occasion, every member of the project-team presented his/her recent results and brainstorming sessions were organized. Jacques-Alexandre Sepulchre (INLN, Univ. Nice) was invited as a guest speaker.

## BIOVISION Team

# 7. Partnerships and Cooperations

## 7.1. National Initiatives

### 7.1.1. ANR

#### 7.1.1.1. Trajectory

Title: Encoding and predicting motion trajectories in early visual networks

Programm: ANR

Duration: October 2015 - September 2020

Coordinator: Invibe Team, Institut des Neurosciences de la Timone, Frédéric Chavane,

Partners:

AMU INT Aix-Marseille, Université Institut de Neurosciences de la Timone

INSERM IDV INSERM Institut de la Vision

USM UV U Santa Maria & U Valparaiso

Inria contact: Bruno Cessac

Global motion processing is a major computational task of biological visual systems. When an object moves across the visual field, the sequence of visited positions is strongly correlated in space and time, forming a trajectory. These correlated images generate a sequence of local activation of the feed-forward stream. Local properties such as position, direction and orientation can be extracted at each time step by a feed-forward cascade of linear filters and static non-linearities. However such local, piecewise, analysis ignores the recent history of motion and faces several difficulties, such as systematic delays, ambiguous information processing (e.g., aperture and correspondence problems) high sensitivity to noise and segmentation problems when several objects are present. Indeed, two main aspects of visual processing have been largely ignored by the dominant, classical feed-forward scheme. First, natural inputs are often ambiguous, dynamic and non-stationary as, e.g., objects moving along complex trajectories. To process them, the visual system must segment them from the scene, estimate their position and direction over time and predict their future location and velocity. Second, each of these processing steps, from the retina to the highest cortical areas, is implemented by an intricate interplay of feed-forward, feedback and horizontal interactions. Thus, at each stage, a moving object will not only be processed locally, but also generate a lateral propagation of information. Despite decades of motion processing research, it is still unclear how the early visual system processes motion trajectories. We, among others, have proposed that anisotropic diffusion of motion information in retinotopic maps can contribute resolving many of these difficulties. Under this perspective, motion integration, anticipation and prediction would be jointly achieved through the interactions between feed-forward, lateral and feedback propagations within a common spatial reference frame, the retinotopic maps. Addressing this question is particularly challenging, as it requires to probe these sequences of events at multiple scales (from individual cells to large networks) and multiple stages (retina, primary visual cortex (V1)). “TRAJECTORY” proposes such an integrated approach. Using state-of-the-art micro- and mesoscopic recording techniques combined with modeling approaches, we aim at dissecting, for the first time, the population responses at two key stages of visual motion encoding: the retina and V1. Preliminary experiments and previous computational studies demonstrate the feasibility of our work. We plan three coordinated physiology and modeling work-packages aimed to explore two crucial early visual stages in order to answer the following questions: How is a translating bar represented and encoded within a hierarchy of visual networks and for which condition does it elicit

anticipatory responses? How is visual processing shaped by the recent history of motion along a more or less predictable trajectory? How much processing happens in V1 as opposed to simply reflecting transformations occurring already in the retina? The project is timely because partners master new tools such as multi-electrode arrays and voltage-sensitive dye imaging for investigating the dynamics of neuronal populations covering a large segment of the motion trajectory, both in retina and V1. Second, it is strategic: motion trajectories are a fundamental aspect of visual processing that is also a technological obstacle in computer vision and neuroprostheses design. Third, this project is unique by proposing to jointly investigate retinal and V1 levels within a single experimental and theoretical framework. Lastly, it is mature being grounded on (i) preliminary data paving the way of the three different aims and (ii) a history of strong interactions between the different groups that have decided to join their efforts.

## 7.2. European Initiatives

### 7.2.1. FP7 & H2020 Projects

#### 7.2.1.1. RENVISION

Title: Retina-inspired ENcoding for advanced VISION tasks

Programm: FP7

Duration: March 2013 - February 2016

Coordinator: Instituto Italiano di Tecnologia (Pattern Analysis and Computer vision) Vittorio Murino

Partners:

PAVIS,NET3 Fondazione Istituto Italiano di Tecnologia (Italy)

Institute for Adaptive and Neural Computation, The University of Edinburgh (UK)

Institute of Neuroscience, University of Newcastle Upon Tyne (UK)

Inria contact: Bruno Cessac

The retina is a sophisticated distributed processing unit of the central nervous system encoding visual stimuli in a highly parallel, adaptive and computationally efficient way. Recent studies show that rather than being a simple spatiotemporal filter that encodes visual information, the retina performs sophisticated non-linear computations extracting specific spatio-temporal stimulus features in a highly selective manner (e.g. motion selectivity). Understanding the neurobiological principles beyond retinal functionality is essential to develop successful artificial computer vision architectures. RENVISION's goal is, therefore, twofold: i) to achieve a comprehensive understanding of how the retina encodes visual information through the different cellular layers; ii) to use such insights to develop a retina-inspired computational approach to high-level computer vision tasks. To this aim, exploiting the recent advances in high-resolution light microscopy 3D imaging and high-density multielectrode array technologies, RENVISION will be in an unprecedented position to investigate pan-retinal signal processing at high spatio-temporal resolution, integrating these two technologies in a novel experimental setup. This will allow for simultaneous recording from the entire population of ganglion cells and functional imaging of inner retinal layers at near-cellular resolution, combined with 3D structural imaging of the whole inner retina. The combined analysis of these complex datasets will require the development of novel multimodal analysis methods. Resting on these neuroscientific and computational grounds, RENVISION will generate new knowledge on retinal processing. It will provide advanced pattern recognition and machine learning technologies to ICTs by shedding a new light on how the output of retinal processing (natural or modelled) allows solving complex vision tasks such as automated scene categorization and human action recognition.

## 7.3. International Initiatives

### 7.3.1. Informal International Partners



- Maria-Jose Escobar, University Santa-Maria, Valparaiso;
- Adrian Palacios, Centro de Neurociencia, Valparaiso

## **7.4. International Research Visitors**

### ***7.4.1. Visits of International Scientists***

#### *7.4.1.1. Internships*

- Marco Benzi (grant: Stage Master Transverse Biovision–GraphDeco), Retina-inspired tone mapping. Supervisors: Pierre Kornprobst and Adrien Rousseau (GraphDeco), in collaboration with Maria-Jose Escobar (Universidad Técnica Federico Santa María, Valparaíso, Chile)
- Alberto Patino (grant: CONACYT), Studying image transforms at neuronal level and in Virtual Reality. Supervisors: Pierre Kornprobst (Biovision) and Fabio Solari (University of Genoa, Italy)

## CAMIN Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

- LABEX NUMEV (postdoc):  
Participants: Mitsuhiro Hayashibe, Denis Mottet (EUROMOV).  
A 1-year postdoc was funded by the NUMEV Labex on "Control of Arm Synergies After a Stroke (CASAS)".
- LABEX NUMEV (PhD grants co-fundings): Participants: Christine Azevedo, David Andreu, Benoit Sijobert.  
Participants: Sofiane Ramdani, François Bonnetblanc, Anthony Boyer.

## 9.2. National Initiatives

- BCI-LIFT: an Inria Project-Lab Participants : Mitsuhiro Hayashibe, Saugat Bhattacharyya.  
BCI-LIFT is a large-scale 4-year research initiative (2015-2018) which 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. We work on BCI-FES study for promoting motor learning.
- ADT PersoBalance2  
Participants : Mitsuhiro Hayashibe, Philippe Fraisse.  
A half-year engineer was funded by Inria ADT on "Personalized Balance Assessment in Home Rehabilitation, version2 (PersoBalance2)".

### 9.2.1. Excellence initiative, PSPC

- Project INTENSE 2012-2018
- Leader: LIVANOVA
- Partners: LTSI, INRA Rennes, CEA LETI, HEGP, CHU Rennes, MXM-Axonic, 3D+
- the aim of the project is to treat severe obesity and cardiac failure through Vagus Nerve Stimulation (VNS). Our contribution concerned the development of innovative hardware and software architecture to allow for selective stimulation. We developed the models that were used to optimize the settings of the stimulators taking into account the geometry of the 12-pole neural electrode. The selectivity and the efficacy of the stimulation were also improved through the study of original stimulus waveforms. As a whole the idea was to further enhance the therapy while limiting the side effects that VNS may induce.
- the cardiac application stops end of august due to internal decisions at LIVANOVA but the obesity application continues to be investigated.

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

Program: FP7

Project acronym: EPIONE

Project title: Natural sensory feedback for phantom limb pain modulation and therapy

Duration: 2013-2017

Coordinator: AAU (Aalborg, Denmark)

Other partners: Ecole polytechnique fédérale de Lausanne (EPFL), IUPUI (Indianapolis, USA), Lund University (LUNDS UNIVERSITET), MXM (Vallauris, France), Novosense AB (NS), IMTEK (Freiburg, Germany), UAB (Barcelona, Spain), Aalborg Hospital, Università Cattolica del Sacro Cuore (UCSC), Centre hospitalier Universitaire Vaudois (CHUV)

Abstract: <http://project-epione.eu/>. The aim of the project is to treat phantom limb pain. CAMIN is only involved in the invasive approach using intrafascicular electrodes. We developed certified software with EPFL and AAU, co-supervised animal tests and data processing with UAB, provide support to clinical trials with IMTEK and UCSC and developed a new stimulator with MXM.

## 9.4. International Initiatives

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

#### 9.4.1.1. NEUROPHYS4NEUROREHAB

Title: Development of neurophysiological test setup for customizing and monitoring patient-specific non-invasive electrical stimulation-facilitated neurorehabilitation.

International Partners (Institution - Laboratory - Researcher):

IITH (India) - Centre for VLSI and Embedded Systems Technology - Shubhajit Roy Chowdhury

IIT Gandhinagar (India) - Department of Electrical Engineering- Uttama Lahiri

Start year: 2014

See also: <https://team.inria.fr/nphys4nrehab/>

Stroke presents with heterogeneous patient-specific impairments in motor, sensory, tone, visual, perceptual, cognition, aphasia, apraxia, coordination, and equilibrium where the functional limitations following stroke are varied, including gait dysfunction, fall risk, limited activities of daily living, difficulties in swallowing, reduced upper extremity function, altered communication, besides others. These heterogeneous patient-specific impairments make planning of the neurorehabilitation therapy challenging. Here, it may be important to stratify the stroke survivors for restorative neurorehabilitation based on the prognosis and the ability of the stroke survivor to undergo therapy depending on their cardiovascular and neuromuscular capacity besides psychological factors such as motivation where the therapy needs to be tailored to individual health condition. The WHO International Classification of Functioning (ICF) model recommends intervention at multiple levels (e.g., impairment, activity, participation) where environment and personal factors can play an important role in resource-limited India. In fact, deconditioned chronic stroke survivor will need to recondition their cardiovascular endurance, metabolic fitness, and muscle conditions with a gradual increase in the intensity (number of hours per day) and frequency (number of days per week) of therapy, providing a higher level as they improve their function. Towards that overarching goal in a low-resource setting, we propose development of neurophysiological screening and monitoring tools using low-cost sensors.

#### 9.4.1.2. CACAO

Title: Lower limb electrical stimulation for function restoration

International Partner (Institution - Laboratory - Researcher):

UNB (Brazil) - NTA AI - FACHIN-MARTINS Emerson

UNB (Brazil) - LARA - Padilha-Bo Antonio

Start year: 2016

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

Electrical stimulation (ES) can activate paralyzed muscles to support rehabilitation. ES applied to fully or partially paralyzed muscles artificially induces muscle contraction substituting or completing the normal volitional control. In CACAO team we will join our efforts and specific expertise to develop approaches of lower limb function restoration in spinal cord injured individuals. Two main applications will be addressed: 1) Functional Electrical Stimulation (FES) to assist SCI individuals to perform pivot transfers and 2) FES-assisted cycling (we already jointly prepared and participated to CYBATHLON'16). We aim at proposing solutions that can have an effect on patients' quality of life, thus our choices intend to be realistic from a practical point of view. We will take care in evaluating both functional and psychological effects of our solutions and to constrain technical choices to be acceptable by final user. CACAO project will be a good opportunity to combine "bioengineer" (DEMAR) and "physiology/rehabilitation" (NTAAI) visions and knowledges towards solutions for clinical applications.

## 9.5. International Research Visitors

### 9.5.1. Visits to International Teams

#### 9.5.1.1. France-Stanford program

The Executive Committee of the France-Stanford Center for Interdisciplinary Studies supported our collaboration (§7.1.1) with Prof. Jessica Rose (Department of Orthopaedic Surgery, Stanford University). As part of the collaboration, Professor Rose presented a keynote lecture on Artificial Walking Technologies for Neuro-muscular stimulation-assisted Gait for children with cerebral palsy at the International Functional Electrical Stimulation Society (IFESS) conference hosted by CAMIN. In July, a Benoît Sijobert spent 2 weeks in July 2016 to setup the experiment and Christine Azevedo Coste 1 week to run experiments.

#### 9.5.1.2. Asgard program

From may 5 to may 13, François Bonnetblanc visited The Endestad Brain Imaging Group, the Institute of Basic Medical Sciences, Akershus universitetssykehus HF, Sunnaas Sykehus HF, UiO Department of Psychology, and the Norwegian School of Sport Sciences in Norway thanks to the Asgard programme. (<http://www.france.no/if/oslo/cooperation/sciences/programmes-sciences/asgard/>)

A shared project about the closed-loop stimulation of urinal control of pigs has been proposed with the Institute of Basic Medical Sciences in the framework of Aurora (followup of Adgard).

#### 9.5.1.3. Research Stays Abroad

Christine Azevedo Coste spent 2,5 months (November 2015-February 2016) at Brasilia University as an invited researcher in collaboration within Emerson FACHIN-MARTINS responsible of the NTAAl (Nucléo de Tecnologia Assistiva, Acessibilidade e Inovacão) initiative.

Brazilian program: Science without borders (Ciências sem fronteiras) CAPES. She spent 10 days in May 2016 together with Charles FATTAL to perform experiments.

Mitsuhiro Hayashibe was invited to participate to JSPS Program: Program for Advancing Strategic International Networks to Accelerate the Circulation of Talented Researchers. (PI Prof. Hitoshi Hirata, Dep. of Med. Nagoya Univ.)(Feb. 2016)

Mitsuhiro Hayashibe was visiting Researcher at EPFL, BIOROB supported by Swiss National Science Foundation (Sep.-Oct. 2016)

## CASTOR Project-Team

## 6. Partnerships and Cooperations

### 6.1. National Initiatives

#### 6.1.1. ANR

- ANEMOS : ANR-11-MONU-002  
ANEMOS : Advanced Numeric for Elms : Models and Optimized Strategies associates JAD Laboratory/Inria (Nice, Manager), IRFM-CEA (Cadarache), Maison de la Simulation (Saclay) and Inria EPI Bacchus (Bordeaux). Final report, oral talk and poster to the "Journées des Rencontres Numériques de l'ANR" (16-17 nov. 2016), <http://www.rencontres-numerique-anr.fr/>.

#### 6.1.2. Inria Project Lab: *FRATRES (Fusion Reactors Research and Simulation)*

- Participants : Inria project-teams : CASTOR, IPSO, TONUS,
- Partners : IRFM-CEA, Max Planck Institute-IPP Garching, LJLL-Jussieu, IMT-Toulouse

Controlled nuclear fusion can be considered as an example of grand challenge in many fields of computational sciences from physical modelling, mathematical and numerical analysis to algorithmics and software development and several Inria teams and their partners are developing mathematical and numerical tools in these areas.

Since January 2015, H. Guillard is coordinating the Inria Project Lab FRATRES (<https://team.inria.fr/ipl-fratres/>) to organize these developments on a collaborative basis in order to overcome the current limitations of today numerical methodologies. The ambition is to prepare the next generation of numerical modelling methodologies able to use in an optimal way the processing capabilities of modern massively parallel architectures. This objective requires close collaboration between a) applied mathematicians and physicists that develop and study mathematical models of PDE; b) numerical analysts developing approximation schemes; c) specialists of algorithmic proposing solvers and libraries using the many levels of parallelism offered by the modern architecture and d) computer scientists. This Inria Project Lab will contribute in close connection with National and European initiatives devoted to nuclear Fusion to the improvement and design of numerical simulation technologies applied to plasma physics and in particular to the ITER project for magnetic confinement fusion.

Contact : Hervé Guillard

### 6.2. European Initiatives

#### 6.2.1. FP7 & H2020 Projects

##### 6.2.1.1. EuroFusion Consortium

CASTOR participates to the following EuroFusion consortium projects :

- CfP-WP14-ER-01/Swiss Confederation-01. École Polytechnique Fédérale de Lausanne (PI: Paolo Ricci) "Synergetic numerical-experimental approach to fundamental aspects of turbulent transport in the tokamak edge"
- CfP-WP14-ER-01/CEA-01. CEA (PI: Matthias Hoelzl IPP) "JOEKE, BOUT++ non-linear MHD modelling of MHD instabilities and their control in existing tokamaks and ITER"
- EUROfusion WPCD (Working Package Code Development)
  - ACT1: Extended equilibrium and stability chain (participation)
  - ACT2: Free boundary equilibrium and control (participation and coordination)

### 6.2.1.2. *EoCoE*

The team also participates in the EoCoE European project. Grant Agreement number: 676629 — EoCoE — H2020-EINFRA-2014-2015/H2020-EINFRA-2015-1.

Title: Energy oriented Centre of Excellence for computer applications

Programm: H2020

Duration: October 2015 - October 2018

Coordinator: CEA

Partners:

Barcelona Supercomputing Center - Centro Nacional de Supercomputacion (Spain)

Commissariat à l'Énergie Atomique et Aux Énergies Alternatives (France)

Centre Europeen de Recherche et de Formation Avancee en Calcul Scientifique (France)

Consiglio Nazionale Delle Ricerche (Italy)

The Cyprus Institute (Cyprus)

Agenzia Nazionale Per le Nuove Tecnologie, l'energia E Lo Sviluppo Economico Sostenibile (Italy)

Fraunhofer Gesellschaft Zur Forderung Der Angewandten Forschung Ev (Germany)

Instytut Chemii Bioorganicznej Polskiej Akademii Nauk (Poland)

Forschungszentrum Julich (Germany)

Max Planck Gesellschaft Zur Foerderung Der Wissenschaften E.V. (Germany)

University of Bath (United Kingdom)

Universite Libre de Bruxelles (Belgium)

Universita Degli Studi di Trento (Italy)

Inria contact: Michel Kern

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

## **6.3. International Initiatives**

### ***6.3.1. Inria Associate Teams Not Involved in an Inria International Labs***

#### *6.3.1.1. AMOSS*

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

International Partner (Institution - Laboratory - Researcher):

NCKU (Taiwan) - Yih-Chin Tai

Start year: 2014

Our objective here is to generalize the promising modelling strategy proposed by S. Gavrilyuk (2012-2013) 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. Cross validations will be achieved by experiments and numerical simulations with applications to landslides.

Closing workshop of the associated team, 7-10 nov. 2016 - Tainan (Taiwan)

### ***6.3.2. Inria International Partners***

#### *6.3.2.1. Informal International Partners*

The team collaborates with TUC (Technical University of Crete, Prof. Argyris Delis) on the subject of shallow water models. Part of this collaboration is common with the works done in the framework of the AMOSS associate team.

## COFFEE Project-Team

## 8. Partnerships and Cooperations

### 8.1. Regional Initiatives

The team is involved in the recently granted project UCA-JEDI.

### 8.2. National Initiatives

#### 8.2.1. ANR

The ANR-project Monumentalg, led by M. Ribot, is devoted to the modeling and simulation of biological damage on monuments and algae proliferation.

Coffee is among the partners of the project CHARMS, with a funding starting in 2016; the project is devoted to the modeling of reservoirs in complex hydrothermal networks.

#### 8.2.2. National and European networks

- GdR MANU.  
The research group MANU has activities centered around scientific computing, design of new numerical schemes and mathematical modelling (upscaling, homogenization, sensitivity studies, inverse problems,...). Its goal is to coordinate research in this area, as well as to promote the emergence of focused groups around specific projects
- S. Junca is involved in the GdR-e “Wave Propagation in Complex Media for Quantitative and non Destructive Evaluation”.

### 8.3. International Initiatives

#### 8.3.1. Declared Inria International Partners

Team **COKLYCO**

Title: Modeling, analysis and simulation of kinetic and fluid models for MEMS

International Partner (Institution - Laboratory - Researcher):

Kyoto (Japan) - Department of Mechanical Engineering and Science (ME) - Aoki Kazuo

Start year: 2014 End year: 2016.

See also: [https://team.inria.fr/coffee/?page\\_id=323](https://team.inria.fr/coffee/?page_id=323)

We wish to elaborate and analyse new models of microscopic and macroscopic type for Micro-Electro-Mechanical Systems (MEMS). The tiny scales of such technical devices induce new and challenging difficulties. A specific attention will be paid to the treatment of coupling conditions from moving boundaries, and to the multi-scale character of the problem. The project is based on a strong interplay between mathematical analysis, experiments and numerical simulations, made possible by the composition of the team.

#### 8.3.2. Informal International Partners

Quite recently, S. Junca has started a collaboration with Mathias Legrand, from the Mechanical Engineering department at Mc Gill, Montréal with the supervision of the internship of a master student (S. Heng, 6 months, June-Nov. 2013). Furthermore, S. Junca is an active member of the European network “Wave propagation in complex media for quantitative and non destructive evaluation”<sup>0</sup>

<sup>0</sup><http://www.gdre-us.cnrs-mrs.fr/spip.php?rubrique8>



S. Krell has a collaboration with Martin Gander (University of Geneva, Switzerland) on domain decomposition methods, adapted to DDFV discretizations.

M. Ribot started a collaboration with Roberto Natalini a couple of years ago. Connections with experts in Firenze was the starting point of the research on biofilm formation and algae proliferation. M. Ribot and R. Natalini have also worked on new well-balanced strategy — the so-called AHO schemes — in order to preserve equilibria and to capture correctly large time solutions for complex PDEs system, without knowing explicitly the equilibrium solution. They have co-advised 2 PhD thesis.

Finally, we have many international collaborations, with variable peaks of activity, in our research networks: A. Vasseur (U. T. Austin), P.E. Jabin (Univ. Maryland), J.-A. Carrillo (Imperial College London), S. Jin (U. W. Madison and Jiao Tong Univ.), R. Aavatsmark (Univ. of Bergen), etc.

M. Ribot spent a semester, funded by CNRS at ICL, UK.

#### **8.4. International Research Visitors**

Kazuo Aoki, from Taiwan, Satushi Taguchi, Takeru Yano, Shingo Kosuge from Kyoto and Osaka University.

## LEMON Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

- **Cart'Eaux** project (European Regional Development Fund (ERDF)): in partnership with colleagues of LIRMM and HSM (Montpellier) and with Berger-Levrault company, Carole DELENNE and Benjamin COMMANDRE are developing a methodology that will collect and merge multi-sources data in the aim of mapping urban drainage networks for hydraulic modeling purpose. This chain of treatment includes: 1) detection of manhole covers from remote sensing data (aerial images, numerical elevation models. . .), 2) development of an algorithm to retrieve the network from the detected points and other information such as roads or topography, 3) data manning to extract useful characteristics for the hydraulic model, from various databases available or from documents automatically gathered from the web. A confidence index will be given to each characteristic assessed and a sensitivity analysis will enable the software to propose a hydraulic model together with an associated uncertainty.
- The GeRIMU project (Gestion du Risque d'Inondation en Milieu Urbain) counts 3 partners: Cerec Ingénierie, HSM and Predict Services. In this project, the upscaled shallow water model with porosity SW2D developed at HSM is embedded in a software chain that will allow fast urban flood computations from forecasted precipitation fields. The project is funded under the Feder scheme. It has earned a distinction from the local Scientific Advisory Committee ("Coup de coeur du COSTI").

## 9.2. National Initiatives

### 9.2.1. ANR

Fabien MARCHE is member of the ANR project BonD (PI Sylvie Benzoni), 2013-2017

Fabien MARCHE is member of the ANR project ACHYLLES (PI Rodolphe Turpault), 2014-2017

Fabien CAMPILLO is member of the ANR project Slofadybio, 2015-2016

Antoine ROUSSEAU is member of the ANR project ANSWER (PI Céline Casenave), 2016-2019

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

Vincent GUINOT was the main investigator of an International Training Network (ITN) proposal in 2016. The proposal was not accepted and will be submitted again in 2017, accounting for the remarks made by the reviewers.

## 9.4. International Initiatives

### 9.4.1. Inria International Labs

#### 9.4.1.1. Inria Chile

Antoine ROUSSEAU spent 9 months at Inria Chile from January to October 2016.

### 9.4.2. Inria International Partners

#### 9.4.2.1. Declared Inria International Partners

In 2015, the *Marine Energies Research International Center* (MERIC) was launched in Chile by CORFO. Antoine ROUSSEAU will be the scientific coordinator for Inria, and several members of LEMON, CARDAMOM and TOSCA research teams will be involved in this 8 years project driven by DCNS. Antoine ROUSSEAU and Fabien MARCHE are involved in the research line *advanced modeling for marine energy*.

#### *9.4.2.2. Informal International Partners*

Vincent GUINOT collaborates with B.F. Sanders (Irvine University, Californie, USA)

Carole DELENNE and Vincent GUINOT collaborates with S. Soares-Fraza (Unité de Génie Civil, Université catholique de Louvain, Belgium)

Antoine ROUSSEAU continues to collaborate with H. Ramirez (CMM, Santiago) and P. Gajardo (UTFSM, Valparaiso) after the end of the Inria associated team Dymecos (2015).

## **9.5. International Research Visitors**

### ***9.5.1. Research Stays Abroad***

Antoine ROUSSEAU spent 9 months at Inria Chile from January to October 2016. He co-advised 2 master students and 1 research engineer in the framework of the MERIC project in Chile. Antoine ROUSSEAU also participated to the TsunamiLab project between Inria Chile and CIGIDEN.

## MATHNEURO Team

# 6. Partnerships and Cooperations

## 6.1. Regional Initiatives

Olivier Faugeras is a member of the scientific committee of the "Axe Interdisciplinaire de Recherche de l'Université de Nice Sophia Antipolis" entitled "Modélisation Théorique et Computationnelle en Neurosciences et Sciences Cognitives".

## 6.2. National Initiatives

### 6.2.1. ANR

#### 6.2.1.1. SloFaDyBio

Title: a network for Slow-Fast Dynamics in the Biosciences

Programm: ANR "amorçage"

Duration: January 2015 - January 2017 (extension up to January 2018)

Coordinator: Inria

PI: Mathieu Desroches

Partners:

see the [webpage](#) of the project.

The SloFaDyBio project targets to gather European researchers from about 10 cost countries in order to build up a network project on "Multi-Scale Dynamics in Neuroscience" and to submit within two years a large-scale proposal to a European funding agency such as COST. The initial fund provided by the ANR is used to meet regularly over this period and write a complete proposal. We now have an operational team and we are in the process of writing a full proposal which will be submitted at the next COST call, that is, at the end of September 2017.

## 6.3. European Initiatives

### 6.3.1. FP7 & H2020 Projects

#### 6.3.1.1. HBP

Title: The Human Brain Project

Programm: FP7

Duration: October 2013 - March 2016 (first part) and then : April 2016 - March 2018 (second part)

Coordinator: EPFL

Partners:

see the [webpage](#) of the project.

Inria contact: Olivier Faugeras (first part) and then : Romain Veltz (second part)

Understanding the human brain is one of the greatest challenges facing 21st century science. If we can rise to the challenge, we can gain profound insights into what makes us human, develop new treatments for brain diseases and build revolutionary new computing technologies. Today, for the first time, modern ICT has brought these goals within sight. The goal of the Human Brain Project, part of the FET Flagship Programme, is to translate this vision into reality, using ICT as a catalyst for a global collaborative effort to understand the human brain and its diseases and ultimately to emulate its computational capabilities. The Human Brain Project will last ten years and will consist of a ramp-up phase (from month 1 to month 36) and subsequent operational phases.

This Grant Agreement covers the ramp-up phase. During this phase the strategic goals of the project will be to design, develop and deploy the first versions of six ICT platforms dedicated to Neuroinformatics, Brain Simulation, High Performance Computing, Medical Informatics, Neuromorphic Computing and Neurorobotics, and create a user community of research groups from within and outside the HBP, set up a European Institute for Theoretical Neuroscience, complete a set of pilot projects providing a first demonstration of the scientific value of the platforms and the Institute, develop the scientific and technological capabilities required by future versions of the platforms, implement a policy of Responsible Innovation, and a programme of transdisciplinary education, and develop a framework for collaboration that links the partners under strong scientific leadership and professional project management, providing a coherent European approach and ensuring effective alignment of regional, national and European research and programmes. The project work plan is organized in the form of thirteen subprojects, each dedicated to a specific area of activity.

A significant part of the budget will be used for competitive calls to complement the collective skills of the Consortium with additional expertise.

## **6.4. International Research Visitors**

### **6.4.1. Visits of International Scientists**

Invitation of Martin Wechselberger, University of Sydney (Australia), June 2016

Invitation of Daniele Avitabile, University of Nottingham (UK), June 2016

Invitation of James MacLaurin, University of Sydney (Australia), December 2016

Invitation of Tim O'Leary, University of Cambridge (UK), December 2016

Invitation of Antonio Teruel, University of the Balearic Islands (Spain), December 2016

#### *6.4.1.1. Internships*

Cantin Baron (collaboration with H. Marie at IPMC, Feb-June 2016)

Raphaël Fourquet (collaboration with H. Marie at IPMC, Feb-June 2016)

### **6.4.2. Visits to International Teams**

Visit of Mathieu Desroches to Daniele Avitabile (University of Nottingham, UK) in April 2016

Visit of Romain Veltz to Cian O'Donnell (University of Bristol, UK) in April 2016

Visit of Mathieu Desroches to Martin Wechselberger (University of Sydney, Australia) in August 2016

Visit of Mathieu Desroches to Vivien Kirk (University of Auckland, New Zealand) in September 2016

Visit of Mathieu Desroches to Daniele Avitabile (University of Nottingham, UK) in April 2016

Visit of Mathieu Desroches to Serafim Rodrigues (Plymouth University, UK) in October 2016

## MORPHEME Project-Team

# 7. Partnerships and Cooperations

## 7.1. Regional Initiatives

### 7.1.1. LABEX SIGNALIFE

The MORPHEME team is member of the SIGNALIFE Laboratory of Excellence.

Florence Besse and Xavier Descombes are members of the Scientific Committee.

Florence Besse and Xavier Descombes participated in the selection committee for LabeX PhD program students.

## 7.2. National Initiatives

### 7.2.1. ANR RNAGRIMP

**Participants:** Florence Besse [PI], Xavier Descombes, Eric Debreuve, Djampa Kozlowski, Nicolas Cedilnik.

Here, we propose to study the molecular bases underlying the assembly and regulation of RNA granules, using the highly conserved IMP-containing granules as a paradigm. Specifically, we propose to perform an unbiased genome-wide RNAi screen on *Drosophila* cultured cells to identify mutant conditions in which the organization and/or distribution of IMP-containing granules is altered. To quantitatively and statistically analyze mutant conditions, and to define precise and coherent classes of mutants, we will combine high throughput microscopy with the development of a computational pipeline optimized for automatic analysis and classification of images. The function of positive hits isolated in the screen will then be validated *in vivo* in *Drosophila* neurons using fly genetics and imaging techniques, and characterized at the molecular and cellular levels using biochemical assays, *in vitro* phase transition experiments and live-imaging. Finally, the functional conservation of identified regulators will be tested in zebrafish embryos combining gene inactivation and live-imaging techniques. This integrative study will provide the first comprehensive analysis of the functional network that regulates the properties of the conserved IMP RNA granules. Our characterization of the identified regulators *in vivo* in neuronal cells will be of particular significance in the light of recent evidence linking the progression of several degenerative human diseases to the accumulation of non-functional RNA/protein aggregates.

This 4-years project started january, 2016 and is leaded by F. Besse (iBV, Nice). Participants are iBV, institut de biologie Paris Seine (IBPS, Paris), and Morpheme.

### 7.2.2. ANR HMOVE

**Participants:** Xavier Descombes, Eric Debreuve.

Among the signaling molecules involved in animal morphogenesis are the Hedgehog (Hh) family proteins which act at distance to direct cell fate decisions in invertebrate and vertebrate tissues. To study the underlying process we will develop accurate tracking algorithm to compare trajectories of different Hh pools transportation in live animals. This will allow us to analyze the contribution of the different carriers in the establishment of the Hh gradient. Moreover, we will develop new methods to modify the spatio-temporal and dynamical properties of the extra-cellular Hh gradient and separate the contribution of the apical versus basal Hh pools. We will complete this study with a genome-wide screen to identify genes and related cellular processes responsible for Hh release. The particular interest of this collaboration lies in the combination of development of tracking algorithm to analyze Hh distribution and trajectories with extremely powerful genetics, ease of *in vivo* manipulation and lack of genetic redundancy of *Drosophila*.

This 4-years project started january, 2016 and is leaded by P. Théron (iBV, Nice). Participants are iBV and Morpheme.

### 7.2.3. ANR DIG-EM

**Participants:** Grégoire Malandain, Xavier Descombes, Gaël Michelin.

Morphogenesis controls the proper spatial organization of the various cell types. While the comparatively simple process of patterning and cell differentiation has received considerable attention, the genetic and evolutionary drivers of morphogenesis are much less understood. In particular, we very poorly understand why some morphogenetic processes evolve very rapidly, while others show remarkable evolutionary stability.

This research program aims at developing a high-throughput computational framework to analyze and formalize high-throughput 4D imaging data, in order to quantify and formally represent with cellular resolution the average development of an organism and its variations within and between species. In addition to its biological interest, a major output of the project will thus be the development of robust general computational methods for the analysis, visualization and representation of massive high-throughput light-sheet data sets.

This 4-years project started october the 1st, 2014 and is leaded by P. Lemaire (CRBM, Montpellier). Participants are the CRBM, and two Inria project-team, Morpheme and Virtual Plants.

### 7.2.4. ANR PhaseQuant

**Participants:** Grégoire Malandain, Eric Debreuve.

The PhaseQuantHD project aims at developing a high-content imaging system using quadriwave lateral shearing interferometry as a quantitative phase imaging modality. Automated analysis methods will be developed and optimized for this modality. Finally an open biological study question will be treated with the system.

This 3-years project started october the 1st, 2014 and is leaded by B. Wattelier (Phasics, Palaiseau). Participants are Phasics, and three academic teams TIRO (UNS/CEA/CAL), Nice, Mediacoding (I3S, Sophia-Antipolis), and Morpheme.

### 7.2.5. Inria Large-scale initiative Morphogenetics

**Participants:** Grégoire Malandain, Xavier Descombes, Gaël Michelin.

This action gathers the expertise of three Inria research teams (Virtual Plants, Morpheme, and Evasion) and other groups (RDP (ENS-CNRS-INRA, Lyon), RFD (CEA-INRA-CNRS, Grenoble)) and aimed at understanding how shape and architecture in plants are controlled by genes during development. To do so, we will study the spatio-temporal relationship between genetic regulation and plant shape utilizing recently developed imaging techniques together with molecular genetics and computational modeling. Rather than concentrating on the molecular networks, the project will study plant development across scales. In this context we will focus on the Arabidopsis flower, currently one of the best-characterized plant systems.

### 7.2.6. Octopus Project

**Participant:** Eric Debreuve.

The Octopus project deals with automatic classification of images of zooplankton. It is conducted in collaboration with the Laboratoire d'Océanographie de Villefranche-sur-mer (LOV) et l'ENSTA Paris. The kickoff meeting took place in May 2015 and a 3-day *brainstorming* meeting on Deep Learning took place in December 2015. Participants are I3S (Frédéric Precioso and Mélanie Ducoffe), LOV (Marc Picheral and Jean-Olivier Irisson), and ENSTA Paris (Antoine Manzanera).

## **7.3. European Initiatives**

### **7.3.1. Collaborations in European Programs, Except FP7 & H2020**

- COST Action (The COST Program is supported by the EU Framework Program H2020). We are part of a consortium of teams which submitted in December a COST Action proposal on machine learning and intelligent systems for the marine and aquatic sciences.

## **7.4. International Research Visitors**

### **7.4.1. Visits of International Scientists**

#### *7.4.1.1. Internships*

Mohammed Lamine Benomar, PhD, Université Abou Bekr Belkaid Tlemcen, Algérie, from October 2016 until April 2017.

Hibetallah Ouazaa, PhD, National Engineering School of Tunis, from May 2016 until Jun 2016



## VIRTUAL PLANTS Project-Team

# 8. Partnerships and Cooperations

## 8.1. Regional Initiatives

### 8.1.1. *New pearl*

**Participants:** Sixtine Passot, Yann Guédon, Soazig Guyomarc'h [Montpellier University, DIADE], Laurent Laplaze [IRD, DIADE].

Funding: Labex Agro (Contractor for Virtual Plants: CIRAD, from 2014 to 2017)

Pearl millet is an orphan crop regarding research effort despite its key role for food safety in Sub-Saharan Africa. The objective of the New Pearl project is to develop basic biological knowledges concerning Pearl millet development and genetic diversity. We are more specifically involved in the study of the root system development and the genetic diversity on the basis of root phenotypic traits.

### 8.1.2. *MecaFruit3D*

**Participants:** Mik Cieslak, Frédéric Boudon, Christophe Godin, Nadia Bertin [PSH, Avignon].

Funding: Labex Agro (Contractor for Virtual Plants: INRA, from 2013 to 2016)

The fruit cuticle plays a major role in fruit development and shelf-life. It is involved in water losses, cracking, and protection against stress, and thus it may have major economic impacts. Objectives of the project are to better understand the multiple roles of the fruit cuticle in the control of fleshy fruit growth and quality.

The multicellular model for fruit growth that we develop (see section 6.3.2) will be used to study qualitatively the impact of the cuticle mechanical properties.

Partners: PSH, INRA, Avignon; LCVN, IES, Université Sud de France, Montpellier.

### 8.1.3. *Integrated model of plant organ growth*

**Participants:** Yann Guédon, Christine Granier [INRA, LEPSE], Garance Koch [INRA, LEPSE], Nadia Bertin [INRA, PSH], Valentina Baldazzi [INRA, PSH].

Funding: Labex Agro (Contractor for Virtual Plants: CIRAD. From 2015 to 2018)

The objective of this project is to develop a generic model which will predict interactions among the main processes controlling the development of source and sink organs in tomato, i.e. cell division, cell expansion and endoreduplication in relation to carbon and water fluxes under fluctuating environment. To achieve this objective we will i) capitalize on expertise, multi-scale phenotyping tools and genetic resources already compiled on the fruit model tomato and the model plant *Arabidopsis thaliana*; ii) perform new experiments to collect phenotyping data currently missing in this field, especially concerning the early phase of fruit and leaf development in tomato and the interactions between genes and environment; iii) develop a process-based model of organ growth which will integrate knowledge collected at the different scales.

Partners: PSH, INRA, Avignon; LEPSE, INRA, Montpellier, Biologie du fruit et Pathologie INRA, Bordeaux;

## 8.2. National Initiatives

### 8.2.1. *HydroRoot*

**Participants:** Mikaël Lucas [IRD], Christophe Pradal, Christophe Godin, Yann Boursiac [BPMP], Christophe Maurel [BPMP].

Funding: ANR (Contractor for Virtual Plants: Cirad, From 2012 to 2016)

The HydroRoot project proposes a unique combination of approaches in the model plant *Arabidopsis thaliana* to enhance our fundamental knowledge of root water transport. Accurate biophysical measurements and mathematical modeling are used, in support of reverse and quantitative genetics approaches, to produce an integrated view of root hydraulics. The HydroRoot project will address as yet unknown facets of root water transport. It will lead to an integrated view of root hydraulics that considers both tissue hydraulics and root architecture and explains how these components are controlled at the molecular level by physiological and/or environmental cues. Because of its strong physiological and genetic background, this research may also directly impact on breeding programs, for production of crops with optimised water usage and stress responses.

### 8.2.2. *Phenome*

**Participants:** Christian Fournier, Christophe Pradal, Yann Guédon, Sarah Cohen-Boulakia, Simon Artzet, Jerome Chopard, Patrick Valduriez.

Funding: ANR-Investissement d'avenir (Contractor for Virtual Plants: INRA, From 2015 to 2018)

The goal of Phenome is to provide France with an up-to-date, versatile, high- throughput infrastructure and suite of methods allowing characterisation of panels of genotypes of different species under climate change scenarios. We are involved in the methodological part of the project, that aims at developing a software framework dedicated to the analysis of high throughput phenotyping data and models. It will be based on the OpenAlea platform that provides methods and softwares for the modelling of plants, together with a user-friendly interface for the design and execution of scientific workflows. We also develop the InfraPhenoGrid infrastructure that allows high throughput computation and recording of provenance during the execution of Workflows.

### 8.2.3. *DigEM*

**Participants:** Christophe Godin, Grégoire Malandain, Patrick Lemaire.

Funding: ANR (Contractor for Virtual Plants: Inria, From 2015 to 2019)

In this project, we will use advanced light-sheet imaging of live embryos to quantitatively describe embryonic morphogenesis in ascidians, a class of animals that undergo very rapid genomic divergence, yet show an extraordinary stasis of embryonic morphologies, based on invariant early cell lineages shared by all studied species. The global aims of the proposal, which will bridge micro- and macroevolutionary scales of analysis, are: i) to provide a global systems-level description at cellular resolution of an animal embryonic program; ii) to use this description to characterize intra-specific and inter-specific patterns of morphogenetic variations; iii) to analyze possible molecular mechanisms explaining the unusual robustness of this program to environmental and genetic perturbations. To achieve these aims, we will combine advanced live light-sheet microscopy, computational biology, functional gene assays and evolutionary approaches.

### 8.2.4. *Leaf Serration*

**Participants:** Christophe Godin, Eugenio Azpeitia.

Funding: ANR (Contractor for Virtual Plants: Inria, From 2014 to 2019)

Leaf growth and development result from the coordination in time and space of cellular divisions and cellular expansion, and expansion of certain plant cells reaches up to one thousand times their size when living the meristem. Transcription factors belonging to the CUP-SHAPED COTYLEDON (CUC) genes and homeodomain genes of the KNOTTED-LIKE (KNOXI) family were shown to be essential for the control of leaf size and shape. In addition, the phytohormone auxin is a critical regulator of growth and development, involved in the regulation and coordination of cell division and cell expansion. The mechanisms of auxin signalling are based on a complex set of co-receptors exhibiting high to low affinity for auxin and an even more complex modular network of transcriptional repressors and activators tightly controlling the expression of a large set of genes.

The SERRATIONS project is based on recent data relative to key transcription factors regulating leaf morphogenesis and advanced knowledge on the generic signalling mechanisms of the phytohormone auxin that plays a critical role in the control and coordination of cellular responses sustaining leaf size and shape. The goal of the project is to identify auxin signalling modules involved in leaf morphogenesis and to integrate these data in mathematical modelling to provide new insights into complex regulatory networks acting on leaf morphogenesis and to further test model-derived hypotheses.

### **8.2.5. Other national grants**

#### **8.2.5.1. SCOOP**

**Participants:** Pierre Fernique, Yann Guédon, Christophe Pradal, Christophe Godin, Frédéric Boudon, Jean-Baptiste Durand.

Funding: Inria ADT (Contractors for Virtual Plants: Inria from 2014 to 2016)

The goal of this project is to improve the software quality and the dissemination of Vplants components for plant phenotyping. Virtual Plants team has played a pioneering role in the development of methods for analyzing plant development that take account of the complexity of plant architecture. Numerous software components has been developed for more than 20 years and a profound re- engineering is now necessary to facilitate the collaborations with biologist and agronomists of CIRAD, INRA and IRD and to help the dissemination of ours methods in the scientific community.

#### **8.2.5.2. Morphogenetics**

**Participants:** Christophe Godin, Frédéric Boudon, Olivier Ali, Jean Phillipe Bernard, Hadrien Oliveri, Christophe Pradal, Guillaume Cerutti, Grégoire Malandain, François Faure, Jan Traas, François Parcy, Arezki Boudaoud, Teva Vernoux.

Funding: Inria Project Lab (From 2013 to 2017)

Morphogenetics is an Inria transversal project gathering 3 Inria teams and two Inra teams. It aimed at understanding how flower shape and architecture are controlled by genes during development. Using quantitative live-imaging analysis at cellular resolution we will determine how specific gene functions affect both growth patterns and the expression of other key regulators. The results generated from these experiments will be integrated in a specially designed database (3D Atlas) and used as direct input to new predictive computational models for morphogenesis and gene regulation. Model predictions will then be further tested through subsequent rounds of experimental perturbation and analysis. A particular emphasis will be put on the modeling of mechanics in tissues for which different approaches will be developed.

Partners: RDP ENS-Lyon; Imagine Inria Team (Grenoble); Morpheme Inria Team (Sophia-Antipolis), UMR PCV (Grenoble).

#### **8.2.5.3. Rose**

**Participants:** Christophe Godin, Frédéric Boudon.

Funding: INRA - PhD project (From 2016 to 2019)

In this project we want to quantify and understand how sugars interfere with hormonal signals (auxin, cytokinins) to regulate lateral bud outgrowth of aerial stems of roses. Experiments will be made on Rose stems to test different levels of sugar conditions and hormonal concentrations on bud outgrowth. An extension of the recently published hormonal model of apical dominance will be made to take into account the role of carbon as a signaling molecule.

Partners: UMR SAGAH, Angers

#### **8.2.5.4. ReProVirtuFlow**

**Participants:** Christophe Pradal, Sarah Cohen-Boulakia, Jerome Chopard.

In the life science domain, scientists are facing the deluge and the size of available data, the composition of a myriad of existing tools, and the complexity of computational experiment. In this context, reproducing an experiment is particularly difficult, as evidenced by numerous recent studies. The aim of this GDR CNRS project is to make a complete review of existing approaches in this field, considering in priority as elements of solution: (i) scientific workflows, (ii) data provenance, and (iii) virtual machines. This project brings together experts in data bases, algorithms and virtual environments, working in the domain of life science.

Funding: GDR - CNRS

## 8.3. European Initiatives

### 8.3.1. Collaborations with Major European Organizations

#### 8.3.1.1. Hook

**Participants:** Christophe Godin, Olivier Ali.

A new collaboration started with the University of Umeå (Sweden) on the modeling of the apical hook in the hypocotyl of *Arabidopsis thaliana*. The question we want to answer is what regulates the opening dynamics of the apical hook at the tip of the hypocotyl and how. For this, a multidisciplinary approach, combining 3D laser imaging, molecular biology, genetics and modeling will be developed by the partners.

Partners: University of Umeå, RDP ENS-Lyon.

## 8.4. International Initiatives

### 8.4.1. ANR-DFG

#### 8.4.1.1. AlternApp

**Participants:** Yann Guédon, Maryam Aliee.

Funding: ANR-DFG (Contractor for Virtual Plants: INRA, From 2015 to 2019)

The aim of the AlternApp project is to investigate functional hypotheses on the genetic and environmental control of floral induction in apple tree progenies. Two segregating populations will be studied in two different environmental conditions for floral induction and bearing behavior, in order to identify genomic regions associated with regular phenotypes. The specific contribution of the team will be to develop statistical methods to quantify phenotype and genotype, as well as years and climatic effects on alternation. Transcriptome of varieties contrasted in their bearing behavior and artificially set into high or low cropping conditions will be explored by New Generation Sequencing Technology (NGS) to identify new candidate genes and allelic variations of interest. By this project, new results are expected on floral induction in apple tree in relation to their alternate bearing behavior and more applied results linked to the discovery of allelic variation in key genes that could be used in breeding programs.

Partners: AFEF INRA team (Montpellier), PIAF INRA team (Clermont-Ferrand), JKI (Dresden, Germany), UHOH (Hohenheim, Germany), Foundation E. Mach (San Michele all'Adige, Italy)

### 8.4.2. Inria International Partners

#### 8.4.2.1. BioSensors

**Participants:** Guillaume Cerutti, Sophie Ribes, Frédéric Boudon, Christophe Godin, Teva Vernoux [ENS-Lyon], Géraldine Brunoud [ENS-Lyon], Carlos Galvan-Ampudia [ENS-Lyon].

Funding: Human Frontiers - HFSP (From 2014 to 2017)

We propose to elucidate the basis for positional information by hormones during plant morphogenesis. While it is known that cell fate decisions require simultaneous input from multiple hormones, to-date a precise understanding of how these signals are coordinated and act together to drive morphogenesis does not exist. Our limited mechanistic understanding is largely due to the difficulty to quantify the distribution of these small molecules in space and time. To explore this fundamental question, we will exploit recent advances in synthetic biology to engineer an RNA-based biosensor platform applicable to a broad range of small molecules and in particular to hormones. Using live-imaging technologies, we will use the sensors to obtain quantitative dynamic 3D maps of hormone distributions and relate these maps to the spatio-temporal distribution of cell identities, both during normal morphogenesis and upon perturbations of hormone levels. This analysis will be done on the shoot apical meristem, one of the best characterized developmental systems in higher plants. In this context, mathematical approaches will be essential to analyze and establish a predictive model for how multiple hormones influence cell fate in a spatio-temporal manner.

#### *8.4.2.2. Informal International Partners*

An important collaboration with the CIRAD research unit HortSys at the Reunion island and in particular Frédéric Normand, Yann Guédon, Pierre Fernique and Christophe Pradal has been established for several years. The topic of the collaboration is the study of the phenology of mango tree. This is a tripartite collaboration that also involves Pierre-Eric Lauri of the System research unit (INRA, Montpellier).

We have for several years a strong partnership with Ted de Jong group at UC Davis concerning the influence of various agronomic practices (water stress, pruning) on fruit tree branching and production. This is a tripartite collaboration that also involves Evelyne Costes of the AGAP/AFEF team.

A collaboration in plant phenotyping with the CSIRO and the INRA/Lepse team has been established for several years. The topic of the collaboration is to develop a full pipeline using OpenAlea 2.0 on plant phenotyping platforms. This is a joint collaboration with UMR LEPSE in Montpellier (François Tardieu).

A collaboration started in the last two years with the group of Henrik Jönsson of the Sainsbury Lab, Cambridge, UK. The collaboration is related to several modeling projects in the context of shoot apical and flower meristems development, with a particular focus on the use of quantitative 3D reconstructions of meristem structures. Yassin Refahi from the Sainsbury Lab is regularly paying visits to Montpellier. The Virtual Plants team is also regularly invited to Cambridge.

## **8.5. International Research Visitors**

### *8.5.1. Visits of International Scientists*

Julia Pulwicki from the University of Calgary, Canada, spent 10 days at our lab in May to study the opportunity to define a post-doctoral project for her and to set up the basis of a joint scientific project. This project has lead us to submit to the Inria post-doctoral programme a project on that was accepted. Julia arrived for a 12 month post-doctoral project in November.

In this study, we want to formalize the analogy between the development of shapes in biology and the feedback between mass and space curvature in general relativity. Our aim is to propose a quantitative approach of such a vision by developing a mathematical and computational framework combining formalisms from non-euclidean geometry developed in general relativity and models of signal propagation and gene regulation in plant tissues.

#### *8.5.1.1. Research Stays Abroad*

In the context of the project on mango modelling and the PhD of S. Persello, F. Boudon is currently positioned in the Reunion island in the Hortsys unit for one year. He develops there a project on Mango modelling in collaboration with F. Normand.

## COATI Project-Team

## 9. Partnerships and Cooperations

### 9.1. National Initiatives

#### 9.1.1. ANR

##### 9.1.1.1. ANR Blanc STINT, 2014-2017

**Participants:** Pierre Aboulker, Jean-Claude Bermond, David Coudert, Frédéric Havet, Luc Hogue, William Lochet, Nicolas Nisse, Stéphane Pérennes, Michel Syska.

The STINT project (*STRUCTURES INTerdites*) is led by the MC2 group (LIP, ENS-Lyon) and involves the G-SCOP laboratory (Grenoble).

The aim of STINT is to answer the following fundamental question: *given a (possibly infinite) family  $\psi$  of graphs, what properties does a  $\psi$ -free graph have?* To this end, it will firstly establish bounds on some classical graph parameters (e.g., clique number, stability number, chromatic number) for  $\psi$ -free graphs. Then, it will design efficient algorithms to recognize  $\psi$ -free graphs and to determine or approximate some parameters for those graphs. These studies shall result in the development of new proof techniques.

(<http://www.ens-lyon.fr/LIP/MC2/STINT/>)

#### 9.1.2. PEPS

##### 9.1.2.1. PEPS MoMis SYSTEMIC, 2015 (extended in 2016)

**Participant:** Frédéric Giroire.

The SYSTEMIC project was led by COATI and involves the LAMA (Paris Est), GREDEG (Sophia Antipolis) and CREM (Rennes) laboratories.

The aim of SYSTEMIC was to bring together the expertises of researchers in economics, graph theory and financial mathematics to propose new models to evaluate the systemic risk of networks of financial institutions, and to propose new methods to mitigate the risk of contagions in such networks. The novelty of the project was in particular to consider strategies for a dynamic control of heterogeneous networks.

#### 9.1.3. GDR Actions

##### 9.1.3.1. Action ResCom, ongoing (since 2006)

Réseaux de communications, working group of GDR RSD, CNRS.

(<http://rescom.asr.cnrs.fr/>)

##### 9.1.3.2. Action Graphes, ongoing (since 2006)

Action Graphes, working group of GDR IM, CNRS.

(<http://gtgraphes.labri.fr/>)

## 9.2. European Initiatives

### 9.2.1. Collaborations with Major European Organizations

AOR (Vassilis Zissimopoulos) : University of Athens, Department of Informatics and Telecommunications (Greece)

Combinatorial Optimization, Games and Applications (COGA), June 2015- September 2016

Participants : Jean-Claude Bermond, David Coudert, Frédéric Giroire, Nicolas Nisse, Stéphane Pérennes

## 9.3. International Initiatives

### 9.3.1. Inria International Labs

Inria Chile

Associate Team involved in the International Lab:

#### 9.3.1.1. *ALDYNET*

Title: distributed ALgorithms for DYnamic NETworks

International Partner (Institution - Laboratory - Researcher):

Universidad Adolfo Ibañez (Chile) - Facultad de Ingeniería y Ciencias - Karol SUCHAN

Start year: 2016

See also: <https://team.inria.fr/coati/projects/aldynet/>

This associated team would be the natural continuation of the fruitful EA AIDyNet (2013-2015, <https://team.inria.fr/coati/projects/aldynet/>)

The main goal of this Associate Team is to design and implement practical algorithms for computing graph structural properties. We will then use these algorithms on a concrete case of study which concerns the transportation network of the Santiago agglomeration. We are both interested in theoretical results concerning the feasibility of computing graph properties, and by their practical implementation (using SageMath, [www.sagemath.org/](http://www.sagemath.org/)) for our application and their diffusion in the scientific community. There are three main objectives:

- 1) Design efficient algorithms to compute important graph properties (hyperbolicity, treelength, centrality, treewidth...) in real networks. We are not only interested by the worst-case time-complexity of these algorithms but by their performance in practice.
- 2) Implement and document our algorithms using the open-source framework SageMath. One advantage of using SageMath is that it has interfaces with other graph libraries (igraph, Boost...) and with Linear Programming solver (GLPK, Cplex...). Moreover, the success of SageMath (which has accumulated thousands of users over the last 10 years) will participate to the diffusion of our algorithms.
- 3) Apply our algorithms on the Santiago transportation network that have been collected by our Chilean partner during the last year of AIDyNet (2013-2015). Based on the results, propose tools for decision support in designing bus routes, timetables, etc. More precisely, we have collected information about the use of public transport (data of smart cards for automatic fare collection - BIP-, bus routes and bus schedules, etc.), urban infrastructure information, schools' addresses, and approximate locations where students live. We have started to clean and consolidate these data. We will then develop decision support tools, for example, for improving quality education accessibility.

### 9.3.2. *Inria International Partners*

#### 9.3.2.1. *Informal International Partners*

Apart from formal collaboration COATI members maintain strong connections with the following international teams, with regular visits of both sides.

Univ. of Southern Denmark, Prof. Jorgen Bang Jensen

RWTH Aachen Univ., Lehrstuhl II für Mathematik, Germany, Prof. Arie M.C.A. Koster

Concordia Univ. - Montréal, Quebec, Canada, Prof. Brigitte Jaumard

#### 9.3.3. *Participation in Other International Programs*

GAIATO : Graphs and Algorithms Applied to Telecommunications, International Cooperation FUNCAP/FAPs/Inria/INS2i-CNRS, no. INC-0083-00047.01.00/13, with Federal University of Ceará, Brasil, 2014-2016.

## 9.4. International Research Visitors

### 9.4.1. *Visits of International Scientists*

Daniela Aguirre Guerrero

Universitat de Girona, Girona, Spain, Visiting PhD Student, from Sep 2016 until Nov 2016.

Jean Francois Baffier

Japanese-French Laboratory for Informatics UMI 3527, Japan, Visiting Scientist, June 2016.

Jorgen Bang Jensen

University of Southern Denmark, Odense, Denmark, Visiting Scientist, from June 2016 until Jul 2016.

Augustin Chaintreau

Columbia University, New York, US, Visiting Scientist, 19-21st January 2016.

Clément Charpentier

Université Joseph Fourier, Grenoble, France, Visiting Scientist, 21-26th February 2016.

Romuald Elie

Université Paris-Est Marne-la-Vallée, Visiting Scientist, October 24-November 2, 2016.

Takako Kodate

Tokyo Woman's Christian Univ., Japan, Visiting Scientist, Apr 2016.

Christian Konrad

Reykjavik University, Iceland, Visiting Scientist, February 28th to March 3rd, 2016.

Aurélie Lagoutte

Université de Princeton, USA, 9-11th March, 2016.

Zvi Lotker

Ben Gurion University of the Negev, Israel, 22-27th February, 2016.

Ana Karolinna Maia De Oliveira

Univ. Federal do Ceara, Fortaleza, Brazil, Visiting Scientist, Oct 2016.

Colin McDiarmid

University of Oxford, UK, Visiting Scientist, September 26-30th 2016.

Ioannis Milis

Athens University of Economics and Business, Athens, Greece, Visiting Scientist, Feb 2016.

Eduardo Moreno

Univ. Adolfo Ibanez, Santiago, Chile, Visiting Scientist, Sep 2016.

Julio Cesar Silva Araujo

Univ. Federal do Ceara, Fortaleza, Brazil, Visiting Scientist, Oct 2016.

Guillem Perarnau-Llobet

University of Birmingham, UK, Visiting Scientist, May 9-13rd 2016.

Jean-Sébastien Sereni

CNRS, France, 22-25th February.

Yllka Velaj

Gran Sasso Science Institute, L'Aquila, Italia, Visiting PhD Student, from Feb 2016 until Apr 2016.

Joseph Yu

University of the Fraser Valley, Abbotsford, Canada, Visiting Scientist, Apr 2016.



Vassilis Zissimopoulos

National and Kapodistrian University of Athens, Athens, Greece, Visiting Scientist, Feb 2016.

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

#### *9.4.2.1. Research Stays Abroad*

Julien Bensmail

LaBRI, University of Bordeaux, October 10-14, 2016;

LIF, Aix-Marseille University, October 17-19, 2016.

Jean-Claude Bermond

Department of Informatics and Telecommunications of the National and Kapodistrian University of Athens, Greece, June 7-21, 2016.

David Coudert

LIP6, UPMC, Paris, October 11-13, 2016;

Univ. Adolfo Ibañez and Univ. Chile, Santiago, Chile, in the context of Inria associated team AIDyNet, October 24-November 11, 2016.

Frédéric Giroire

Orange Labs, Chatillon, May 17-20, 2016;

Computer Science and Software Engineering department, Concordia University, Montréal, Canada, September 28-October 7, 2016.

Nicolas Huin

Concordia University, Montreal, Canada, August 22-November 22, 2016.

William Lochet

Université libre de Bruxelles, Belgique, June 20-25th, 2016.

Nicolas Nisse

Univ. Federal do Ceará, Fortaleza, Brazil, April, 2016;

LIF, Aix-Marseille University, July 18-22, 2016;

Univ. Adolfo Ibañez and Univ. Chile, Santiago, Chile, in the context of Inria associated team AIDyNet, October 24-November 11, 2016.

Bruce Reed

National Institute of Informatics Tokyo Japan, June 1-28th 2016;

Pacific Institute of Mathematical Sciences, June 28th-September 5th 2016;

National Institute of Informatics Tokyo Japan, October 1st-December 31th 2016.

## DIANA Project-Team

# 8. Partnerships and Cooperations

## 8.1. Inria internal funding

- **User Discrimination on the Web:** we have been awarded funding for two post-doc positions each for one year with the the “Inria Actions Marquantes” with Nataliia Bielova from the INDES project-team. Natasa Sarafijanovic-Djukic have just started her post-doc on this project.
- **ADT ElectroSmart:** in the context of the Inria ADT call, we have a funding for a two year engineering position on the ElectroSmart project for the 2017-2019 period.
- **Transverse Master Internships:** we have a funding for a 6-month internship with Nataliia Bielova on Pixel Tracking.
- **ACQUA:** in the context of the Inria ADT call, we have a funding for a two year engineering position on the ACQUA project for the 2015-2017 period. Thierry Spetebroot is hired on this position.

## 8.2. UCN@Sophia Labex and UCA Idex funding

- **ElectroSmart:** this project has a funding for a two year engineering position from the UCN@Sophia Labex for the 2016-2018 period (Ravi Mondy is hired on this position) and 30KEuros from the UCA (Université Côte d’Azur) RISE Academy.
- **PhD sholarships:** our team has currently four ongoing PhD thesis (Karyna Gogunska, Mohamed Naoufal Mahfoudi, Vitalii Poliakov and Luigi Vigneri) funded by the UCN@Sophia Labex.

## 8.3. Regional Initiatives

- **Plate-forme Telecom (Com4innov)** (2011-2017) is a DGCIS funded project, in the context of the competitiveness cluster SCS, that aims at providing to PACA region industrials wishing to develop or validate new products related to future mobile networks and services and M2M application, a networking infrastructure and tools helpful for development, test and validation of those products. Other partners : 3Roam, Audilog Groupe Ericsson, Ericsson, Eurecom, Inria, iQsim, MobiSmart, Newsteo, OneAccess, Orange Labs, SCS cluster, ST Ericsson, Telecom Valley. Our contribution is centred around providing a test methodology and tools for wireless networks experimentation. In the context of this project we have realized a study on MPTCP performance in a wireless-wired environment with Orange Labs Sophia. The software tools that were developed in the project have been integrated in the R<sup>2</sup>lab anechoic chamber.

## 8.4. National Initiatives

### 8.4.1. ANR

- **ANR FIT** (2011-2018): FIT (Future Internet of Things) aims at developing an experimental facility, a federated and competitive infrastructure with international visibility and a broad panel of customers. It will provide this facility with a set of complementary components that enable experimentation on innovative services for academic and industrial users. The project will give French Internet stakeholders a means to experiment on mobile wireless communications at the network and application layers thereby accelerating the design of advanced networking technologies for the Future Internet. FIT is one of 52 winning projects from the first wave of the French Ministry of Higher Education and Research’s Equipements of Excellence (Equipex) research grant programme. The project will benefit from a 5.8 million euro grant from the French government. Other partners are UPMC, IT, Strasbourg University and CNRS. See also <http://fit-equipex.fr/>.

- **ANR DISCO** (2014-2016): DISCO (Distributed SDN COntrollers for rich and elastic network services) aims at exploring the way how Software Defined Networking changes network monitoring, control, urbanisation and abstract description of network resources for the optimisation of services. The project works throughout experimentations and application use cases on the next generation of Software-Defined Networking solutions for large and critical distributed systems. The project studied the distribution of the current SDN control plane and the optimization of network operations that the integrated system view of cloud computing-based architectures allows. See also <http://anr-disco.ens-lyon.fr/>.
- **ANR REFLEXION** (2015-2017): REFLEXION (REsilient and FLEXible Infrastructure for Open Networking) research project will study the robustness and scalability of the current SDN architectures and the flexibility leveraged by SDN for provisioning resources and virtualized network functions (VNF). The project will address four main scientific objectives: (1) Fault and disruption management for virtualized services, (2) Robust and scalable control plane for next generation SDN, (3) Dynamic performance management of low level resources in SDN/NFV environments and (4) Distribution and optimization of virtual network functions in SDN environments. Our contribution in this project will be focused on fault and disruption management for virtualized services. See also <http://anr-reflexion.telecom-paristech.fr/>.
- **ANR BottleNet** (2016-2019): BottleNet aims to deliver methods, algorithms, and software systems to measure Internet Quality of Experience (QoE) and diagnose the root cause of poor Internet QoE. This goal calls for tools that run directly at users' devices. The plan is to collect network and application performance metrics directly at users' devices and correlate it with user perception to model Internet QoE, and to correlate measurements across users and devices to diagnose poor Internet QoE. This data-driven approach is essential to address the challenging problem of modeling user perception and of diagnosing sources of bottlenecks in complex Internet services. ANR BottleNet will lead to new solutions to assist users, network and service operators as well as regulators in understanding Internet QoE and the sources of performance bottleneck.

## 8.5. European Initiatives

### 8.5.1. FP7 & H2020 Projects

Program: FP7 FIRE programme

Project acronym: Fed4Fire+

Project title: Federation for FIRE Plus

Duration: January 2017 - December 2021

Coordinator: iMinds (Belgium)

Other partners: 20 european partners including IMEC (Belgium), UPMC (Fr), Fraunhofer (Germany), TUB (Germany), etc.

Web site: <http://www.fed4fire.eu/>

Abstract: The Fed4FIRE+ project has the objective to run and further improve Fed4FIRE's best-in-town federation of experimentation facilities for the Future Internet Research and Experimentation initiative. Federating a heterogeneous set of facilities covering technologies ranging from wireless, wired, cloud services and open flow, and making them accessible through common frameworks and tools suddenly opens new possibilities, supporting a broad range of experimenter communities covering a wide variety of Internet infrastructures, services and applications. Fed4FIRE+ will continuously upgrade and improve the facilities and include technical innovations, focused towards increased user satisfaction (user-friendly tools, privacy-oriented data management, testbed SLA and reputation, experiment reproducibility, service-level experiment orchestration, federation ontologies, etc.). It will open this federation to the whole FIRE community and beyond, for experimentation by industry and research organisations, through the organization of Open Calls and Open Access

mechanisms. The project will also establish a flexible, demand-driven framework which allows test facilities to join during the course of its lifetime by defining a set of entry requirements for new facilities to join and to comply with the federation. FIRE Experimental Facilities generate an ever increasing amount of research data that provides the foundation for new knowledge and insight into the behaviour of FI systems. Fed4FIRE+ will participate in the Pilot on Open Research Data in Horizon 2020 to offer open access to its scientific results, to the relevant scientific data and to data generated throughout the project's lifetime. Fed4FIRE+ will finally build on the existing community of experimenters, testbeds and tool developers and bring them together regularly (two times a year) in engineering conferences to have maximal interaction between the different stakeholders involved.

## 8.6. International Initiatives

### 8.6.1. Inria Associate Teams Not Involved in an Inria International Labs

#### 8.6.1.1. UHD-on-5G

Title: Ultra High Definition video streaming on future 5G networks

International Partner (Institution - Researcher):

National Institute of Information and Communications Technology (NICT) (Japan) -  
Hitoshi Asaeda

Start year: 2016

See also: <https://team.inria.fr/diana/uhd-on-5g/>

The aim of this collaboration is to design and develop efficient mechanisms for streaming UHD video on 5G networks and to evaluate them in a realistic and reproducible way by using novel experimental testbeds.

Our approach leverages and extends when necessary ICN and SDN technologies to allow very high quality video streaming at large scale. We also plan to use Virtual Network Functions (VNF) in order to place easily and dynamically different functions (e.g. transcoding, caching) at strategic locations within the network. Specifically, the placement of these functions will be decided by SDN controllers to optimize the quality of experience (QoE) of users. Moreover, we plan to integrate ICN functionalities (e.g., name-based forwarding and multipath transport using in-network caching) with SDN/NFV to provide better QoE and mobility services support to users than traditional IP architectures. Monitoring mechanisms such as the Contrace tool we developed in a previous associated team (SIMULBED) will be helpful to provide an accurate view of the network at the SDN controllers side. In addition, we will build a large-scale testbed to evaluate our solutions through reproducible experimentations based on two testbeds: the ICN wired CUTEi testbed developed by NICT and the wireless R<sup>2</sup>lab testbed developed by Inria.

## 8.7. International Research Visitors

### 8.7.1. Visits of International Scientists

Max Ott from Data61/CSIRO (previously NICTA) visited us in November 2016. He gave a seminar on "Confidential Computing - Analysing Data Without Seeing Data" and an invited talk at the R<sup>2</sup>lab inauguration ceremony.

#### 8.7.1.1. Internships

Ramon Dos Reis Fontes

Date: from Apr 2016 until Sep 2016

Institution: PhD intern, University of Campinas

Supervisor: Thierry Turletti

Subject: Evaluating and Validating Mininet-WiFi

Anastasia Kuznetsova

Date: from Mar 2016 until Aug 2016

Institution: Ubinet Master intern, University of Nice Sophia Antipolis

Supervisor: Arnaud Legout

Subject: User discrimination on Pinterest

Ahmed Loukili

Date: from Mar 2016 until Aug 2016

Institution: Ubinet Master intern, University of Nice Sophia Antipolis

Supervisor: Damien Saucez

Subject: Content Distribution over Software Defined Networks

Hakob Melkonyan

Date: from Mar 2016 until Aug 2016

Institution: Ubinet Master intern, University of Nice Sophia Antipolis

Supervisor: Arnaud Legout

Subject: ElectroSmart Android Project for Exploring Electromagnetic Exposition

Farzaneh Pakzad

Date: from November 2016 to December 2016

Institution: PhD intern, University of Queensland

Supervisor: Thierry Turletti and Walid Dabbous

Subject: Using R<sup>2</sup>lab to evaluate MANET routing protocols

Jimmy Rogala

Date: from May 2016 until Aug 2016

Institution: ENS Rennes intern

Supervisor: Arnaud Legout

Subject: Collecting statistics on Pinterest users

Nawfal Abbassi Saber

Date: from Mar 2016 until Aug 2016

Institution: Ubinet Master intern, University of Nice Sophia Antipolis

Supervisor: Chadi Barakat

Subject: Experimenting and modeling YouTube Quality of Experience

#### 8.7.2. Visits to International Teams

Walid Dabbous, Thierry Turletti and Hardik Soni visited NICT in Tokyo Japan in the context of the UHD-on-5G associated team in December 2016.

## FOCUS Project-Team

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

- REVER (Programming Reversible Recoverable Systems) is an ANR project with a 4-year duration. REVER aims to study the possibility of defining semantically well-founded and composable abstractions for dependable computing on the basis of a reversible programming language substrate, where reversibility means the ability to undo any distributed program execution, possibly step by step. The critical assumption behind REVER is that by adopting a reversible model of computation, and by combining it with appropriate notions of compensation and modularity, one can develop systematic and composable abstractions for recoverable and dependable systems. Main persons involved: Giachino, Lanese, Laneve, Zavattaro.
- PACE (Processus non-standard: Analyse, Coinduction, et Expressivité) is an ANR project with a 4-year duration. The project targets three fundamental ingredients in theories of concurrent processes, namely coinduction, expressiveness, and analysis techniques. The project targets processes that are beyond the realm of "traditional" processes. Specifically, the models studied exhibit one or more of the following features: probabilities, higher-order, quantum, constraints, knowledge, and confidentiality. These models are becoming increasingly important for today's applications. Coinduction is intended to play a pivotal role. Indeed, the approaches to expressiveness and the analysis techniques considered in the project are based on coinductive equalities. Main persons involved: Hirschhoff (project coordinator), Dal Lago, Lanese, Sangiorgi, Zavattaro.
- ELICA (Expanding Logical Ideas for Complexity Analysis) is an ANR project that started on October 2014 and that will finish on September 2018. ELICA focuses on methodologies for the static analysis of programs and their resource consumption. The project's aim is to further improve on logical methodologies for complexity analysis (type systems, rewriting, etc.). More specifically, one would like to have more powerful techniques with less false negatives, being able at the same time to deal with nonstandard programming paradigms (concurrent, probabilistic, etc.). Main persons involved: Avanzini, Cappai, Dal Lago, Hirschhoff, Martini, Sangiorgi.
- REPAS (Reliable and Privacy-Aware Software Systems via Bisimulation Metrics) is an ANR Project that started on October 2016 and that will finish on October 2020. The project aims at investigating quantitative notions and tools for proving program correctness and protecting privacy. In particular, the focus will be put on bisimulation metrics, which are the natural extension of bisimulation to quantitative systems. As a key application, we will develop a mechanism to protect the privacy of users when their location traces are collected. Main persons involved: Dal Lago, Martini, Sangiorgi.
- COCAHOLA (Cost models for Complexity Analyses of Higher-Order Languages) is an ANR Project that started on October 2016 and that will finish on October 2019. The project aims at developing complexity analyses of higher-order computations. The focus is not on analyzing fixed programs, but whole programming languages. The aim is the identification of adequate units of measurement for time and space, i.e. what are called reasonable cost models. Main persons involved: Dal Lago, Martini.

## 8.2. European Initiatives

### 8.2.1. FP7 & H2020 Projects

- ENVISAGE (Engineering Virtualized Services) is a EU FP7 project, with starting date October 1st, 2013, and with a 3-year duration. The project is about model-based development of virtualized services, including tool support for resource analysis. Most Focus members are involved.

### 8.2.2. Collaborations in European Programs, Except FP7 & H2020

- The ICT COST Action BETTY (Behavioural Types for Reliable Large-Scale Software Systems). initiated in October 2012 and with a 4-year duration, uses behavioural type theory as the basis for new foundations, programming languages, and software development methods for communication-intensive distributed systems. Behavioural type theory encompasses concepts such as interfaces, communication protocols, contracts, and choreographies. Main persons involved: Bravetti, Giachino, Hirschhoff, Lanese, Laneve, Mauro, Sangiorgi, Zavattaro.
- ICT COST Action IC1405 (Reversible computation - extending horizons of computing). Initiated at the end of April 2015 and with a 4-year duration, this COST Action studies reversible computation and its potential applications, which include circuits, low-power computing, simulation, biological modeling, reliability and debugging. Reversible computation is an emerging paradigm that extends the standard forwards-only mode of computation with the ability to execute in reverse, so that computation can run backwards as naturally as it can go forwards.

Main persons involved: Giachino, Lanese (vice-chair of the action).

- ICT COST Action IC1402 ARVI (Runtime Verification beyond Monitoring) Initiated in December 2014 and with a 4-year duration, this COST Action studies runtime verification, a computing analysis paradigm based on observing a system at runtime to check its expected behaviour.

Main persons involved: Bravetti, Lanese.

- SMALL (Smart Mobility for All) SMALL is an EIT project that runs during 2016.

The aim of the project is to develop a service-oriented platform, called the SMALL platform<sup>0</sup>, to support the creation of a liquid market for transportation, facilitating the publication, retrieval, and orchestration of functionalities for transportation, owned by different operators.

Jolie plays a prominent part in the development of the SMALL platform: it is the main language for the development of both the platform — the architecture of services that support publishing, organisation, and interaction among the functionalities for transportation — and of the services for mobility.

### 8.2.3. Collaborations with Major European Organizations

Simone Martini is a member of the Executive Board of EQANIE (European Quality Assurance Network for Informatics Education), from October 2014.

We list here the cooperations and contacts with other groups, without repeating those already listed in previous sections.

- ENS Lyon (on concurrency models and resource control). Contact person(s) in Focus: Dal Lago, Martini, Sangiorgi, Vignudelli. Some visit exchanges during the year, in both directions. A new joint PhD started in september 2016 (Adrien Durier).
- Inria EPI Spades (on models and languages for components, reversibility). Contact person(s) in Focus: Lanese. Some visit exchanges during the year, in both directions.
- Laboratoire d'Informatique, Université Paris Nord, Villetaneuse (on implicit computational complexity). Contact person(s) in Focus: Dal Lago, Martini. An Italian PhD student (Marco Solieri) is working on his PhD thesis with joint supervision (Martini, Guerrini).
- Institut de Mathématiques de Luminy, Marseille (on lambda-calculi, linear logic and semantics). Contact person(s) in Focus: Dal Lago, Martini.
- Team PPS, IRIF Lab, University of Paris-Diderot Paris 7 (on logics for processes, resource control). Contact person(s) in Focus: Dal Lago, Martini, Sangiorgi. Some short visits in both directions during the year.

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<sup>0</sup><https://github.com/small-dev/SMALL.Wiki/wiki>

- IRILL Lab, Paris (on models for the representation of dependencies in distributed package based software distributions). Contact person(s) in Focus: Mauro, Zavattaro. Some short visits in both directions during the year.
- EPI Carte, Inria-Nancy Grand Est and LORIA (on implicit computational complexity). Contact person(s) in Focus: Dal Lago.
- LMU Munich (M. Hofmann) (on implicit computational complexity and IntML). Contact person(s) in Focus: Dal Lago.
- IMDEA Software, Madrid (G. Barthe) (on implicit computational complexity for cryptography). Contact person(s) in Focus: Dal Lago, Sangiorgi. Some visits during the year.
- Facultad de Informatica, Universidad Complutense de Madrid (on web services). Contact person(s) in Focus: Bravetti. Bravetti is an external collaborator in the project “Desarrollo y Análisis formal de sistemas complejos en contextos DistribuidOS: fundamentos, herramientas y aplicaciones (DARDOS)” (Development and formal analysis of complex systems in distributed contexts: foundations, tools and applications) January 2016 - December 2018, funded by the Spanish Ministerio de Economía y Competitividad.

## 8.3. International Initiatives

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

#### 8.3.1.1. CRECOGI

Title: Concurrent, Resourceful and Effectful Computation, by Geometry of Interaction

International Partner (Institution - Laboratory - Researcher):

Tokyo (Japan) - Department of Computer Science, Graduate School of Information Science and Technology - Ichiro HASUO

Start year: 2015

See also: <http://crecogi.cs.unibo.it>

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

## 8.4. International Research Visitors

### 8.4.1. Visits of International Scientists

The following researchers have visited Focus for short periods; we list them together with the title of the talk they have given during their stay, or the topic discussed during their stay.

- Marco Bernardo: "Disjunctive Probabilistic Modal Logic is Enough for Bisimilarity on Reactive Probabilistic Systems."
- Guillermo Roman Diez: "Resource Analysis."



- Lukasz Mikulski: "On Concurrency Paradigms."
- Jean-Pierre Jouannaud: "Coq modulo theory."
- Paul Blain Levy: "Trace semantics of well-founded processes via commutativity."
- Akihisa Yamada: "Certifying Safety and Termination Proofs for Integer Transition Systems" (long visit).
- Ryo Tanaka: semantics of higher-order functional languages (long visit).
- Antonio Ravara: "Behavioural Type Inference for Object-Oriented Languages".
- Lukasz Mikulski: "On concurrency paradigms".
- Ludovic Henrio, "Deadlock analysis in distributed object systems".

#### **8.4.2. Visits to International Teams**

- Ugo Dal Lago: has spent two weeks in April at ENS Lyon, and 1 month at IRIF, Université Paris 7, in May/June.
- Charles Grellois has taken part in the programme "Automata, Logic and Games", 5 weeks (August-September), Singapore.
- Valeria Vignudelli has spent six months in the Inria Comète team, Inria Saclay/Ecole Polytechnique, Paris.
- Abel Garcia has spent 6 months at the Department of Computer Science, TUD Darmstadt.

##### *8.4.2.1. Sabbatical programme*

Maurizio Gabbrielli is, since 15 September 2014, Head of the EIT ICT Labs Doctoral School with Paris as his principal location.

## INDES Project-Team

# 6. Partnerships and Cooperations

## 6.1. National Initiatives

### 6.1.1. ANR AJACS

The AJACS project (Analyses of JavaScript Applications: Certification & Security) is by the ANR for 42 months, starting December 2014. The goal of AJACS project is to provide strong security and privacy guarantees on the client side for web application scripts. The Indes members are involved in the tasks WP2 Certified Analyses and WP3 Security of JavaScript Applications. The partners of this project include Inria teams Celtique (coordinator), Toccatà, and Prosecco.

### 6.1.2. FUI UCF

The 3 years long UCF project aims at developing a reactive Web platforms for delivering multimedia contents. The partners of the project are the startups Alterway, OCamlPro, and XWiki, and the academic research laboratories of University Pierre et Marie Curie, and Denis Diderot.

#### 6.1.2.1. Actions marquante

Inria Sophia-Antipolis Actions Marquante is a special funding for 2 postdocs during one year to explore a new research direction. The joint project with DIANA team “User discrimination on the Web: measurement, causation and prevention” has obtained this funding. The goal of this project is to detect when users get discriminated on the Web, what are the technologies used to discriminate users and how we can prevent it without breaking the functionality and sometimes useful personalisation within Web applications.

## 6.2. European Initiatives

### 6.2.1. FP7 & H2020 Projects

#### 6.2.1.1. RAPP

Program: <http://rapp-project.eu>

Title: Robot App Store

Collaborator: Inria Hephaistos

Abstract: RAPP is a 36 months pan-european FP7 project, started in December 2013. Hop.js technology is used by partner academic and SME R&D teams to develop a distributed software platform and applications for assistive robotics.

### 6.2.2. Collaborations in European Programs, Except FP7 & H2020

#### 6.2.2.1. ICT Cost Action IC1201 BETTY

Program: BETTY

Project acronym: BETTY

Project title: Behavioural Types for Reliable Large-Scale Software Systems

Duration: October 2012 - October 2016

Coordinator: Simon Gay, University of Glasgow

Other partners: several research groups, belonging to 22 european countries

Abstract: The aim of BETTY is to investigate and promote behavioural type theory as the basis for new foundations, programming languages, and software development methods for communication-intensive distributed systems. Behavioural type theory encompasses concepts such as interfaces, communication protocols, contracts, and choreography.

#### 6.2.2.2. *ICT Cost Action IC1405 on Reversible Computation*

Program: COST

Project acronym: RC

Project title: Reversible computation - extending horizons of computing

Duration: November 2014 - November 2018

Coordinator: Irek Ulidowski, University of Leicester

Other partners: several research groups, belonging to 23 european countries

Abstract: Reversible computation is an emerging paradigm that extends the standard mode of computation with the ability to execute in reverse. It aims to deliver novel computing devices and software, and to enhance traditional systems. The potential benefits include the design of reversible logic gates and circuits - leading to low-power computing and innovative hardware for green ICT, new conceptual frameworks and language abstractions, and software tools for reliable and recovery-oriented distributed systems. This is the first European network of excellence aimed at coordinating research on reversible computation.

#### 6.2.2.3. *Bilateral PICS project SuCCeSS*

Program: PICS

Project acronym: SuCCeSS

Project title: Security, Adaptability and time in Communication

Duration: June 2016 - June 2019

Coordinator: Cinzia Di Giusto, I3S, Sophia Antipolis

Other partners: I3S, University of Gröningen

Abstract: The project SuCCeSS is a CNRS-funded “Projet coopératif” (PICS 07313), involving 2 French teams in Sophia Antipolis (the MDSC team at the laboratory I3S, acting as coordinator, and the INDES team) and one Dutch team at the University of Gröningen. The project started in June 2016 and is due to end in June 2019. The objective of the project is to study formal models for reliable distributed communication-centric software systems. The project focusses on analysis and validation techniques based on behavioural types, aimed at enforcing various properties (safety, liveness, security) of structured communications.

## **6.3. International Research Visitors**

### **6.3.1. Visits of International Scientists**

#### **6.3.1.1. Internships**

Raimil Cruz

Date: 01/05/16 - 30/07/16

Institution: University of Chile

## MAESTRO Project-Team

# 9. Partnerships and Cooperations

## 9.1. National Initiatives

### 9.1.1. ANR Marmote

**Participants:** Alain Jean-Marie, Issam Rabhi.

ANR Program: Modèles Numériques (MN) 2012, number ANR-12-MONU-0019

Project title: MARKovian MOdeling Tools and Environments

Duration: January 2013 - June 2017

Coordinator: Alain Jean Marie (Inria)

Partners: Inria (project-teams DYOGENE, MAESTRO and MESCAL), Univ. Versailles-Saint-Quentin (DAVID lab.), Telecom SudParis (SAMOVAR lab.), Univ. Paris-Est Créteil (LACL), and Univ. Pierre-et-Marie-Curie (LIP6)

Abstract: ANRMARMOTE aims, among other goals, at realizing the prototype of a software environment dedicated to modeling with Markov chains. It brings together seven partner teams, expert in Markovian analysis, who will develop advanced solution algorithms and applications in different scientific domains: reliability, distributed systems, biology, physics and economics.

<https://wiki.inria.fr/MARMOTE/Welcome>

## 9.2. European Initiatives

### 9.2.1. Collaborations in European Programs, Except FP7 & H2020

**Participant:** Konstantin Avrachenkov.

Program: EU COST

Project acronym: ACROSS

Project title: Autonomous Control for a Reliable Internet of Services

Duration: November 2013 - November 2017

Coordinator: Rob Van Der Mei (CWI) and J.L. Van Den Berg (TNO), The Netherlands

Other partners: see <http://www.cost-across.nl/>

Abstract: Currently, we are witnessing a paradigm shift from the traditional information-oriented Internet into an Internet of Services (IoS). This transition opens up virtually unbounded possibilities for creating and deploying new services. Eventually, the ICT landscape will migrate into a global system where new services are essentially large-scale service chains, combining and integrating the functionality of (possibly huge) numbers of other services offered by third parties, including cloud services. At the same time, as our modern society is becoming more and more dependent on ICT, these developments raise the need for effective means to ensure quality and reliability of the services running in such a complex environment. Motivated by this, the aim of this Action is to create a European network of experts, from both academia and industry, aiming at the development of autonomous control methods and algorithms for a reliable and quality-aware IoS.

Program: EU COST

Project acronym: COSTNET

Project title: European Cooperation for Statistics of Network Data Science

Duration: May 2016 - April 2020

Coordinator: Ernst Wit (NL), Gesine Reinert (UK)

Other partners: see [http://www.cost.eu/COST\\_Actions/ca/CA15109](http://www.cost.eu/COST_Actions/ca/CA15109)

Abstract: A major challenge in many modern economic, epidemiological, ecological and biological questions is to understand the randomness in the network structure of the entities they study: for example, the SARS epidemic showed how preventing epidemics relies on a keen understanding of random interactions in social networks, whereas progress in curing complex diseases is aided by a robust data-driven network approach to biology.

Although analysis of data on networks goes back to at least the 1930s, the importance of statistical network modelling for many areas of substantial science has only been recognized in the past decade. The USA is at the forefront of institutionalizing this field of science through various interdisciplinary projects and networks. Also in Europe there are excellent statistical network scientists, but until now cross-disciplinary collaboration has been slow.

This Action aims to facilitate interaction and collaboration between diverse groups of statistical network modellers, establishing a large and vibrant interconnected and inclusive community of network scientists. The aim of this interdisciplinary Action is two-fold. On the scientific level, the aim is to critically assess commonalities and opportunities for cross-fertilization of statistical network models in various applications, with a particular attention to scalability in the face of Big Data. On a meta-level, the aim is to create a broad community which includes researchers across the whole of Europe and at every stage in their scientific career and to facilitate contact with stakeholders.

### 9.3. International Initiatives

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

##### 9.3.1.1. THANES

**Participants:** Eitan Altman, Konstantin Avrachenkov, Jithin Kazhuthuveetil Sreedharan, Philippe Nain, Giovanni Neglia.

Title: THEory and Application of NETwork Science

International Partners (Institution - Laboratory - Researcher):

CMU (Brazil) - Department of Computer Science - Bruno Ribeiro

UFRJ (Brazil) - Department of Computer and Systems Engineering - Edmundo de Souza e Silva, Daniel Ratton Figueiredo, Daniel Sadoc

Duration: 2014 – 2017

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

Our goal is to study how services in Online Social Networks (OSN) can be efficiently designed and managed. This research requires to answer 3 main questions: 1) How can the topology of an OSN be discovered? Many services need or can take advantage of some knowledge of the network structure that is usually not globally available and in any case changes continuously due to structural dynamics. 2) How does services' adoption spread across the OSN? On the one hand the popularity of a service is determined by word-of-mouth through the links of the OSN and, on the other end, the service may contribute to reshape the structure of the OSN (e.g. by creating new connections). 3) How do different services compete for the finite attention and money of OSN users? In particular our purpose is to provide analytical models (corroborated by simulations and experiments on real networks) to understand such complex interactions.

#### 9.3.2. Inria International Partners

##### 9.3.2.1. Informal International Partners

MAESTRO has continued collaborations with researchers from GERAD, Univ. Montreal (Canada), Flinders Univ. (Australia), National Univ. of Rosario (Argentina), Technion - Israel Institute of Technology (Israel), Univ. of Arizona (USA), Univ. of Illinois at Urbana-Champaign (USA), Univ. of Liverpool (UK), Univ. of Massachusetts at Amherst (USA), Univ. of Florence (Italy), Univ. of Palermo (Italy), Univ. of Twente (The Netherlands) and Petrozavodsk State Univ. (Russia); Ghent Univ. (Belgium); see Sections 9.4.1.1 and 9.4.2.1

#### 9.3.3. Participation in Other International Programs

MAESTRO has continued collaborations with researchers from IIT Mumbai and IISc Bangalore. In 2015, these collaborations were partly supported by IFCAM and Cefipra.

### 9.3.3.1. International Initiatives

#### **DyGaMe**

Title: Dynamic Games Methods: theory, algorithmics and application

International Partners (Institution - Laboratory - Researcher):

Univ. de Chile (Chile) - Department of Industrial Engineering - Fernando Ordóñez

Univ. Nacional de Rosario (Argentina) - Facultad de Ciencias Exactas, Ingeniería y Agrimensura - Eugenio Della Vecchia

CNRS (France) - LIP6 - Emmanuel Hyon

Duration: 2016 - 2017

Start year: 2016

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

Stochastic Dynamic Game Theory is developing in Engineering sciences and is in need of more theoretical results, algorithms and applications. This project brings together researchers from Applied Mathematics, Operations Research and Economics, with the objective of contributing to these aspects. It will more specifically concentrate on agent rationality and the game structure, look for efficient solution algorithms by crossing Applied Mathematics and Operations Research techniques, and apply the results to problems originating from, on the one hand, security/conservation concerns, and on the other hand, sustainable development problems.

#### **CEFIPRA Grant Monte Carlo, no.5100-IT1**

Title: Monte Carlo and Learning Schemes for Network Analytics

International Partners (Institution - Laboratory - Researcher):

IIT Bombay (India) - Department of Electrical Engineering - Prof. V.S. Borkar;

IIS Bangalore (India) - Department of Electrical Engineering - Prof. R. Sundaresan.

Duration: 2014 - 2017

Start year: 2014

The project aims to approach various computation problems in network analytics by means of Markov Chain Monte Carlo (MCMC) and related simulation techniques as well as machine learning algorithms such as reinforcement learning, ant colony optimization, etc. This will include network diagnostics such as ranking, centrality measures, computation on networks using local message passing algorithms, resource allocation issues pertaining to networks and network-based systems such as the internet, peer-to-peer networks, social networks. The work will involve both development of analytical tools and extensive validation thereof using simulation studies. The research will draw upon techniques from graph theory, probability, optimization, and distributed computation.

## 9.4. International Research Visitors

### 9.4.1. Visits of International Scientists

#### 9.4.1.1. Professors / Researchers

Bernardo Amorim

Date: 4-8 April 2016

Institution: Federal Univ. of Rio de Janeiro (Brazil)

Vivek Borkar

Date: 26-29 May and 4-17 September 2016

Institution: IIT Mumbai (India)

Damiano Carra

Date: 22-27 February and 18-22 July 2016

Institution: Univ. of Verona (Italy)

Francesco De Pellegrini

Date: 19-22 December 2016

Institution: CREATE-NET (Italy)

Ioannis Dimitriou

Date: 5-10 September 2016

Institution: Univ. of Patras (Greece)

Daniel Figueiredo

Date: 4-8 April 2016

Institution: Federal Univ. of Rio de Janeiro (Brazil)

Michele Garetto

Date: 4-5 April 2016

Institution: Univ. of Torino (Italy)

Moshe Haviv

Date: 15-19 June 2016

Institution: Univ. of Jerusalem (Israel)

Nidhi Hegde

Date: 10-13 June 2016

Institution: Nokia Bell Labs (France)

Giulio Iacobelli

Date: 11-21 January and 4-8 April 2016

Institution: Federal Univ. of Rio de Janeiro (Brazil)

Philippe Jacquet

Date: 1 December 2016

Institution: Nokia Bell Labs (France)

Jean-Yves Le Boudec

Date: 2 June 2016

Institution: EPFL (Switzerland)

Emilio Leonardi

Date: 6-16 December 2016

Institution: Politecnico di Torino (Italy)

Nelly Litvak

Date: 1-4 December 2016

Institution: Univ. of Twente (Netherlands)

Natalia Markovich

Date: 18-27 June 2016

Institution: Russian Academy of Sciences (Russia)

Evzey Morozov

Date: 21-29 July 2016

Institution: Petrozavodsk Univ. (Russia)

Fernando Ordóñez

Date: 27-30 September

Institution: Univ. of Chile (Chile)

Sreenath Ramanath

Date: 17-27 May 2016

Institution: IIT Bombay (India)

Bruno Ribeiro

Date: 10-20 June 2016

Institution: Carnegie Mellon Univ. (USA)

Daniel Sadoc

Date: 4-8 April 2016

Institution: Federal Univ. of Rio de Janeiro (Brazil)

Matteo Sereno

Date: until March 2016 and 28 Nov-2 Dec 2016

Institution: Univ. of Torino (Italy)

Vinod Sharma

Date: 15-30 November 2016

Institution: IIS Bangalore (India)

Flora Spieksma

Date: 5-7 July 2016

Institution: Univ. of Leiden (Netherlands)

Rajesh Sundaresan

Date: 05-26 May 2016

Institution: IIS Bangalore (India)

Josh Taylor

Date: 24 June 2016

Institution: Univ. of Toronto (Canada)

Don Towsley

Date: 1-3 December 2016

Institution: Univ. of Massachusetts (USA)

Kavitha Voleti Veeraruna

Date: 17-27 May 2016

Institution: IIT Bombay (India)

Uri Yechiali

Date: 15-28 April 2016

Institution: Tel Aviv Univ. (Israel)

#### *9.4.1.2. Post-doc / Ph.D. students*

Víctor Bucarey López

Date: 27-30 September 2016

Institution: Univ. of Chile

Ricardo Coelho Silveira

Date: from Sep 2016 until Nov 2016

Institution: Univ. of Rio de Janeiro (Brazil)



Eduardo Hargreaves

Date: 20-23 June 2016

Institution: Univ. of Rio de Janeiro (Brazil)

Yahui Tian

Date: from Jun 2016 until Jul 2016

Institution: Univ. of Texas (USA)

#### *9.4.1.3. Internships*

Mikhail Kamalov

Date: from Jun 2016 until Jul 2016

Institution: Saint Petersburg State Univ. (Russia)

Supervisor: Konstantin Avrachenkov

Mohamed Lamghari

Date: from Apr 2016 until Aug 2016

Institution: UNS (France)

Supervisor: Giovanni Neglia

Maksim Mironov

Date: from Aug 2016 until Sept 2016

Institution: MIPT (Russia)

Supervisor: Konstantin Avrachenkov

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

#### *9.4.2.1. Research Stays Abroad*

Konstantin Avrachenkov

Date: 4 - 8 April 2016

Institution: IIT Mumbai (India)

Date: 25 April - 5 May 2016

Institution: Moscow Institute of Physics and Technology and Yandex (Russia)

Date: 10-11 August 2016

Institution: Aalto Univ. (Finland)

Alain Jean-Marie

Date: 5 - 16 December 2016

Institution: Univ. of Montreal (Canada)

Date: 28 March - 1 April 2016

Institution: Univ. National of Rosario (Argentina)

Date: 3 - 14 April 2016

Institution: Univ. de Chile (Chile)

Arun Kadavankandy

Date: 12-30 April 2016

Institution: Yandex (Russia)

Date: 12-17 July 2016

Institution: IIS Bangalore (India)

Giovanni Neglia

Date: 14 - 22 February; 1 - 4 April; 20 - 25 September; 7 - 10 and 25 - 30 October 2016

Institution: Univ. of Florence (Italy)

Dates: 11 - 16 May; 21 - 23 December 2016

Institution: Univ. of Palermo (Italy)

Dimitra Politaki

Date: 18 October - 2 November and 12 - 20 December 2016

Institution: Univ. of Torino (Italy)

## AYIN Team

# 7. Partnerships and Cooperations

## 7.1. Regional Initiatives

- Josiane Zerubia has been in contact with Dr. Sandrine Mathieu, image processing quality expert at Thales Alenia Space in Cannes (<https://www.thalesgroup.com/en/worldwide/space>) to discuss AYIN's research in remote sensing.
- Josiane Zerubia is part of the FAULTS-R-GEMS project funded by Academy 3 of IDEX UCA-Jedi (<http://univ-cotedazur.fr/english/idx-uca-jedi/academies-of-excellence>), PI: Isabelle Manighetti of Geoazur (OCA, CNRS, UCA), in collaboration with Yuliya Tarabalka from TITANE Inria team, as well as members of UCA, Institut de Physique du Globe in Paris, Geoscience in Montpellier, ETH Zurich, CalTech, Arizona State University and UNAVCO consortium in the USA.

## 7.2. International Initiatives

### 7.2.1. Inria International Partners

- Josiane Zerubia has a strong collaboration with University of Genoa, Italy, for more than 20 years [11].
- Another collaboration in Canada with Mc Master University, Hamilton, started in 2012 [9], and has been extended to Juravinski Cancer Center (<http://www.jcc.hhsc.ca/>) in Hamilton and Simon Fraser University.

## 7.3. International Research Visitors

### 7.3.1. Visits of International Scientists

#### 7.3.1.1. Research Stays Abroad

Josiane Zerubia was invited to spend 2 months, from late August to late October, at the Coordinated Science Laboratory (CSL, <http://www.csl.illinois.edu/>) of the University of Illinois at Urbana Champaign (UIUC) to work with Prof. Farzad Kamalabadi (<https://www.ece.illinois.edu/directory/profile/farzadk>) and his team on FUV image processing for ICON NASA mission.

## GRAPHDECO Project-Team

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

### 8.1.1. ANR

#### 8.1.1.1. ANR DRAO

**Participant:** Adrien Bousseau.

<https://www-sop.inria.fr/members/Adrien.Bousseau/drao/>

The ANR DRAO is a young researcher project coordinated by Adrien Bousseau, in collaboration with the InSitu project team at Inria Saclay - Ile de France (W. Mackay and T. Tsandilas) and the MANAO project team (P. Barla and G. Guennebaud) and POTIOC project team (M. Hachet) at Inria Bordeaux - Sud Ouest. The goal of this collaboration is to develop novel drawing tools for amateurs as well as for expert designers and illustrators, combining expertise in Computer Graphics (REVES and MANAO) and Human-Computer Interaction (InSitu, POTIOC). This ANR project funds the PhD of Emmanuel Iarussi.

While the ANR DRAO ended in 2015, it has resulted in a publication at ACM Conference on Human Factors in Computing Systems (CHI) 2016 [9]. Adrien Bousseau received an ANR Young Researcher Award for coordinating this project.

#### 8.1.1.2. ANR SEMAPOLIS

**Participants:** George Drettakis, Abdelaziz Djelouah, Theo Thonat.

This ANR project started in October 2013. The goal is to use semantic information to improve urban reconstruction and rendering. The consortium is led by ENPC (R. Marlet) and includes the Inria Willow team and the GREY-C laboratory on image processing. Our contribution will be in the rendering of urban models, in particular using image-based rendering algorithms.

This year, the ANR SEMAPOLIS resulted in five publications on multi-view segmentation [10], multi-view inpainting [13], image-based rendering of cars [12] and interiors [6], and procedural modeling of buildings [8]. Two of these projects rely on a deep learning method from the ENPC group to identify semantic object categories in images (e.g., cars, people etc.) [13], [12]. In [12] we also collaborated with the ENPC group to use a deep learning method to allow the use of rendered images to identify objects in photographs. These collaborations have been extremely fruitful for our group, and have opened the way to several new collaborations with ENPC.

## 8.2. European Initiatives

### 8.2.1. FP7 & H2020 Projects

#### 8.2.1.1. CR-PLAY – Capture Reconstruct Play

<http://www.cr-play.eu>

Type: COOPERATION (ICT)

Instrument: Specific Targeted Research Project

Objectif: Creativity

Duration: November 2013 - October 2016

Coordinator: Testaluna SA (IT)

Partner: TU Darmstadt (DE), UC London (UK), U. Patras (GR), Miniclip UK, Cursor Oy (FI)

Inria contact: George Drettakis

Abstract: The goal of this project is to use image- and video-based rendering and relighting techniques in the context of games and in particular mobile or casual games. The computer graphics and vision partners (UCL, TUD) are leaders in their fields, and have developed algorithms allowing easy capture of scenes using images and video, and reconstruction using vision algorithms. UCL and Inria have developed image- and video-based rendering algorithms which can be useful for games. These tools need to be perfected, reducing artifacts and difficulty of use so that they can be useful and productive for games companies. For evaluation, the HCI lab of the University of Patras will provide cutting-edge methodologies to make the resulting systems useable. The consortium is led by the games company Testaluna, based in Genova Italy. Other industrial partners include Cursor Oy (a regional group of games companies in Finland, which is a leader in Europe in Casual games) and Miniclip, which is one of the major players in the online game market.

This year we had four results related to CR-PLAY on multi-view segmentation [10], multi-view inpainting [13], image-based rendering of cars [12] and indoors [6]. The work on indoors rendering was led by the CR-PLAY partner UCL. The CR-PLAY project ended in October, and was successfully evaluated in November. The project has resulted in a number of technological developments related to the Ph.D. work of R. Ortiz-Cayon and T. Thonat, as well as the postdoc of A. Djelouah which will be the object of a market study in the goal of a technology transfer.

#### 8.2.1.2. *EMOTIVE*

Type: COOPERATION (ICT)

Instrument: Research Innovation Action

Objectif: Virtual Heritage

Duration: November 2016 - October 2019

Coordinator: EXUS SA (UK)

Partner: Diginext (FR), ATHENA (GR), Noho (IRL), U Glasgow (UK), U York (UK)

Inria contact: George Drettakis

Abstract: Storytelling applies to nearly everything we do. Everybody uses stories, from educators to marketers and from politicians to journalists to inform, persuade, entertain, motivate or inspire. In the cultural heritage sector, however, narrative tends to be used narrowly, as a method to communicate to the public the findings and research conducted by the domain experts of a cultural site or collection. The principal objective of the EMOTIVE project is to research, design, develop and evaluate methods and tools that can support the cultural and creative industries in creating Virtual Museums which draw on the power of 'emotive storytelling'. This means storytelling that can engage visitors, trigger their emotions, connect them to other people around the world, and enhance their understanding, imagination and, ultimately, their experience of cultural sites and content. EMOTIVE will do this by providing the means to authors of cultural products to create high-quality, interactive, personalized digital stories.

GRAPHDECO will contribute by developing novel image-based rendering techniques to help museum curators and archeologists provide more engaging experiences.

## 8.3. International Initiatives

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

#### 8.3.1.1. *CRISP2*

Title: Creating and Rendering Images based on the Study of Perception

International Partner (Institution - Laboratory - Researcher):

University of California Berkeley (United States) - Electrical Engineering and Computer Science Department (EECS) - Maneesh Agrawala

Start year: 2014

See also: <http://www-sop.inria.fr/reves/crisp/>

The CRISP collaboration aims at developing novel techniques to create and manipulate effective numerical imagery. We adopt a multidisciplinary approach, focusing on understanding how people create and perceive images, on developing new rendering algorithms based on this understanding, and on building interactive tools that enable users to efficiently produce the images they have in mind. The participants of CRISP share complementary expertise in computer graphics, human computer interaction and human visual perception. In 2016, the CRISP collaboration supported the postdoc of George Koulieris, who spent 6 months at UC Berkeley and is now at Inria. Johanna Delanoy also spent 2 weeks at UC Berkeley to collaborate with Alexei Efros.

### **8.3.2. Inria International Partners**

#### *8.3.2.1. Informal International Partners*

**Canada.** A. Bousseau collaborates regularly with the University of Toronto (K. Singh) and the University of British Columbia (A. Sheffer).

**India.** A. Bousseau collaborates with Vinay Namboodiri from IIT Kanpur and hosted several of his students for internships (Rahul Arora and Srinivasa Rao Gadhamchetty).

**UK.** G. Drettakis collaborates with UCL in the context of the CR-PLAY projects, resulting in a publication on indoor image-based rendering [6].

**United States.** We regularly collaborate with Adobe Research. Most recently, G. Drettakis worked with Eli Shechtman and Sylvain Paris on multi-view inpainting [13]. We also collaborate with Daniel Aliaga from Purdue University on sketch-based procedural modeling [8].

## **8.4. International Research Visitors**

### *8.4.1. Visits of International Scientists*

Martin Banks (UC Berkeley) visited our group for two weeks in the context of the Associate Team CRISP (Sec. 8.3.1.1). We also hosted Philip Isola, Richard Zhang and Alexei Efros (UC Berkeley) for two days, also in the context of CRISP. Several international researchers made short visits and talks: Elena Garces (University of Zaragoza), Yulia Gryditskaya (MPI), Jan Jermyn (Durham University), Christian Lessig (Otto-von-Guericke Universitat Magdeburg), Marc Stamminger (Erlangen University). Finally, we hosted Frédo Durand from MIT (10 months) and Eugene Fiume from university of Toronto (6 months) for their sabbatical.

#### *8.4.1.1. Internships*

Sai Praveen Bangaru and Srinivasa Rao Gadhamchetty were master interns from IIT Madras and IIT Kampur respectively.

### *8.4.2. Visits to International Teams*

#### *8.4.2.1. Research Stays Abroad*

George Koulieris spent 6 months at UC Berkeley (Feb. 1 - Jul. 31) to work with Martin S. Banks in the context of the CRISP Inria associate team. Johanna Delanoy also visited UC Berkeley for two weeks to work with Alexei Efros.

## GRAPHIK Project-Team

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

### 8.1.1. ANR

#### 8.1.1.1. ASPIQ

**Participants:** Jean-François Baget, Madalina Croitoru, Fabien Garreau, Marie-Laure Mugnier, Jérôme Fortin, Michel Leclère, Odile Papini, Swan Rocher.

ASPIQ (ASP technologies for Querying large scale multisource heterogeneous web information), is an ANR white project that started in January 2013 (duration: 4 years, extended to July 2017). It involves partners from CRIL, LERIA and LSIS. The project coordinator is Odile Papini (LSIS). <http://aspiq.lsis.org/>

The main objective of this project is to propose:

- extensions of standard ASP for representing OWL2 tractable sublanguages;
- new operations for merging conflicting information in this extended ASP;
- the identification of subclasses of this extended ASP allowing for efficient query answering mechanisms;
- an implementation of a prototype reasoning system.
- *See Section 6.1 and 6.2 for this year's results.*

#### 8.1.1.2. Pagoda

**Participants:** Meghyn Bienvenu, Jean-François Baget, Marie-Laure Mugnier, Swan Rocher, Federico Ulliana.

Pagoda (Practical Algorithms for Ontology-based Data Access) is an ANR JCJC (young researchers) project that started in Jan. 2013 (duration: 4 years, extended to August 2017). The project coordinator is Meghyn Bienvenu (initially in LRI, now member of GraphIK). It involves partners from the EPI LEO, the LIG, and the Anatomy Laboratory of Grenoble. <http://pagoda.lri.fr/>

The primary aim of this project is to address challenges brought by scalability and the handling of data inconsistencies by developing novel OBDA (Ontology Based Data Access) query answering algorithms and practical methods for handling inconsistent data.

- *See Section 6.1 and 6.2 for this year's results.*

#### 8.1.1.3. Qualinca

**Participants:** Michel Leclère, Michel Chein, Madalina Croitoru, Rallou Thomopoulos, Alain Gutierrez, Swan Rocher, Clément Sipieter, Marie-Laure Mugnier.

Qualinca is an ANR Contint project that started in Apr. 2012 (duration: 4 years, extended to September 2016). The project coordinator is Michel Leclère (GraphIK). It involves partners from LRI, LIG, ABES and INA. <http://www.lirmm.fr/qualinca/index8ece.html?q=en/en/home>

The main objective is to elaborate mechanisms allowing to:

- evaluate the quality of an existing document base;
- maintain a given level of quality by controlling updating operations;
- increase the quality of a given base;
- develop generic methods that take into account the quality of a given base (for instance for searching documents or interconnecting bases).
- *See Section 6.3 for this year's results.*

#### 8.1.1.4. Dur-Dur

**Participants:** Abdallah Arioua, Pierre Bisquert, Patrice Buche, Madalina Croitoru, Jérôme Fortin, Abdelraouf Hecham, Rallou Thomopoulos.

Dur-Dur (Innovations agronomiques, techniques et organisationnelles pour accroître la DURabilité de la filière blé DUR) is an ANR project that started in March 2014 (duration: 3 years). It is led by IATE Laboratory. <http://umr-iate.cirad.fr/projets/dur-dur>

The Dur-Dur project develops a systematic approach to investigate the questions related to the management of the nitrogen, energy and contaminants, to guarantee a global quality of products throughout the production and the processing chain. The knowledge representation task of Dur-Dur proposes to map the stakeholders' objectives into a multicriteria cartography, as well as possible means to reach them, and computes the compatibility / incompatibility of these objectives on the basis of argumentation methods. The research methods used are qualitative and based both on argumentation theory and on Social Multi- Criteria Evaluation (SMCE) theory. They will be extended and adapted to the needs of the project to provide a formal framework of assessment of the various orientations considered for the durum wheat chain.

- See Section 6.2 for this year's results.

### 8.1.2. Other projects

#### 8.1.2.1. Pack4Fresh

**Participants:** Patrice Buche, Pierre Bisquert, Madalina Croitoru, Bruno Yun.

Pack4Fresh (Sept. 2015 - Sept. 2017) is a project selected in the framework of the GloFood INRA-CIRAD metaprogramme. The multi-year metaprogramme GloFoodS (Transitions to global food security) is dedicated to the investigation of pathways to worldwide food security in a context of competition for land and natural resources, and is jointly conducted by INRA and Cirad, the two leading French research institutions for agriculture. Involving research on crop yield and livestock systems, land use changes, food processing and waste, nutrition and governance, GloFoodS aims at articulating global modeling of food supply and demand, with local issues of production and access to food.

In this context, Pack4Fresh focuses on the big fragility of fresh foods which generates enormous post-harvest wastes, short shelf-life, and constitutes a major lock to their consumption and health benefit. This project aims at initiating an eco-design approach of the post-harvest phase of fresh foods working on the interdependency relation between environmental impact (1) positive for waste reduction, et (2) negative for technologies, which aims at reducing the waste, in order to minimize the ratio between those two parameters.

- See Section 6.2 for this year's results.

#### 8.1.2.2. OBDA-KeyVal: Ontology-Based Data Access for NoSQL Databases

**Participants:** Federico Ulliana, Marie-Laure Mugnier.

OBDA-KeyVal is a one-year PEPS project (JCJC INS2I 2016, funded by CNRS-INS2I) dedicated to Ontology Based Data Access for NOSQL Databases. Its goal is to study the problem of answering ontology-mediated queries on top of non-relational databases, and more precisely Key-Value stores. These are a family of NOSQL databases dealing with data represented as nested-structures (JSON records), processed on distributed systems but also increasingly exchanged on the Web, slowly replacing XML and RDF formats. Key-value stores have been designed with performance and scalability in mind, and this opens the possibility to implement OBDA in a novel and efficient distributed setting. The work carried out in this project builds on our first results published at AAAI 2016 [39], see also Sect. 6.1. We addressed both practical and theoretical aspects of OBDA for key-value stores. First, a prototype of the reasoning framework for key-value stores has been developed by master students (<https://github.com/OBDA-KEYVAL/graal-keyval>). Second, a novel first-order logic semantics for the setting (in contrast to the former operational semantics) has been defined and investigated from a decidability viewpoint. This still ongoing work is a necessary step towards bridging this setting with the relational OBDA.

## 8.2. European Initiatives

### 8.2.1. FP7 & H2020 Projects

#### 8.2.1.1. NoAW (No Agricultural Waste)

**Participants:** Patrice Buche, Pierre Bisquert, Madalina Croitoru, Nikolaos Karanikolas, Rallou Thomopoulos.

**Website:** [http://cordis.europa.eu/project/rcn/203384\\_en.html](http://cordis.europa.eu/project/rcn/203384_en.html)

NoAW (No Agricultural Waste) is an H2020 european project led by INRA-IATE, started in Oct. 2016. Driven by a “near zero-waste” society requirement, the goal of NoAW project is to generate innovative efficient approaches to convert growing agricultural waste issues into eco-efficient bio-based products opportunities with direct benefits for both environment, economy and EU consumer. To achieve this goal, the NoAW concept relies on developing holistic life cycle thinking able to support environmentally responsible R&D innovations on agro-waste conversion at different TRLs, in the light of regional and seasonal specificities, not forgetting risks emerging from circular management of agro-wastes (e.g. contaminants accumulation).

GraphIK will contribute on two aspects. On one hand we will participate in the annotation effort of knowledge bases (using the @Web tool). On the other hand we will further investigate the interplay of argumentation with logically instantiated frameworks and its relation with social choice in the context of decision making.

### 8.2.2. Collaborations in European Programs, Except FP7 & H2020

#### 8.2.2.1. COST FoodMC.

**Participants:** Madalina Croitoru, Rallou Thomopoulos.

**Website:** <http://www6.inra.fr/foodmc>

Rallou Thomopoulos is involved as Co-coordinator (together with Alberto Tonda and Kamal Kansou) in the European COST Action "FoodMC" (Mathematical and Computer Science Methods for Food Science and Industry) started in 2016. Both Madalina Croitoru and Rallou Thomopoulos are Members of the Management Committee, representing France.

## 8.3. International Initiatives

### 8.3.1. Inria International Partners

#### 8.3.1.1. Informal International Partners

- University of Buenos Aires, Ricardo Rodriguez, since 2013. Work in progress.
- University of Aberdeen, Nir Oren, since 2010. Work in progress.
- Technical University of Dresden, Sebastian Rudolph, since 2012. [34], co-organizer for GKR@IJCAI 2017.
- University of Liverpool, Frank Wolter, since 2009. [11], [27]
- Sapienza University (Rome), Riccardo Rosati, since 2012. [28]
- University of Bremen, Carsten Lutz, since 2009. [27], [11]
- Technical University of Vienna, Magdalena Ortiz and Mantas Simkus, since 2010. Work in progress.
- Laval University (Quebec), Irène Abi-Zeid, since 2015, and Bernard Moulin, since 2012. [44], [38]
- University of Amsterdam, Ulle Endriss, since 2015. Work in progress.

### 8.3.2. Participation in Other International Programs

Patrice Buche is involved in the RDA AgriSemantics working group (<https://www.rd-alliance.org/groups/agrisemantics-wg.html>). The goal of the Agrisemantics WG is to gather community-based requirements and use cases for an infrastructure that supports appropriate use of semantics for data interoperability, with special focus on agriculture.



## 8.4. International Research Visitors

### 8.4.1. Visits of International Scientists

- Nov. 2016 (1 week). Visit of Elena Botoeva (Univ. of Bolzano), Stanislav Kikot (London Univ.), Roman Kontchakov (London Univ.) Vladislav Rhyzhikov (Univ. of Bolzano), and Michael Zakharyashev (London Univ.) to work on the complexity on ontology-mediated query answering with description logics and linear existential rules. Seminars: “Query Inseparability of Description Logic Knowledge Bases and TBoxes” by Elena Botoeva and “The Complexity of Ontology-Based Data Access with OWL 2 QL and Bounded Treewidth Queries” by Stanislav Kikot.
- Nov. 2016 (2 days). Visit of Sebastian Rudolph (TU Dresden) in the context of Swan Rocher’s PhD defense. Seminar: “The Curse of Finiteness: Undecidability of Database-Inspired Reasoning Problems in Very Expressive Description Logics”.
- Sept. 2016 (1 week) Visit of Ricardo Rodriguez (Univ. of Buenos Aires) to work on belief revision for inconsistent tolerant semantics.

### 8.4.2. Visits to International Teams

#### 8.4.2.1. Research Stays Abroad

Pierre Bisquert was an invited researcher at the University of Amsterdam from May 2015 to Apr. 2016.

- In collaboration with Ulle Endriss (Institute for Logic, Language and Computation), he worked on the link between argumentation theory and social choice. The aim of this work was to study and understand how Arrow’s Impossibility Theorem (stating that there is no democratic voting rule) could be avoided thanks to deliberation and argumentation. More precisely, the favored approach was to define a formal framework of the deliberation process predating a vote, and to establish conditions under which deliberation may help to output a democratic and collectively rational choice through the notion of preference structuration, i.e., the changes in preferences that the agents may undergo after discussion.

Rallou Thomopoulos was invited at Laval University (Québec, Canada) for one year until July 2016. She worked on two projects dealing with decision support:

- An academic project conducted with the Computer Science Division of Laval University. It aimed at conceiving a systematic approach to assess several scenarios in agriculture, by combining a qualitative model based on argumentation and a quantitative simulation technique based on system dynamics.
- The second project was conducted both with a private partner and with the Operation and Decision Division of Laval University. It aimed to provide explanations for automatically-computed instructions, to improve human understanding of the situation. These instructions were the results of a commercial software used for real-time decision support for the flow management of a combined and sanitary wastewater system.

## **HEPHAISTOS Project-Team**

# **9. Partnerships and Cooperations**

## **9.1. Regional Initiatives**

- CPER project MADORSON for the assistance to elderly people (with the STARS project)
- we have submitted several projects to the local IDEX without success but we are preparing several projects for the next year

## **9.2. National Initiatives**

### **9.2.1. FHU**

- the team has been involved for the FHU *INOVPAIN : Innovative Solutions in Refractory Chronic Pain* that has been labeled in December

## **9.3. European Initiatives**

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

#### **9.3.1.1. RAPP**

Type: COOPERATION

Instrument: Specific Targeted Research Project

Objective: Robotic Applications for Delivering Smart User Empowering Applications

Duration: December 2013-December 2016

Coordinator: CERTH/ITI

Partner: CERTH/ITI(Greece), Inria, WUT (Poland), ORTELIO (UK), ORMYLIA (Greece), IN-GEMA (Spain)

Inria contact: David Daney, Jean-Pierre Merlet, Manuel Serrano

Abstract: our societies are affected by a dramatic demographic change, in the near future elderly and people requiring support in their daily life will increase and caregivers will not be enough to assist and support them. Socially interactive robots can help to confront this situation not only by physically assisting people but also functioning as a companion. The increasing sales figures of robots are pointing that we are in front of a trend break for robotics. To lower the cost for developers and to increase their interest on developing robotic applications, the RAPP introduces the idea of robots as platforms. RAPP (Robotic Applications for Delivering Smart User Empowering Applications) will provide a software platform in order to support the creation and delivery of robotics applications (RAPPs) targeted to people at risk of exclusion, especially older people. The open-source software platform will provide an API that contains the functionalities for implementing RAPPs and accessing the robot's sensors and actuators using higher level commands, by adding a middleware stack with added functionalities suitable for different kinds of robots. RAPP will expand the computational and storage capabilities of robots and enable machine learning operations, distributed data collection and processing, and knowledge sharing among robots in order to provide personalized applications based on adaptation to individuals. The use of a common API will assist developers in creating improved applications for different types of robots that target to people with different needs, capabilities and expectations, while at the same time respect their privacy and autonomy, thus the proposed RAPP Store will have a profound effect in the robotic application market. The results of RAPP will be evaluated through the development and benchmarking of social assistive RAPPs, which exploit the innovative features (RAPP API, RAPP Store, knowledge reuse, etc.) introduced by the proposed paradigm.

## **9.4. International Initiatives**

### ***9.4.1. Informal International Partners***

We have numerous international collaborations but we mention here only the one with activities that go beyond joint theoretical or experimental works:

- University of Bologna: 2 joint PhD student, publications
- University Innsbruck: joint conference organization
- Fraunhofer IPA, Stuttgart: joint conference organization
- Duisburg-Essen University: joint conference organization
- University of New-Brunswick: 1 joint PhD student
- University Laval, Québec: joint book
- University of Tokyo: joint conference organization
- Tianjin University, China: joint book

## **9.5. International Research Visitors**

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

We have received for an extended stay our joint PhD student J. Pickard from University of New Brunswick together with his canadian supervisor J.A Carretero. We have received the Associate Professor Martin Pfulner from Innsbruck University for an extended stay and and Cuong Trinh Duc, PhD student from University Genova while several other scientists from other domains have visited our robotics flat.

## LAGADIC Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. *ARED NavRob*

**Participants:** Suman Raj Bista, Paolo Robuffo Giordano, François Chaumette.

*no Inria Rennes 8033, duration: 36 months.*

This project funded by the Brittany council ended in October 2016. It supported in part Suman Raj Bista's Ph.D. about visual navigation (see Section 7.4.1).

### 9.1.2. *ARED DeSweep*

**Participants:** Lesley-Ann Dufлот, Alexandre Krupa.

*no Inria Rennes 8033, duration: 36 months.*

This project funded by the Brittany council started in October 2014. It supports in part Lesley-Ann Dufлот's Ph.D. about visual servoing based on the shearlet transform (see Section 7.3.3).

### 9.1.3. *ARED Locoflot*

**Participants:** Ide Flore Kenmogne Fokam, Vincent Drevelle, Eric Marchand.

*no Inria Rennes 9944, duration: 36 months.*

This project funded by the Brittany council started in October 2015. It supports in part Ide Flore Kenmogne Fokam's Ph.D. about cooperative localization in multi-robot fleets using interval analysis (see Section 7.5.3).

### 9.1.4. *ARED Mod4Nav*

**Participants:** Aline Baudry, Marie Babel.

*no INSA Rennes 2016/01, duration: 36 months.*

This project funded by the Brittany council started in October 2016. It supports in part Aline Baudry's Ph.D. about wheelchair modeling.

### 9.1.5. *“Equipement mi-lourd Rennes Métropole”*

**Participant:** Paolo Robuffo Giordano.

*no CNRS Rennes 14C0481, duration: 36 months.*

A grant from “Rennes Métropole” has been obtained in June 2014 and supports the activities related to the use of drones (quadrotor UAVs). The platform described in Section 6.9.5 has been purchased in part thanks to this grant.

### 9.1.6. *IRT Jules Verne Mascot*

**Participant:** François Chaumette.

*no Inria Rennes 10361, duration: 36 months.*

This project started in October 2015. It is managed by IRT Jules Verne in Nantes and realized in cooperation with IRCCyN, Airbus, Renault, Faurecia and Alstom. Its goal is to perform screwing for various industrial applications.

### 9.1.7. *IRT b<>com NeedleWare*

**Participants:** Hadrien Gurnel, Alexandre Krupa.

*no Inria Rennes 9072, duration: 36 months.*

This project started in October 2016. It supports Hadrien Gurnel's Ph.D. about the study of a shared control strategy fusing haptic and ultrasound visual control for assisting manual steering of needles for biopsies or therapy purposes in a synergetic way.

## 9.2. National Initiatives

### 9.2.1. *France Life Imaging WP3-FLI ANFEET*

**Participant:** Alexandre Krupa.

*duration: 24 months.*

This project started in January 2016. Its objective is to initiate collaborative research with the ICube laboratory (Strasbourg) on the control and supervision of flexible endoscopes in the digestive tube using ultrasound images.

### 9.2.2. *ANR Contint Visioland*

**Participants:** Noël Mériaux, Patrick Rives, François Chaumette.

*no Inria Rennes 8304, duration: 48 months.*

This project started in November 2013. It is composed of a consortium managed by Onera in Toulouse with Airbus, Spikenet Technology, IRCCyN, and Lagadic. Its aim is to develop vision-based localization and navigation techniques for autonomous landing on a runway (see Section 7.1.3).

### 9.2.3. *ANR Contint Entracte*

**Participant:** Julien Pettré.

*no Inria Rennes 8013, duration: 42 months.*

This project started in November 2013. It is realized in collaboration with the Gepetto group at Laas, Toulouse, and the Mimetic group at Irisa and Inria Rennes Bretagne Atlantique. It addresses the problem of motion planning for anthropomorphic systems, and more generally, the problem of manipulation path planning. ENTRACTE proposes to study in parallel both the mathematical foundation of artificial motion and the neurocognitive structures used by humans to quickly solve motion problems.

### 9.2.4. *ANR JCJC Percolation*

**Participant:** Julien Pettré.

*no Inria Rennes 7991, duration: 42 months.*

The ANR "Jeune Chercheur" Percolation project started on January 2014. It aims at designing perception-based crowd simulation algorithms. We develop agents which are capable of perceiving their virtual environment through virtual sensors, and which are able to navigate in it, as well as to interact with the other agents.

### 9.2.5. *ANR JCJC SenseFly*

**Participants:** Thomas Bellavoir, Muhammad Usman, Riccardo Spica, Paolo Robuffo Giordano.

*no Irisa CNRS 50476, duration: 36 months.*

The ANR "Jeune Chercheur" SenseFly project started in August 2015. Its goal is to advance the state-of-the-art in multi-UAV in the design and implementation of fully decentralized and sensor-based group behaviors by only resorting to onboard sensing (mainly cameras and IMU) and local communication (e.g., Bluetooth communication, wireless networks). Topics such as individual flight control, formation control robust against sensor limitations (e.g., limited field of view, occlusions), distributed estimation of relative positions/bearings from local sensing, maintenance of architectural properties of a multi-UAV formation will be touched by the project. Part of the platforms described in Section 6.9.5 has been purchased thanks to this grant.

### 9.2.6. ANR PLaTINUM

**Participants:** Eduardo Fernandez Moral, Vincent Drevelle, Patrick Rives.

*no Inria Sophia 10204, duration: 42 months.*

This project started in November 2015. It is composed of a consortium managed by Litis in Rouen with IGN Matis (Paris), Le2i (Le Creusot) and Lagadic group. It aims at proposing novel solutions to robust long-term mapping of urban environments.

### 9.2.7. BPI Romeo 2

**Participants:** Giovanni Claudio, Nicolas Cazy, Suman Raj Bista, Fabien Spindler, François Chaumette.

*no Inria Rennes 7114, duration: 60 months.*

This project started in November 2012. It is composed of a large consortium managed by Softbank Robotics (ex Aldebaran Robotics) with Laas in Toulouse, Isir in Paris, Lirimm in Montpellier, Inria groups Lagadic, Bipop (Pierre-Brice Wieber), Flowers (Pierre-Yves Oudeyer), and many other partners. It aims at developing advanced control and perception functionalities to a humanoid robot. In this project, we are in charge of visual manipulation and navigation with Romeo and Pepper. It supports in part Suman Raj Bista's Ph.D. about visual navigation (see Section 7.4.1), as well as Nicolas Cazy's Ph.D. about model-based predictive control for visual servoing (see Section 7.2.4).

### 9.2.8. Equipex Robotex

**Participants:** Fabien Spindler, François Chaumette.

*no Inria Rennes 6388, duration: 9 years.*

Lagadic is one of the 15 French academic partners involved in the Equipex Robotex network that started in February 2011. It is devoted to get and manage significative equipment in the main robotics labs in France. In the scope of this project, we have got the humanoid robot Romeo (see Section 6.9.4).

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

#### 9.3.1.1. FP7 Space RemoveDEBRIS

**Participants:** Aurélien Yol, Eric Marchand, François Chaumette.

Instrument: Specific Targeted Research Project

Duration: October 2013 - September 2017

Coordinator: University of Surrey (United Kingdom)

Partners: Surrey Satellite Technology (United Kingdom), Airbus (Toulouse, France and Bremen, Germany), Isis (Delft, The Netherlands), CSEM (Neuchâtel, Switzerland), Stellenbosch University (South Africa).

Inria contact: François Chaumette

Abstract: The goal of this project is to validate model-based tracking algorithms on images acquired during an actual space debris removal mission (see Section 7.1.2).

### 9.3.1.2. H2020 Comanoid

**Participants:** Don Joven Agravante, Giovanni Claudio, Souriya Trinh, Fabien Spindler, François Chaumette.

Title: Multi-contact Collaborative Humanoids in Aircraft Manufacturing

Programm: H2020

Duration: January 2015 - December 2018

Coordinator: CNRS (Lirimm)

Partners: Airbus Group (France), DLR (Germany), Università Degli Studi di Roma La Sapienza (Italy), CNRS (I3S)

Inria contact: Francois Chaumette

COMANOID investigates the deployment of robotic solutions in well-identified Airbus airliner assembly operations that are laborious or tedious for human workers and for which access is impossible for wheeled or rail-ported robotic platforms. As a solution to these constraints a humanoid robot is proposed to achieve the described tasks in real-use cases provided by Airbus Group. At a first glance, a humanoid robotic solution appears extremely risky, since the operations to be conducted are in highly constrained aircraft cavities with non-uniform (cargo) structures. Furthermore, these tight spaces are to be shared with human workers. Recent developments, however, in multi-contact planning and control suggest that this is a much more plausible solution than current alternatives such as a manipulator mounted on multi-legged base. Indeed, if humanoid robots can efficiently exploit their surroundings in order to support themselves during motion and manipulation, they can ensure balance and stability, move in non-gaited (acyclic) ways through narrow passages, and also increase operational forces by creating closed-kinematic chains. Bipedal robots are well suited to narrow environments specifically because they are able to perform manipulation using only small support areas. Moreover, the stability benefits of multi-legged robots that have larger support areas are largely lost when the manipulator must be brought close, or even beyond, the support borders. COMANOID aims at assessing clearly how far the state-of-the-art stands from such novel technologies. In particular the project focuses on implementing a real-world humanoid robotics solution using the best of research and innovation. The main challenge will be to integrate current scientific and technological advances including multi-contact planning and control; advanced visual-haptic servoing; perception and localization; human-robot safety and the operational efficiency of cobotics solutions in airliner manufacturing.

### 9.3.1.3. H2020 Romans

**Participants:** Nicolò Pedemonte, Firas Abi Farraj, Fabien Spindler, François Chaumette, Paolo Robuffo Giordano.

Title: Robotic Manipulation for Nuclear Sort and Segregation

Programm: H2020

Duration: May 2015 - April 2018

Coordinator: University of Birmingham

Partners: NLL (UK), CEA (France), Univ. Darmstadt (Germany)

CNRS contact: Paolo Robuffo Giordano

The RoMaNS (Robotic Manipulation for Nuclear Sort and Segregation) project will advance the state of the art in mixed autonomy for tele-manipulation, to solve a challenging and safety-critical “sort and segregate” industrial problem, driven by urgent market and societal needs. Cleaning up the past half century of nuclear waste, in the UK alone (mostly at the Sellafield site), represents the largest environmental remediation project in the whole of Europe. Most EU countries face related challenges. Nuclear waste must be “sorted and segregated”, so that low-level waste is placed in low-level storage containers, rather than occupying extremely expensive and resource intensive high-level storage containers and facilities. Many older nuclear sites (>60 years in UK) contain large

numbers of legacy storage containers, some of which have contents of mixed contamination levels, and sometimes unknown contents. Several million of these legacy waste containers must now be cut open, investigated, and their contents sorted. This can only be done remotely using robots, because of the high levels of radioactive material. Current state-of-the-art practice in the industry, consists of simple tele-operation (e.g. by joystick or teach-pendant). Such an approach is not viable in the long-term, because it is prohibitively slow for processing the vast quantity of material required. The project will: 1) Develop novel hardware and software solutions for advanced bi-lateral master-slave tele-operation. 2) Develop advanced autonomy methods for highly adaptive automatic grasping and manipulation actions. 3) Combine autonomy and tele-operation methods using state-of-the-art understanding of mixed initiative planning, variable autonomy and shared control approaches. 4) Deliver a TRL 6 demonstration in an industrial plant-representative environment at the UK National Nuclear Lab Workington test facility.

### 9.3.2. Collaborations with European Partners

**Participants:** Fabien Spindler, Alexandre Krupa, François Chaumette.

Project acronym: i-Process

Project title: Innovative and Flexible Food Processing Technology in Norway

Duration: January 2016 - December 2019

Coordinator: Sintef (Norway)

Other partners: Nofima, Univ. of Stavanger, NMBU, NTNU (Norway), DTU (Denmark), KU Leuven (Belgium), and about 10 Norwegian companies.

Abstract: This project is granted by the Norwegian Government. Its main objective is to develop novel concepts and methods for flexible and sustainable food processing in Norway. In the scope of this project, the Lagadic group is involved for visual tracking and visual servoing of generic and potentially deformable objects. Prof. Pal Johan from the Norwegian University of Life Sciences (NMBU), and Ekrem Misimi from Sintef spent a short visit in June and October respectively.

## 9.4. International Initiatives

### 9.4.1. Inria Associate Teams

#### 9.4.1.1. SIMS

Title: Realistic and Efficient Simulation of Complex Systems

International Partners:

University of North Carolina at Chapel Hill (USA) - GAMMA Group - Ming C. Lin,  
Dinesh Manocha

University of Minnesota (USA) - Motion Lab - Stephen Guy

Brown University (USA) - VenLab - William Warren

Start year: 2012

See <http://people.rennes.inria.fr/Julien.Pettré/EASIMS/easims.html>

The general goal of SIMS is to make significant progress toward realistic and efficient simulation of highly complex systems, which raise combinatory explosive problems. This proposal is focused on human motion and interaction, and covers 3 active topics with wide application range:

1. Crowd simulation: virtual human interacting with other virtual humans,
2. Autonomous virtual humans interacting with their environment,
3. Physical simulation: real humans interacting with virtual environments.



SIMS is orthogonally structured by transversal questions: the evaluation of the level of realism reached by a simulation (which is a problem by itself in the considered topics), considering complex systems at various scales (micro, meso and macroscopic ones), and facing combinatory explosion of simulation algorithms.

#### 9.4.1.2. *ISI4NAVE*

Title: Innovative Sensors and adapted Interfaces for assistive NAVigation and pathology Evaluation  
International Partner:

University College London (United Kingdom) - Aspire CREATE - Tom Carlson

Start year: 2016

See <http://www.irisa.fr/lagadic/team/MarieBabel/ISI4NAVE/ISI4NAVE.html>

The global ageing population, along with disability compensation constitute major challenging societal and economic issues. In particular, achieving autonomy remains a fundamental need that contributes to the individual's wellness and well-being. In this context, innovative and smart technologies are designed to achieve independence while matching user's individual needs and desires.

Hence, designing a robotic assistive solution related to wheelchair navigation remains of major importance as soon as it compensates partial incapacities. This project will then address the following two issues. First, the idea is to design an indoor / outdoor efficient obstacle avoidance system that respects the user intention, and does not alter user perception. This involves embedding innovative sensors to tackle the outdoor wheelchair navigation problem. The second objective is to take advantage of the proposed assistive tool to enhance the user Quality of Experience by means of biofeedback. Indeed, adapted interfaces should improve the understanding of people that suffer from cognitive and/or visual impairments.

The originality of the project is to continuously integrate medical validation as well as clinical trials during the scientific research work in order to match user needs and acceptance.

### 9.4.2. *Inria International Partners*

#### 9.4.2.1. *Informal International Partners*

- Alexandre Krupa has a collaboration with Prof. Nassir Navab from the Technical University of Munich concerning the joint supervision of Pierre Chatelain's Ph.D. (see Section 7.3.2).

### 9.4.3. *Participation in International Programs*

The Lagadic group is one of the few external partners of the Australian Center for Robotic Vision (see <http://roboticvision.org>). It groups QUT in Brisbane, ANU in Canberra, Monash University and Adelaide University. In the scope of this project, Peter Corke and Ben Upcroft spent a short visit in May 2016 while Jurgen Leitner spent a 1-month visit in October 2016.

## 9.5. International Research Visitors

### 9.5.1. *Visits of International Scientists*

- Nicolas Alt, senior researcher at Technical University of Munich (TUM) was a visiting scientist at Sophia Antipolis from Jan until Feb 2016. He worked on visuo-haptic environment perception.
- Alejandro Perez Yus, Ph.D. student at Universidad de Zaragoza, spent a 3-month visit in Sophia Antipolis from Sep until Nov 2016. He worked on the calibration of multi-camera RGB-D systems.
- Prof. Denis Wolf, associate professor at Univ. Sao Paulo, Brasil, spends a sabbatical year in Sophia Antipolis from Jul 2016 to Aug 2017. He works on semantic learning applied to intelligent vehicles.
- Nicola Battilani, Ph.D. student at University of Modena and Reggio Emilia, spent a 6-month visit in Rennes from May until Oct 2016. He worked on shared control algorithms for optimal 3D reconstruction from vision.
- Prof. Volkan Isler from University of Minnesota, Phillip Schmidt, Ph.D. student from DLR, Prof. Ivan Petrovic from Univ. of Zagreb, Prof. Purang Abolmaesumi from Univ. of British Columbia, Prof. Nassir Navab from Technical University of Munich, and Prof. Russ Taylor from John Hopkins University spent a short visit in the group in 2016.

## STARS Project-Team

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

### 8.1.1. ANR

#### 8.1.1.1. MOVEMENT

Program: ANR CSOSG

Project acronym: MOVEMENT

Project title: AutoMatic BiOmetric Verification and PersonnEl Tracking for SeaMless Airport ArEas Security MaNagement

Duration: January 2014-June 2017

Coordinator: MORPHO (FR)

Other partners: SAGEM (FR), Inria Sophia-Antipolis (FR), EGIDIUM (FR), EVITECH (FR) and CERAPS (FR)

Abstract: MOVEMENT is focusing on the management of security zones in the non public airport areas. These areas, with a restricted access, are dedicated to service activities such as maintenance, aircraft ground handling, airfreight activities, etc. In these areas, personnel movements tracking and traceability have to be improved in order to facilitate their passage through the different areas, while insuring a high level of security to prevent any unauthorized access. MOVEMENT aims at proposing a new concept for the airport's non public security zones (e.g. customs control rooms or luggage loading/unloading areas) management along with the development of an innovative supervision system prototype.

#### 8.1.1.2. SafEE

Program: ANR TESCOAN

Project acronym: SafEE

Project title: Safe & Easy Environment for Alzheimer Disease and related disorders

Duration: December 2013-May 2017

Coordinator: CHU Nice

Other partners: Nice Hospital(FR), Nice University (CobTeck FR), Inria Sophia-Antipolis (FR), Aromatherapeutics (FR), SolarGames(FR), Taichung Veterans General Hospital TVGH (TW), NCKU Hospital(TW), SMILE Lab at National Cheng Kung University NCKU (TW), BDE (TW)

Abstract: SafEE project aims at investigating technologies for stimulation and intervention for Alzheimer patients. More precisely, the main goals are: (1) to focus on specific clinical targets in three domains behavior, motricity and cognition (2) to merge assessment and non pharmacological help/intervention and (3) to propose easy ICT device solutions for the end users. In this project, experimental studies will be conducted both in France (at Hospital and Nursery Home) and in Taiwan.

### 8.1.2. FUI

#### 8.1.2.1. Visionum

Program: FUI

Project acronym: Visionum

Project title: Visonium.

Duration: January 2015- December 2018

Coordinator: Groupe Genious

Other partners: Inria(Stars), StreetLab, Fondation Ophthalmologique Rothschild, Fondation Hospitaliere Sainte-Marie.

Abstract: This French project from Industry Minister aims at designing a platform to re-educate at home people with visual impairment.

## **8.2. European Initiatives**

### **8.2.1. FP7 & H2020 Projects**

#### *8.2.1.1. CENTAUR*

Title: Crowded ENvironments moniToring for Activity Understanding and Recognition

Programm: FP7

Duration: January 2013 - December 2016

Coordinator: Honeywell

Partners:

Ecole Polytechnique Federale de Lausanne (Switzerland)

"honeywell, Spol. S.R.O" (Czech Republic)

Neovision Sro (Czech Republic)

Queen Mary University of London (United Kingdom)

Inria contact: François Bremond

'We aim to develop a network of scientific excellence addressing research topics in computer vision and advancing the state of the art in video surveillance. The cross fertilization of ideas and technology between academia, research institutions and industry will lay the foundations to new methodologies and commercial solutions for monitoring crowded scenes. Research activities will be driven by specific sets of scenarios, requirements and datasets that reflect security operators' needs for guaranteeing the safety of EU citizens. CENTAUR gives a unique opportunity to academia to be exposed to real life dataset, while enabling the validation of state-of-the-art video surveillance methodology developed at academia on data that illustrate real operational scenarios. The research agenda is motivated by ongoing advanced research activities in the participating entities. With Honeywell as a multi-industry partner, with security technologies developed and deployed in both its Automation and Control Solutions and Aerospace businesses, we have multiple global channels to exploit the developed technologies. With Neovision as a SME, we address small fast paced local markets, where the quick assimilation of new technologies is crucial. Three thrusts identified will enable the monitoring of crowded scenes, each led by an academic partner in collaboration with scientists from Honeywell: a) multi camera, multicoverage tracking of objects of interest, b) Anomaly detection and fusion of multimodal sensors, c) activity recognition and behavior analysis in crowded environments. We expect a long term impact on the field of video surveillance by: contributions to the state-of-the-art in the field, dissemination of results within the scientific and practitioners community, and establishing long term scientific exchanges between academia and industry, for a forum of scientific and industrial partners to collaborate on addressing technical challenges faced by scientists and the industry.'

## **8.3. International Initiatives**

### **8.3.1. Inria International Labs**

#### *8.3.1.1. Informal International Partners*

- **Collaborations with Asia:** Stars has been cooperating with the Multimedia Research Center in Hanoi MICA on semantics extraction from multimedia data. Stars also collaborates with the National Cheng Kung University in Taiwan and I2R in Singapore.
- **Collaboration with U.S.A.:** Stars collaborates with the University of Southern California.
- **Collaboration with Europe:** Stars collaborates with Multitel in Belgium, the University of Kingston upon Thames UK, and the University of Bergen in Norway.

#### 8.3.1.2. Other IIL projects

The ANR SafEE (see section 8.1.1.2 ) collaborates with international partners such as Taichung Veterans General Hospital TVGH (TW), NCKU Hospital(TW), SMILE Lab at National Cheng Kung University NCKU (TW) and BDE (TW).

## 8.4. International Research Visitors

### 8.4.1. Visits of International Scientists

This year, Stars has been visited by the following international scientists:

- Salwa Baabou, Ecole Nationale d'Ingénieurs de Gabès, Tunisia;
- Siyuan Chen, University of New South Wales, Australia;
- Adlen Kerboua, University of Skikda, Algeria;
- Karel Krehnac, Neovision, Praha, Czech Republic;
- Jana Trojnova, Honeywell, Praha, Czech Republic;
- Luis Emiliano Sanchez, Rosario University, Argentina.

#### 8.4.1.1. Internships

Seongro Yoon

Date: Apr 2016-Dec 2016

Institution: Korea Advanced Institute of Science and Technology, Daejeon, Korea

Supervisor: François Brémond

Yashas Annadani

Date: May 2016-June 2016

Institution: National Institute Of Technology Karnataka, India

Supervisor: Carlos Fernando Crispim Junior

Chandraja Dharmana

Date: May 2016-June 2016

Institution: Birla Institute of Technology and Science, Pilani, Hyderabad

Supervisor: Carlos Fernando Crispim Junior

Shanu Vashistha

Date: May 2016-June 2016

Institution: Indian Institute of Technology, Kanpur, India

Supervisor: Carlos Fernando Crispim Junior

Nairouz Mrabah

Date: Apr 2016-Sep 2016

Institution: National School of Computer Science (ENSI), Tunisia

Supervisor: Inès Sarray

Isabel Rayas

Date: June 2016-Dec 2016

Institution: Massachusetts Institute of Technology, USA

Supervisor: Farhood Negin

## TITANE Project-Team

# 9. Partnerships and Cooperations

## 9.1. European Initiatives

### 9.1.1. FP7 & H2020 Projects

#### 9.1.1.1. TITANIUM - Software Components for Robust Geometry Processing

Type: IDEAS

Instrument: ERC Proof of concept

Duration: 18 months

Coordinator: Pierre Alliez

Inria contact: Pierre Alliez

Abstract: The TITANIUM project aims to develop a software demonstrator for geometry processing and 3D urban modeling, in order to facilitate the pre-commercialization of novel software components for the Computational Geometry Algorithms Library. The demonstrator will include novel approaches resulting from the ERC-funded IRON project (Robust Geometry Processing, StG-2010-257474), which are illustrated by publications presented at premier conferences in our field and a patent submitted in 2015. The expected outcomes of TITANIUM will be versatile methods for 3D reconstruction and simplification of data gathered from geometric measurements, as well as related methods specifically tailored to urban modeling. These methods represent a significant step forward by offering unrivaled levels of robustness, and automated generation of levels of detail that are semantically meaningful. The acronym TITANIUM, a robust and lightweight material, conveys our wish to streamline the geometric modeling pipeline through robust algorithms and lightweight representations. This Proof of Concept project will also implement the steps required for pre-commercialization. In view of this goal, we have included an industrial partner, GeometryFactory, a spinoff from Inria. We have already established preliminary contacts in the fields of metrology and geographic information systems. These contacts will provide real-world industrial case studies.

## 9.2. International Initiatives

### 9.2.1. Inria International Partners

#### 9.2.1.1. Declared Inria International Partners

We have a long standing collaboration with Prof. Mathieu Desbrun from Caltech.

#### 9.2.1.2. Informal International Partners

We collaborate with researchers from RWTH Aachen.

## 9.3. International Research Visitors

### 9.3.1. Visits of International Scientists

Prof. Mathieu Desbrun visited us for 3 months between August and November, within the framework of the Inria international chair.

#### 9.3.1.1. Internships

Chunlin Xiao (University of Nice Sophia-Antipolis and University of L'Aquila): large-scale remote sensing image segmentation and classification.

## WIMMICS Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. SPARKS Team (I3S)

Wimmics is member of the I3S SPARKS team (Scalable and Pervasive softwARe and Knowledge Systems). It is structured according to three axes: FORUM, ELK and S3.

#### 9.1.1.1. SPARKS ELK Axis

Wimmics contributes to the SPARKS ELK research axis (Knowledge Extraction and Learning). Andrea Tettamanzi is co-animator of this axis together with Frédéric Precioso (I3S).

#### 9.1.1.2. SPARKS FORUM Axis

Wimmics contributes to the SPARKS FORUM research axis (FORMalizing with Users and Models). Catherine Faron-Zucker and Alain Giboin are co-animators of FORUM. This year, three seminars were organized: (1) Visualisation des données liées (Emilie Palagi, Erwan Demairy, Raphaël Boyer, Olivier Corby); (2) Agents BDI possibilistes (Célia Da Costa-Pereira, Serena Villata, Andrea Tettamanzi); (3) Adaptation Dynamique : des processus métiers à l'environnement opérationnel. Application à la continuité de services ambiants (Jean-Yves Tigli, Isabelle Mirbel).

#### 9.1.1.3. SPARKS S3 Axis

Wimmics contributes to the SPARKS S3 research group (Scalable Software Systems). Olivier Corby, Fuqi Song and Erwan Demairy contribute with federated distributed query processing in Corese with Johan Montagnat and Abdoul Macina. Catherine Faron-Zucker and Franck Michel contribute on it with Johan Montagnat on heterogeneous databases federation.

#### 9.1.1.4. SPARKS HCI Group

The HCI Group brings together researchers from the SPARKS team conducting or wishing to conduct research related to Human-Computer Interaction. The group specifically addresses the issues of how to conduct user experiments to evaluate the UIs of the software developed in GLC. The group establishes collaborations between researchers in the design and implementation of experiments. The HCI group is animated by Anne-Marie Dery (I3S).

#### 9.1.1.5. MSHS Axis-2: ICT, Usage and Communities

**Participants:** Alain Giboin, Alexandre Monnin, Fabien Gandon, Emilie Palagi.

Axis-2 of the *Maison des Sciences Humaines et Sociales (MSHS) du Sud-Est (Nice)* aims to federate interdisciplinary research on the relationships between ICT, Practices and Communities. Wimmics is mainly involved in one of the Axis-2 groups-projects, "Artifacts and Coordination." This group-project studies the impact of cognitive technologies on the social and cognitive coordination between individuals in organizational and community contexts. Alain Giboin is member of the Axis-2 scientific committee and co-animator (with Lise Arena, GREDEG, until September 2016; and Evelyne Roubey, GREDEG, from October 2016) of the "Artifacts and Coordination" group-project. He is also co-animator (with Pierre Thérouanne (Lapcos), Lise Arena and Agnès Festré (GREDEG)) of the project "Acceptability of digital devices: an interdisciplinary perspective". This group is animated by Alain Giboin, Alexandre Monnin, Fabien Gandon and Emilie Palagi.

### 9.1.2. TCP-IP + Blockchain UCA Idex Submission

**Participant:** Alexandre Monnin.

We submitted a project proposal around the "TCP-IP + Blockchain (Transdisciplinary Collaborative Platform for Internet of things and Platformcooperativism)" platform, launched and coordinated by Alexandre Monnin inside the UCA Jedi Idex (Wimmics, LEAT, Aoste, Indes, I3S, GREDEG, LAPCOS, SKEMA, Sustainable Design School, Villa Arson, module D, club Cap EF, SCITIAM, Fabrique des Mobilités, Mnémotix, etc.). A host of projects were submitted inside this platform:

- ACCEPT by Lise Arena and Alain Giboin (Idex Academy 5)
- SMART by François Verdier (Idex Academy 1)
- Polisthelia by Alexandre Monnin (ANR, PCRI with Luxemburg)
- SMARTIOT by François Verdier (ANR project on Smart Contracts)

among which ValueModels submitted by Alexandre Monnin (Idex Academy 1) was accepted.

## 9.2. National Initiatives

### 9.2.1. *NiceCampus Research Lab*

**Participant:** Nhan Le Thanh.

NiceCampus Research Lab (from training to/and through research to a Joint International Laboratory) is a framework for cooperation for research training. This framework is proposed by the University of Nice Sophia Antipolis to support the 911 Vietnamese research training program that aims to support the development of Vietnamese universities. The NiceCampus Lab Project was a winner of the AUF Call for Proposals 2016-2017. In this context, the MIRE (Maison de l'innovation et de la recherche NiceCampus) was created at University of Da Nang (Vietnam).

### 9.2.2. *DILPROSPECT*

**Participant:** Andrea Tettamanzi.

We participated in the interdisciplinary DILPROSPECT CNRS Project, with researchers of many other research units, including the UMR 7300 ESPACE and INRA on the study of the interface between constructed and natural land on the French Riviera.

### 9.2.3. *AZKAR*

**Participants:** Alain Giboin, Thierry Bergeron, Michel Buffa, Catherine Faron-Zucker.

AZKAR is a two years French project funded by BPI (Banque Publique d'Investissement), focused on *Fast Control of Mobile Robots over the Internet*.

The project started in September 2014. The first step of the project has been the evaluation and benchmarking of video and data solutions over Internet, based on the WebRTC technology. The second step consists in implementing these solutions on a real mobile robot that has been deployed in museums or in homes for helping seniors in their daily tasks. Semantic Web technologies, have been used in the project for describing the services, the context of the application domain, the content transmitted, etc. We got a best demo award at ISWC this year, for a demo that shown a robot located in France that has been remote controlled from Kobe in Japan during the conference [32].

### 9.2.4. *ANR WASABI*

**Participants:** Michel Buffa, Elena Cabrio.

We will be project leader of this 42 month ANR project that starts in January 2017. Partners are IRCAM, Deezer, Radio France and a french startup named Parisson. WASABI aims to build the biggest song metadata semantic database, mixing audio and cultural content analysis. Client applications target music school, sound engineer schools, composers and musicians, journalists, radios and streaming services.

### 9.2.5. ANR LabCom SMILK

**Participants:** Elena Cabrio, Catherine Faron-Zucker, Fabien Gandon, Zide Meng, Oscar Rodríguez Rocha, Molka Tounsi.

SMILK (Social Media Intelligence and Linked Knowledge) is a joint laboratory (LabCom, 2013-2016) between the Wimmics team and the Research and Innovation unit of VISEO (Grenoble). Natural Language Processing, Linked Open Data and Social Networks as well as the links between them are at the core of this LabCom. The purpose of SMILK is both to develop research and technologies in order to retrieve, analyze, and reason on textual data coming from Web sources, and to make use of LOD, social networks structures and interaction in order to improve the analysis and understanding of textual resources. Topics covered by SMILK include: use of data and vocabularies published on the Web in order to search, analyze, disambiguate and structure textual knowledge in a smart way, but also to feed internal information sources; reasoning on the combination of internal and public data and schemes, query and presentation of data and inferences in natural formats.

### 9.2.6. Inria LabCom EduMICS

**Participants:** Catherine Faron-Zucker, Fabien Gandon, Chihabeddine Bouchenaki, Olivier Corby.

EduMICS (Educative Models Interactions Communities with Semantics) is a joint laboratory (LabCom, 2016-2018) between the Wimmics team and the Educlaver company. Adaptive Learning, Social Learning and Linked Open Data and links between them are at the core of this LabCom. The purpose of EduMICS is both to develop research and technologies with the ultimate goal to adapt educational progressions and pedagogical resource recommendation to learner profiles. Topics covered by EduMICS include: ontology-based modeling of educational resources; ontology-based integration of heterogenous data sources; ontology-based reasoning; semantic analysis of a social network of learners; pedagogical resource recommendation adapted to learner profiles.

### 9.2.7. Ministry of Culture: DBpedia.fr

**Participants:** Raphaël Boyer, Fabien Gandon.

This DBpedia.fr project proposes the creation of a French chapter of the DBpedia database. This project was the first project of the Semanticpedia convention signed by the Ministry of Culture, the Wikimedia foundation and Inria.

Web site: <http://dbpedia.fr>

### 9.2.8. Ministry of Culture: GT 6 for a convention between Inria and the Ministry of Culture

**Participant:** Fabien Gandon.

We supervised the working group GT6 Ministry of Culture on the creation of a research convention to foster research and development at the crossroad of culture and digital sciences. This convention signed between Inria and the Ministry of Culture the 12 December 2016 will provide a framework to support projects at the cross-road of the cultural domain and the digital sciences.

### 9.2.9. ANR OCKTOPUS

**Participants:** Fabien Gandon, Catherine Faron-Zucker, Zide Meng.

OCKTOPUS is an ANR project (2012-2016) which ended during this year. Its general objective was to increase the potential social and economic benefit of the large and quickly growing amounts of user-generated content, by transforming it into useful knowledge. We showed how it is possible to considerably improve upon existing generic Information Retrieval techniques by exploiting the specific structure of this content and of the online communities which produce it. Specifically, we focused on a multi-disciplinary approach in order to address the problem of finding relevant answers to questions within forums and question-answer sites. To create metrics and predictors of content quality and use them to improve the search experience of a user, we took advantage of:



- the experience of the CRG (the management research institute of Ecole Polytechnique and CNRS) to understand better the incentives of, and interactions between individuals who produce online content within large communities;
- the experience of the Wimmics research team to analyze the structural and temporal aspects of the complex typed social graphs found within these communities;
- the ability of Alcméon (a start-up developing a search application dedicated to user-generated content) to integrate and test the results of OCKTOPUS within a common demonstration framework, in order to assess their practical usefulness when applied to concrete large-scale datasets.

Partners: Alcméon, CRG, Inria Wimmics.

Web site: <http://ocktopus.alcmeon.com>

### 9.2.10. GDRI Zoomathia

**Participants:** Olivier Corby, Catherine Faron-Zucker, Alexandre Monnin, Andrea Tettamanzi.

Wimmics is partner of the International Research Group (GDRI) Zoomathia funded by two CNRS institutes: INEE and INSHS. It aims at studying transmission of zoological knowledge from Antiquity to Middle-Age through material resources (bio residues, artefacts), iconography and texts.

One of the goals of the project is to design a thesaurus and semantically annotate resources, capturing different types of knowledge: zoonyme, historical period, zoological speciality (ethology, anatomy, physiology, psychology, zootechnique, etc.), literary genre or iconography.

We collaboratively work with MNHN and CEPAM researchers on the construction of a SKOS thesaurus of zoonyms and a SKOS thesaurus of animal specialties the automatic and on the automatic semantic categorization of text fragments. The ultimate goal is the exploitation of these semantic metadata to help historians in their studies of knowledge transmission through these texts.

Web site: <http://www.cepam.cnrs.fr/zoomathia/>

### 9.2.11. FUI PadDOC

**Participants:** Patrice Pena, Alain Giboin.

PadDOC goal is to contribute to accelerating the digital transition of citizen, local and regional authorities, administrations and enterprises, by : (1) developing an open standard and innovative software and hardware resources to facilitate nearby or distant administrative formalities and procedures; (2) improving the security of the holder's personal data by putting these data under the exclusive control of the holder; (3) by exploiting unmarked communicating supports (such as smartphones or tablets) for all chain actors. PadDOC partners are: Docapost BPO, Anyces, ABC SmartCard and the teams Rainbow, Media-Coding and Wimmics. Wimmics will contribute to: (1) the analysis, design and evaluation of the PadDOC security-oriented user interfaces; (2) the impact assessment of the chain of actors participating in the experiment to validate the viability of the PadDOC social system. The PadDOC project officially began in November 2014.

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

#### 9.3.1.1. MIREL RISE

**Participants:** Serena Villata, Elena Cabrio, Oscar Rodríguez Rocha, Raphaël Gazzotti, Fabien Gandon.

Program: Research and Innovation Staff Exchange (RISE) project, funding under Marie Skłodowska-Curie grant.

Project acronym: MIREL

Project title: MIning and REasoning with legal text

Duration: 2016-2019

Coordinator: Leendert van der Torre, University of Luxembourg

Other partners: University of Bologna (Italy), University of Torino (Italy), University of Huddersfield (UK), Inria (France), APIS (Bulgaria), Nomotika s.r.l. (Italy), DLVSystem s.r.l. (Italy), Zhejiang University (China), Research Organization of Information and Systems (Japan), University of Cape Town (South Africa), National University of La Plata (Argentina), National University of Córdoba (Argentina), Universidad Nacional del Sur in Bahía Blanca (Argentina), National ICT Australia Ltd (Australia), Stanford University (USA).

Abstract: The MIREL project will create an international and inter-sectorial network to define a formal framework and to develop tools for Mining and Reasoning with Legal texts, with the aim of translating these legal texts into formal representations that can be used for querying norms, compliance checking, and decision support. MIREL addresses both conceptual challenges, such as the role of legal interpretation in mining and reasoning, and computational challenges, such as the handling of big legal data, and the complexity of regulatory compliance. It bridges the gap between the community working on legal ontologies and NLP parsers and the community working on reasoning methods and formal logic. Moreover, it is the first project of its kind to involve industrial partners in the future development of innovative products and services in legal reasoning and their deployment in the market. MIREL promotes mobility and staff exchange between SMEs to academies in order to create an inter-continental interdisciplinary consortium in Law and Artificial Intelligence areas including Natural Language Processing, Computational Ontologies, Argumentation, and Logic & Reasoning.

Web site: <http://www.mirelproject.eu/>

#### 9.3.1.2. ALOOF CHIST-ERA

**Participants:** Valerio Basile, Elena Cabrio, Fabien Gandon.

ALOOF (Autonomous Learning of the Meaning of Objects) is a European project (CHIST-ERA 2015-2018) to enable robots to use the ever-growing amount of knowledge available on the Web, by learning from there about the meaning of previously unseen objects, expressed in a form that makes them applicable when acting in situated environments. Partners include: University of Rome La Sapienza (Italy), University of Birmingham (United Kingdom), Technische Universität Wien (Austria), Inria Sophia Antipolis Méditerranée (France).

Web site: <https://project.inria.fr/aloof/>

## 9.4. International Initiatives

### 9.4.1. MoReWAIS

**Participants:** Papa Fary Diallo, Mahamadou Toure, Olivier Corby, Isabelle Mirbel, Fabien Gandon.

Title: Mobile Read Write Access and Intermittent to Semantic Web

International Partner (Institution - Laboratory - Researcher):

UGB (Senegal) - LANI - Moussa Lo, Seydina Ndiaye

Start year: 2016

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

MoReWAIS proposes to explore the specificities (advantages and constraints) of mobile knowledge sharing. The mobile application targeted in MoReWAIS must allow communities and their users to enrich and access more easily the knowledge base using the user's context with its richness (e.g. location, other users close-by) and addressing its limitations (e.g. intermittent access, limited resources).

We will design and develop algorithms, methods and tools for mobile devices allowing users to:

- co-construct locally and on the road the Semantic Web of Data RDF triple stores representing the sociocultural shared knowledge.
- Access and visualize in context relevant data from the knowledge platform. This requires a complete rethinking of RDF storage and SPARQL querying in a mobile and unreliable network environment. This will also require dedicated interaction design to ease and encourage access and contribution.

#### **9.4.2. SEEMPAD**

Title: Social Exchanges and Emotions in Mediated Polemics - Analysis and Data

International Partner (Institution - Laboratory - Researcher):

University of Montréal (Canada) - Higher Educational Research ON tutoring systems (Heron) - Claude Frasson

Start year: 2014

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

Generating, annotating and analyzing a dataset that documents a debate. We aim at synchronizing several dimensions: social links (intensity, alliances, etc.); interactions happening (who talks to whom); textual content of the exchanged messages; social-based semantic relations among the arguments; emotions, polarity, opinions detected from the text; emotions, physical state detected from sensors.

## **9.5. International Research Visitors**

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

#### *9.5.1.1. Internships*

Hatim Aouzal

Date: May – September

Institution: MIAGE UNS & EMSI Casablanca, Morocco

Title: Intelligent System for Mobile Robot Museum Visit.

Supervisor: Michel Buffa

Lautaro Petaccio

Date: July – December

Institution: Universidad de Buenos Aires (Argentina)

Title: Design and development of a Fact-Checking Framework Based on Argumentation Theory and Natural Language Processing Techniques.

Supervisors: Elena Cabrio, Serena Villata

Konstantina Poulida

Date: until January

Institution: University of Patras, Computer Engineering and Informatics Department

Title: Semantic Categorization of Segments of Ancient and Mediaeval Zoological Texts

Supervisors: Catherine Faron-Zucker, Andrea Tettamanzi

Avijit Shah

Date: September – December

Institution: NITK, National Institute of Technology Karnataka, Surathkal (India).

Title: Bootstrapping the Construction of a Knowledge Base of Objects

Supervisors: Valerio Basile and Elena Cabrio

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

### *9.5.2.1. Research Stays Abroad*

Tuan Anh Pham

Date: October 2016 to July 2017.

Erasmus Mundus Scholarship Exchange at University of Danang, Vietnam for 7 months to deploy the result of the PhD in a common project with UNS.

Serena Villata

Date: February-March.

Visit of the Nomotika startup in Turin, Italia, for two months as a secondment of the MIREL H2020 Project.

Topic: This secondment was in the context of WP2, and more specifically it addressed Task 2.2 (Develop NLP systems for mining named entities and concepts, in order to populate the ontology). Serena Villata worked in the past on the topic of ontology-based information extraction from licensing information applying machine learning techniques. The results of her work have been exploited to define the two tools called NLL2RDF<sup>0</sup> and Licentia<sup>0</sup>.

During this secondment, she studied together with the Nomotika personnel how to generalize the approach proposed in NLL2RDF and Licentia in such a way that this kind of processing is applicable to legal texts in general, and not only to licenses. More precisely, the collaboration has been concentrated on the investigation of the following open issues: (i) find and refine (if needed) existing computational ontologies for normative reasoning, and (ii) mine legal texts to extract the main deontic components (i.e., obligations, permissions, and prohibitions) and returning a machine-readable semantic representation of such information extracted from the texts exploiting a distributional semantics approach where the meaning of a word is represented by the set of contexts in which it occurs in texts. The collaboration is still ongoing and results are expected soon (i.e., publications).

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<sup>0</sup><http://www.airpedia.org/nll2rdf/>

<sup>0</sup><http://licentia.inria.fr/>

## ZENITH Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. Labex NUMEV, Montpellier

URL: <http://www.lirmm.fr/numev>

We participate in the Laboratory of Excellence (labex) NUMEV (Digital and Hardware Solutions, Modelling for the Environment and Life Sciences) headed by University of Montpellier in partnership with CNRS, and Inria. NUMEV seeks to harmonize the approaches of hard sciences and life and environmental sciences in order to pave the way for an emerging interdisciplinary group with an international profile. The project is decomposed in four complementary research themes: Modeling, Algorithms and computation, Scientific data (processing, integration, security), Model-Systems and measurements. Florent Masegla co-heads the theme on scientific data.

### 9.1.2. Institute of Computational Biology (IBC), Montpellier

URL: <http://www.ibr-montpellier.fr>

IBC is a 5 year project (2012-2017) with a funding of 2Meuros by the MENRT (PIA program) to develop innovative methods and software to integrate and analyze biological data at large scale in health, agronomy and environment. Patrick Valduriez heads the workpackage on integration of biological data and knowledge.

## 9.2. National Initiatives

### 9.2.1. PIA (*Projets Investissements d'Avenir*)

#### 9.2.1.1. PIA Floris'Tic (2015-2018), 430Keuro.

**Participants:** Julien Champ, Alexis Joly.

Floris'tic aims at promoting the scientific and technical culture of plant sciences through innovative pedagogic methods, including participatory initiatives and the use of IT tools such as the one built within the PI@ntNet project. A. Joly heads the work package on the development of the IT tools. This is a joint project with the AMAP laboratory, the TelaBotanica social network and the Agropolis foundation.

#### 9.2.2. Others

##### 9.2.2.1. CIFRE INA/Inria (2013-2016), 100Keuros

**Participants:** Alexis Joly, Valentin Leveau, Patrick Valduriez.

This contract with INA allows funding a 3-years PhD (Valentin Leveau). This PhD addresses research challenges related to large-scale supervised content-based retrieval in distributed environments.

##### 9.2.2.2. INRA/Inria PhD program, 100Keuros

**Participant:** Alexis Joly.

This contract between INRA and Inria allows funding a 3-years PhD student (Christophe Botella). The addressed challenge is the large-scale analysis of PI@ntNet data with the objective to model species distribution (a big data approach to species distribution modeling). The PhD student is supervised by Alexis Joly with François Munoz (ecologist, IRD) and Pascal Monestiez (statistician, INRA).

## 9.3. European Initiatives

### 9.3.1. FP7 Projects

#### 9.3.1.1. CoherentPaaS

**Participants:** Carlyna Bondiombouy, Boyan Kolev, Oleksandra Levchenko, Patrick Valduriez.

Project title: A Coherent and Rich Platform as a Service with a Common Programming Model

Instrument: Integrated Project

Duration: 2013 - 2016

Total funding: 5 Meuros (Zenith: 500Keuros)

Coordinator: U. Madrid, Spain

Partner: FORTH (Greece), ICCS (Greece), INESC (Portugal) and the companies MonetDB (Netherlands), QuartetFS (France), Sparsity (Spain), Neurocom (Greece), Portugal Telecom (Portugal).

Inria contact: Patrick Valduriez

CoherentPaaS has been developing a PaaS that incorporates a rich and diverse set of cloud data management technologies, including NoSQL data stores, such as key-value data stores and graph databases, SQL data stores, such as in-memory and column-oriented databases, hybrid systems, such as SQL engines on top on key-value data stores, and complex event processing data management systems. It uses a common query language to unify the programming models of all systems under a single paradigm and provides holistic coherence across data stores using a scalable, transactional management system. CoherentPaaS will dramatically reduce the effort required to build and the quality of the resulting cloud applications using multiple cloud data management technologies via a single query language, a uniform programming model, and ACID-based global transactional semantics. CoherentPaaS will design and build a working prototype and will validate the proposed technology with real-life use cases. In this project, Zenith is in charge of designing the CloudMdsQL language and implementing its compiler/optimizer and query engine.

#### 9.3.1.2. HPC4E

**Participants:** Reza Akbarinia, Florent Maseglia, Esther Pacitti, Patrick Valduriez.

Project title: High Performance Computing for Energy

Instrument: H2020

Duration: 2015 - 2017

Total funding: 2 Meuros

Coordinator: Barcelona Supercomputing Center (BSC), Spain

Partner: Europe: Inria, Lancaster University, Centro de Investigaciones Energéticas Medioambientales y Tecnológicas, Repsol S.A., Iberdrola Renovables Energía S.A., Total S.A. Brazil: COPPE/Universidade Federal de Rio de Janeiro, LNCC, Instituto Tecnológico de Aeronáutica (ITA), Universidade Federal do Rio Grande do Sul, Universidade Federal de Pernambuco, Petrobras.

Inria contact: Patrick Valduriez

The main objective is to develop high performance simulation tools that can help the energy industry to respond future energy demands and also to carbon-related environmental issues using HPC systems. The project also aims at improving the usage of energy using HPC tools by acting at many levels of the energy chain for different energy sources. Another objective is to improve the cooperation between energy industries from EU and Brazil. The project includes relevant energy industrial partners from Brazil (Petrobras) and EU (Repsol and Total as O&G industries), which benefit from the project's results. A last objective is to improve the cooperation between the leading research centres in EU and Brazil in HPC applied to energy. This includes sharing supercomputing infrastructures between Brazil and EU. In this project, Zenith is working on Big Data management and analysis of numerical simulations.

#### 9.3.1.3. CloudDBAppliance

**Participants:** Reza Akbarinia, Boyan Kolev, Florent Maseglia, Esther Pacitti, Patrick Valduriez.

Project title: CloudDBAppliance

Instrument: H2020

Duration: 2016 - 2019

Total funding: 5 Meuros (Zenith: 500Keuros)

Coordinator: Bull/Atos, France

Partner: Europe: Inria Zenith, U. Madrid, INESC and the companies LeanXcale, QuartetFS, Nordea, BTO, H3G, IKEA, CloudBiz, and Singular Logic.

Inria contact: Florent Masegla, Patrick Valduriez

The project aims at producing a European Cloud Database Appliance for providing a Database as a Service able to match the predictable performance, robustness and trustworthiness of on premise architectures such as those based on mainframes. The cloud database appliance features: (1) a scalable operational database able to process high update workloads such as the ones processed by banks or telcos, combined with a fast analytical engine able to answer analytical queries in an online manner; (2) an operational Hadoop data lake that integrates an operational database with Hadoop, so operational data is stored in Hadoop that will cover the needs from companies on big data; (3) a cloud hardware appliance leveraging the next generation of hardware to be produced by Bull, the main European hardware provider. This hardware is a scale-up hardware similar to the one of mainframes but with a more modern architecture. Both the operational database and the in-memory analytics engine will be optimized to fully exploit this hardware and deliver predictable performance. Additionally, CloudDBAppliance will tolerate catastrophic cloud data centres failures (e.g. a fire or natural disaster) providing data redundancy across cloud data centres. In this project, Zenith is in charge of designing and implementing the components for analytics and parallel query processing.

## 9.4. International Initiatives

### 9.4.1. MUSIC

Title: MUlTiSite Cloud (MUSIC) data management

Inria principal investigator: Esther Pacitti

International Partner):

Laboratorio Nacional de Computação Científica, Petropolis (Brazil) - Fabio Porto

Universidade Federal do Rio de Janeiro (Brazil) - Alvaro Coutinho and Marta Mattoso

Universidade Federal Fluminense, Niteroi (Brazil) - Daniel Oliveira

Centro Federal de Educa cao Tecnológica, Rio de Janeiro (Brazil) - Eduardo Ogasawara

Duration: 2014 - 2016

See also: <https://team.inria.fr/zenith/projects/international-projects/music/>

By centralizing all data in a large-scale data center, the cloud significantly simplifies the task of system administration. But for scientific data, where different organizations may have their own data centers, a distributed (multisite) cloud model where each site is visible from outside, is needed. The main objective of this research and scientific collaboration is to develop a multisite cloud architecture for managing and analyzing scientific data, including support for heterogeneous data; distributed scientific workflows, and complex big data analysis. The resulting architecture will enable scalable data management infrastructures that can be used to host a variety of scientific applications that benefit from computing, storage, and networking resources that span multiple data centers.

## **9.4.2. Inria International Partners**

### *9.4.2.1. Informal International Partners*

We have regular scientific relationships with research laboratories in

- North America: Univ. of Waterloo (Tamer Özsu), UCSB Santa Barbara (Divy Agrawal and Amr El Abbadi)
- Asia: National Univ. of Singapore (Beng Chin Ooi, Stéphane Bressan), Wonkwang University, Korea (Kwangjin Park)
- Europe: Univ. of Madrid (Ricardo Jiménez-Periz), UPC Barcelona (Josep Lluís Larriba Pey), HES-SO (Henning Müller), University of Catania (Concetto Spampinato), The Open University (Stefan Rüter)
- North Africa: Univ. of Tunis (Sadok Ben-Yahia)
- Australia: Australian National University (Peter Christen)
- Central America: Tecnológico de Costa-Rica (Erick Mata, former director of the US initiative Encyclopedia of Life)

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

We are involved in LifeCLEF lab, a self-organized research platform whose main mission is to promote research, innovation, and development of computer-assisted identification of living organisms. It was initiated by Alexis Joly in 2014 in collaboration with several European colleagues: Henning Müller (CH), Robert B Fisher (UK), Andreas Rauber (AU), Concetto Spampinato (IT), Hervé Glotin (FR). Each year, LifeCLEF releases large-scale experimental data covering tens of thousands of species (plants images, birds audio recordings and fish sub-marine videos). About 100-150 research groups register each year to get access to it and tens of them submit reports describing their conducted research (published in CEUR-WS proceedings). Results are then synthesized and further analyzed in joint research papers.

## **9.5. International Research Visitors**

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

Marta Mattoso (UFRJ, Brazil) gave a seminar on “Exploratory Analysis of Raw Data Files through Dataflows” in march.

Jose Mario Carranza Rojas (PhD student, Tecnológico de Costa-Rica) spent two days per week in the team in the context of a 4 months internship at the Montpellier research lab AMAP in the context of the Floris’Tic project).