



RESEARCH CENTER  
Saclay - Île-de-France

FIELD

# Activity Report 2017

## Section Partnerships and Cooperations

Edition: 2018-02-19



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## COMETE Project-Team

# 7. Partnerships and Cooperations

## 7.1. Regional Initiatives

### 7.1.1. OPTIMEC

Project title: Optimal Mechanisms for Privacy Protection

Funded by: DigiCosme

Duration: September 2016 - August 2019

Coordinator: Catuscia Palamidessi, Inria Saclay, EPI Comète

Other PI's: Serge Haddadm ENS Cachan.

Abstract: In this project we plan to investigate classes of utility and privacy measures, and to devise methods to obtain optimal mechanisms with respect to the trade-off between utility and privacy. In order to represent the probabilistic knowledge of the adversary and of the user, and the fact that mechanisms themselves can be randomized, we will consider a probabilistic setting. We will focus, in particular, on measures that are expressible as linear functions of the probabilities.

## 7.2. National Initiatives

### 7.2.1. REPAS

Program: ANR Blanc

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

Duration: October 2016 - September 2021

Coordinator: Catuscia Palamidessi, Inria Saclay, EPI Comète

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

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

## 7.3. International Initiatives

### 7.3.1. Inria Associate Teams

#### 7.3.1.1. LOGIS

Title: Logical and Formal Methods for Information Security

Inria principal investigator: Konstantinos Chatzikokolakis

International Partners:

Mitsuhiro Okada, Keio University (Japan)

Yusuke Kawamoto, AIST (Japan)

Tachio Terauchi, JAIST (Japan)

Masami Hagiya, University of Tokyo (Japan)

Start year: 2016

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

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

### **7.3.2. Inria International Partners**

#### **7.3.2.1. Informal International Partners**

Giovanni Cherubin, Royal Holloway, University of London, UK  
Geoffrey Smith, Florida International University, USA  
Carroll Morgan, NICTA , Australia  
Annabelle McIver, Maquarie University, Australia  
Moreno Falaschi, Professor, University of Siena, Italy  
Mario Ferreira Alvim Junior, Assistant Professor, Federal University of Minas Gerais, Brazil  
Camilo Rueda, Professor, Universidad Javeriana de Cali, Colombia  
Carlos Olarte, Universidade Federal do Rio Grande do Norte, Brazil  
Camilo Rocha, Associate Professor, Universidad Javeriana de Cali, Colombia

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

#### **7.3.3.1. CLASSIC**

Program: Colciencias - Conv. 712.  
Project acronym: CLASSIC.  
Project title: Concurrency, Logic and Algebra for Social and Spatial Interactive Computation.  
Duration: Oct 2016 - Oct 2019.  
URL: <http://goo.gl/Gv6Lij>  
Coordinator: Camilo Rueda, Universidad Javeriana de Cali, Colombia.  
Other PI's and partner institutions: Carlos Olarte, Universidade Federal do Rio Grande do Norte, Brazil. Frank Valencia, CNRS-LIX and Inria Saclay.  
Abstract: This project will advance the state of the art of domains such as mathematical logic, order theory and concurrency for reasoning about spatial and epistemic behaviour in multi-agent systems..

#### **7.3.3.2. EPIC**

Program: STIC-Amsud.  
Project acronym: EPIC.  
Project title: EPistemic Interactive Concurrency/  
Duration: Oct 2016 - Oct 2019.  
URL: <https://sites.google.com/site/sticamsudepic/>  
Coordinator: Frank Valencia, CNRS-LIX and Inria Saclay.  
Other PI's and partner institutions: Carlos Olarte, Universidade Federal do Rio Grande do Norte, Brazil. Camilo Rueda, Universidad Javeriana de Cali, Colombia.  
Abstract: The aim of the project is to coherently combine and advance the state of the art of domains such as concurrency theory, information theory and rewriting systems for reasoning about social networks.

## **7.4. International Research Visitors**

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

David de Frutos Escrig, Professor, Universidad Complutense Madrid, Spain. Jan-Feb 2017  
Giovanni Cherubin, PhD student, Royal Holloway, University of London, UK. May 2017 and Oct 2017  
Yusuke Kawamoto, Assistant Professor, National Institute of Advanced Industrial Science and Technology (AIST), Japan. July 2017 and Nov 2017  
Carlos Olarte, Assistant Professor, Universidade Federal do Rio Grande do Norte, Brazil. July 2017  
Camilo Rocha, Associate Professor, Universidad Javeriana de Cali, Colombia. Oct 2017  
Camilo Rueda, Professor, Universidad Javeriana de Cali, Colombia. Nov 2017  
Mario Ferreira Alvim Junior, Assistant Professor, Federal University of Minas Gerais, Brazil. Dec 2017

### **7.4.2. Internships**

Anna Pazii. Univ. of Kiev, Ukraine. From July 2016 until Jan 2017.  
Hector Delgado, Universidad Javeriana de Cali, Colombia. From May 2017 until July 2017.  
Marco Romanelli. Univ. of Siena, Italy. From June 2017 until Sept 2017.  
Georgi Dikov. Tech. Univ. of Munich, Germany. From Sept 2017 until Nov 2017.  
Joaquin Felici. Univ. of Cordoba, Argentina. From Sept 2017 until Jan 2018.  
Santiago Quintero, Universidad Javeriana de Cali, Colombia. From Nov until Dec 2017.

## DATASHAPE Project-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 from October 2013 to September 2017.
- 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. GUDHI

Title: Algorithmic Foundations of Geometry Understanding in Higher Dimensions

Programm: FP7

Type: ERC

Duration: February 2014 - January 2019

Coordinator: Inria

Inria contact: 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, Mathematical Sciences Publishers, Canada (June and November 2017)

Arijit Ghosh, Indian Statistical Institute, Kolkata (June and november 2017)

Kim Jisu, CMU, Pittsburgh, USA (November 2017).

Wolfgang Polonik, UC Davis, USA (June 2017).

Konstantin Mischaikow, Rutgers University, USA, (November 2017).

Magnus Botnan, TU Munich, Germany (March 2017).



Sara Kalisnik, MPI, Germany (November 2017).

*9.4.1.1. Internships*

Divyansh Pareek, IIT Bombay (May-July 2017)

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

*9.4.2.1. Research Stays Abroad*

Vincent Divol, UC Davis (April-June 2017)

## **DEDUCTEAM Project-Team**

## **7. Partnerships and Cooperations**

### **7.1. National Initiatives**

#### **7.1.1. ANR PROGRAMme**

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

### **7.2. International Initiatives**

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

##### **7.2.1.1. International Initiatives**

###### **FoQCoSS**

Title: Foundations of Quantum Computation: Syntax and Semantics

International Partners (Institution - Laboratory - Researcher):

Universidad Nacional de Quilmes (Argentina) - Alejandro Díaz-Caro

CNRS (France) - Simon Perdrix

Universidade Federal de Santa Maria (Brazil) - Juliana Kaizer Vizzotto

Duration: 2016 - 2017

Start year: 2016

The design of quantum programming languages involves the study of many characteristics of languages which can be seen as special cases of classical systems: parallelism, probabilistic systems, non-deterministic systems, type isomorphisms, etc. This project proposes to study some of these characteristics, which are involved in quantum programming languages, but also have a more immediate utility in the study of nowadays systems. In addition, from a more foundational point of view, we are interested in the implications of computer science principles for quantum physics. For example, the consequences of the Church-Turing thesis for Bell-like experiments: if some of the parties in a Bell-like experiment use a computer to decide which measurements to make, then the computational resources of an eavesdropper have to be limited in order to have a proper observation of non-locality. The final aim is to open a new direction in the search for a framework unifying computer science and quantum physics.

### **7.3. International Research Visitors**

#### **7.3.1. Visits of International Scientists**

A. Díaz-Caro (Universidad Nacional de Quilmes, Argentina) visited Deducteam 3 weeks.

#### **7.3.2. Visits to International Teams**

##### **7.3.2.1. Research Stays Abroad**

F. Thiré has visited the Computation and Logic Group at McGill University for three months.

G. Dowek has visited the university of Quilmes in Buenos Aires for two weeks.

G. Dowek has visited the Pontifical University at Rio for three weeks.

## GRACE Project-Team

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

### 8.1.1. ANR

MANTA (accepted July 2015, starting March 2016): “Curves, surfaces, codes and cryptography”. This project deals with applications of coding theory error correcting codes to in cryptography, multi-party computation, and complexity theory, using advanced topics in algebraic geometry and number theory. The kickoff was a one week-retreat in Dordogne (20 participants), and we had another four day meeting in Saclay in November 17. See <http://anr-manta.inria.fr/>.

## 8.2. European Initiatives

### 8.2.1. FP7 & H2020 Projects

#### 8.2.1.1. PQCRYPTO

Title: Post-quantum cryptography for long-term security

Programm: H2020

Duration: March 2015 - March 2018

Coordinator: TECHNISCHE UNIVERSITEIT EINDHOVEN

Partners:

Academia Sinica (Taiwan)

Bundesdruckerei (Germany)

Danmarks Tekniske Universitet (Denmark)

Katholieke Universiteit Leuven (Belgium)

Nxp Semiconductors Belgium Nv (Belgium)

Ruhr-Universitaet Bochum (Germany)

Stichting Katholieke Universiteit (Netherlands)

Coding Theory and Cryptology group, Technische Universiteit Eindhoven (Netherlands)

Technische Universitaet Darmstadt (Germany)

University of Haifa (Israel)

Inria contact: Nicolas Sendrier

Online security depends on a very few underlying cryptographic algorithms. Public-key algorithms are particularly crucial since they provide digital signatures and establish secure communication. Essentially all applications today are based on RSA or on the discrete-logarithm problem in finite fields or on elliptic curves. Cryptographers optimize parameter choices and implementation details for these systems and build protocols on top of these systems; cryptanalysts fine-tune attacks and establish exact security levels for these systems.

It might seem that having three systems offers enough variation, but these systems are all broken as soon as large quantum computers are built. The EU and governments around the world are investing heavily in building quantum computers; society needs to be prepared for the consequences, including cryptanalytic attacks accelerated by these computers. Long-term confidential documents such as patient health-care records and state secrets have to guarantee security for many years, but information encrypted today using RSA or elliptic curves and stored until quantum computers are available will then be as easy to decipher.

PQCRYPTO will allow users to switch to post-quantum cryptography: cryptographic systems that are not merely secure for today but that will also remain secure long-term against attacks by quantum computers. PQCRYPTO will design a portfolio of high-security post-quantum public-key systems, and will improve the speed of these systems, with reference implementations.

Our team is engaged in WP3.3 “advanced applications for the cloud”. We envision to focus essentially on secure multiparty computation, essentially the information theoretically secure constructions, who are naturally secure against a quantum computer invoked on classical queries. We will study whether these protocols still resist quantum queries. This work sub package started March 2015, and is dealt with by D. Augot.

## **8.3. International Initiatives**

### **8.3.1. Inria International Partners**

#### *8.3.1.1. Informal International Partners*

B. Smith has continued our successful informal partnership with the cryptography research group at Radboud University, Nijmegen (NL). 2017 has seen visits from researchers in both directions, and the production of the **qDSA** signature scheme package.

## **8.4. International Research Visitors**

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

Beth Malmskog (Colorado College) visited the team from November 27 to December 1 2017 and gave a talk on locally recoverable codes based on fibre products of algebraic curves.

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

#### *8.4.2.1. Research Stays Abroad*

B. Smith was an invited researcher in the Computer Science department at CINVESTAV (Mexico City, Mexico) for the month of August 2017, hosted by Professor Francisco Rodríguez Henríquez.

J. Lavauzelle visited Incidence Geometry team at Gent University (Belgium) for the month of April 2017, hosted by Professor Leo Storme.

E. Barelli visited the COMPUTE team in the DTU University at Lyngby (Danemark) during one month in february-march 2017, hosted by Professor Peter Beelen.

## MEXICO Project-Team

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

- Thomas Chatain, Stefan Haar , Serge Haddad and Stefan Schwoon are participating in the ANR Project **ALGORECELL**.
- Matthias Függer participates in the ANR project FREDDA.

## 8.2. International Initiatives

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

#### 8.2.1.1. LifeForm

Title: Life Sciences need formal Methods !

International Partner (Institution - Laboratory - Researcher):

Newcastle University (United Kingdom) - School of Computing Science - Victor Khomenko

Start year: 2016

See also: <http://projects.lsv.ens-cachan.fr/LifeForm/>

This project extends an existing cooperation between the MEXICO team and Newcastle University on partial-order based formal methods for concurrent systems. We enlarge the partnership to bioinformatics and synthetic biology. The proposal addresses challenges concerning formal specification, verification, monitoring and control of synthetic biological systems, with use cases conducted in the Center for Synthetic Biology and the Bioeconomy (CSBB) in Newcastle. A main challenge is to create a solid modelling framework based on Petri-net type models that allow for causality analysis and rapid state space exploration for verification, monitoring and control purposes; a potential extension to be investigated concerns the study of attractors and cell reprogramming in Systems Biology.

## 8.3. International Research Visitors

### 8.3.1. Visits of International Scientists

Joost-Pieter Katoen, Aachen, spent two weeks with MEXICO.

#### 8.3.1.1. Internships

Aalok Thakkar, 2nd year student from CMI (India), did a two-month research internship on 'Semantics of Mutation Dynamics' under the supervision of Stefan Haar, from May 2nd to July 21st, 2017.

### 8.3.2. Visits to International Teams

**PARSIFAL Project-Team**

## 7. Partnerships and Cooperations

### 7.1. European Initiatives

#### 7.1.1. FISP: ANR blanc International

**Participants:** Kaustuv Chaudhuri, François Lamarche, Sonia Marin, Dale Miller, Lutz Straßburger.

Title: The Fine Structure of Formal Proof Systems and their Computational Interpretations

Duration: 01/01/2016 – 31/10/2019

Partners:

University Paris VII, PPS (PI: Michel Parigot)

Inria Saclay-IdF, EPI Parsifal (PI: Lutz Straßburger)

University of Innsbruck, Computational Logic Group (PI: Georg Moser)

Vienna University of Technology, Theory and Logic Group (PI: Matthias Baaz)

Total funding by the ANR: 316 805 EUR

The FISP project is part of an ambitious, long-term project whose objective is to apply the powerful and promising techniques from structural proof theory to central problems in computer science for which they have not been used before, especially the understanding of the computational content of proofs, the extraction of programs from proofs and the logical control of refined computational operations. So far, the work done in the area of computational interpretations of logical systems is mainly based on the seminal work of Gentzen, who in the mid-thirties introduced the sequent calculus and natural deduction, along with the cut-elimination procedure. But that approach shows its limits when it comes to computational interpretations of classical logic or the modelling of parallel computing. The aim of our project, based on the complementary skills of the teams, is to overcome these limits. For instance, deep inference provides new properties, namely full symmetry and atomicity, which were not available until recently and opened new possibilities at the computing level, in the era of parallel and distributed computing.

#### 7.1.2. COCA HOLA: ANR JCJC Project

**Participant:** Beniamino Accattoli.

Title: COst model for Complexity Analyses of Higher-Order programming Languages.

Collaborators: Ugo Dal Lago (University of Bologna & Inria), Delia Kesner (Paris Diderot University), Damiano Mazza (CNRS & Paris 13 University), Claudio Sacerdoti Coen (University of Bologna).

Duration: 01/10/2016 – 31/09/2019

Total funding by the ANR: 155 280 EUR

The COCA HOLA project aims at developing complexity analyses of higher-order computations, i.e. that approach to computation where the inputs and outputs of a program are not simply numbers, strings, or compound data-types, but programs themselves. The focus is not on analysing 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. The problem is non-trivial because the evaluation of higher-order languages is defined abstractly, via high-level operations, leaving the implementation unspecified. Concretely, the project will analyse different implementation schemes, measuring precisely their computational complexity with respect to the number of high-level operations, and eventually develop more efficient new ones. The goal is to obtain a complexity-aware theory of implementations of higher-order languages with both theoretical and practical downfalls.

The project stems from recent advances on the theory of time cost models for the lambda-calculus, the computational model behind the higher-order approach, obtained by the principal investigator and his collaborators (who are included in the project).

COCA HOLA will span over three years and is organised around three work packages, essentially:

1. extending the current results to encompass realistic languages;
2. explore the gap between positive and negative results in the literature;
3. use ideas from linear logic to explore space cost models, about which almost nothing is known.

## 7.2. International Initiatives

### 7.2.1. Participation in Other International Programs

#### 7.2.1.1. PHC Amadeus: Analytic Calculi for Modal Logics

**Participants:** Kaustuv Chaudhuri, Sonia Marin, Giselle Reis, Lutz Straßburger.

Title: Analytic Calculi for Modal Logics

Duration: 01/01/2016 – 31/12/2017

Austrian Partner: TU Wien, Institute for Computer Science (Department III)

Modal logics are obtained from propositional logics by adding modalities  $\Box$  and  $\Diamond$ , meaning necessity and possibility. Originally studied by philosophers in order to reason about knowledge and belief, modal logics have nowadays many applications in computer science. Well known examples are epistemic logics, which allow to formally reason about the knowledge of independently acting and interacting agents, temporal logics, which allow to reason about temporal properties of processes, and authentication logics, which are used to formally reason about authentication protocols.

The purpose of this project is to develop a proof theory for variants of modal logic that have applications in modern computer science but that have been neglected by traditional proof theory so far.

## 7.3. International Research Visitors

### 7.3.1. Visits of International Scientists

#### 7.3.1.1. Internships

Riccardo Treglia was an intern funded by COCA HOLA during March, April, and May 2017. He was advised by Accattoli and worked on the complexity analysis of abstract machines for the  $\lambda$ -calculus.

### 7.3.2. Visits to International Teams

#### 7.3.2.1. Research Stays Abroad

Stéphane Graham-Lengrand spent 8 months, from January 2017 to August 2017, at SRI International, Computer Science Lab. This visit developed a collaboration with N. Shankar, MP Bonacina, and D. Jovanovic, on new algorithms and new architectures for automated and interactive theorem proving, as well as on new programme verification techniques.

## SPECFUN Project-Team

# 7. Partnerships and Cooperations

## 7.1. National Initiatives

### 7.1.1. ANR

**FastRelax** (ANR-14-CE25-0018). Goal: Develop computer-aided proofs of numerical values, with certified and reasonably tight error bounds, without sacrificing efficiency. Leader: B. Salvy (Inria, ENS Lyon). Participants: Assia Mahboubi, Th. Sibut-Pinote. Website: <http://fastrelax.gforge.inria.fr/>.

## 7.2. International Research Visitors

### 7.2.1. Visits of International Scientists

- Marni Mishna (Simon Fraser University) visited the team for one week in January.
- Emre Sertöz (Max Planck Institute Leipzig) visited the team for one week in November. He worked with Pierre Lairez on applications to algebraic geometry of two tools developed at Specfun: the computations of periods (Lairez's PhD) and numerical analytic continuation (Mezzarobba's PhD, 2011).
- Karen Yeats (Simon Fraser University) visited the team for a few days in June. She continued a work on bijective combinatorics of words with Frédéric Chyzak. A text is now under writing.

#### 7.2.1.1. Internships

- Pascal Fong did a Master internship from March to August. Under the supervision of Pierre Lairez and Mohab Safey El Din (UPMC), he studied the numerical computation of the length of plane algebraic curves.
- Rémy Garnier did a Master internship from March to July. Under the supervision of Alin Bostan and Frédéric Chyzak, he studied existing algorithms to solve linear differential systems for their rational-function solutions.
- Meissa M'baye did a Master internship from February to June. Under the remote supervision of Assia Mahboubi, he studied the principles of proof assistants and surveyed formalization methodologies for elementary number theory.

### 7.2.2. Visits to International Teams

- Frédéric Chyzak and Alin Bostan have been invited by the Erwin Schrödinger Institute (Vienna, Austria) for two weeks, to participate to the thematic program "Algorithmic and Enumerative Combinatorics" <http://www.mat.univie.ac.at/~kratt/esi4/>.
- Pierre Lairez visited Felipe Cucker (City University of Hong Kong) for two weeks. The outcome is a strengthened collaboration on the study of the complexity of numerical algorithms. A publication is in preparation: the second part of [10].
- Georges Gonthier was invited at the Newton Institute, for six weeks, as co-organiser and participant to the Big Proof thematic program.
- Assia Mahboubi visited Sander Dahmen (VU Amsterdam, The Netherlands) for three days. She has started a collaboration with his team, to obtain formal guarantees of computations for number theory.
- Assia Mahboubi has been invited by the Newton Institute (Cambridge, UK) for one month. She participated to the Big Proof thematic program.



## TOCCATA Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

### 9.1.1. *ELEFFAN*

**Participant:** Sylvie Boldo [contact].

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

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

Partners: ENSTA Paristech (A. Chapoutot)

## 9.2. National Initiatives

### 9.2.1. *ANR CoLiS*

**Participants:** Claude Marché [contact], Andrei Paskevich.

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

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

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

### 9.2.2. *ANR Vocal*

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

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

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

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

### 9.2.3. *ANR FastRelax*

**Participants:** Sylvie Boldo [contact], Guillaume Melquiond.

This is a research project funded by the programme “Ingénierie Numérique & Sécurité” of the ANR. It is funded for a period of 48 months and it has started on October 1st, 2014. <http://fastrelax.gforge.inria.fr/>

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

Partners: team ARIC (Inria Grenoble Rhône-Alpes), team MARELLE (Inria Sophia Antipolis - Méditerranée), team SPECFUN (Inria Saclay - Île-de-France), Université Paris 6, and LAAS (Toulouse).

#### 9.2.4. ANR Soprano

**Participants:** Sylvain Conchon [contact], Guillaume Melquiond.

The Soprano research project is funded by the programme "Sciences et technologies logicielles" of the ANR, for a period of 42 months, starting on October 1st, 2014. <http://soprano-project.fr/>

The SOPRANO project aims at preparing the next generation of verification-oriented solvers by gathering experts from academia and industry. We will design a new framework for the cooperation of solvers, focused on model generation and borrowing principles from SMT (current standard) and CP (well-known in optimization). Our main scientific and technical objectives are the following. The first objective is to design a new collaboration framework for solvers, centered around synthesis rather than satisfiability and allowing cooperation beyond that of Nelson-Oppen while still providing minimal interfaces with theoretical guarantees. The second objective is to design new decision procedures for industry-relevant and hard-to-solve theories. The third objective is to implement these results in a new open-source platform. The fourth objective is to ensure industrial-adequacy of the techniques and tools developed through periodical evaluations from the industrial partners.

Partners: team DIVERSE (Inria Rennes - Bretagne Atlantique), Adacore, CEA List, Université Paris-Sud, and OCamlPro.

#### 9.2.5. FUI LCHIP

**Participant:** Sylvain Conchon [contact].

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

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

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

#### 9.2.6. ANR PARDI

**Participant:** Sylvain Conchon [contact].

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

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

### 9.3. European Initiatives

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

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

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

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

Duration: 2015-2019

Coordinator: Herman Geuvers, Radboud University Nijmegen, The Netherlands

Other partners: 36 members countries, see [http://www.cost.eu/COST\\_Actions/ca/CA15123?parties](http://www.cost.eu/COST_Actions/ca/CA15123?parties)

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

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

### 9.4. International Research Visitors

#### 9.4.1. Visits of International Scientists

Ran Chen is a PhD student from Institute of Software (Chinese Academy of Sciences, Beijing, China) visiting the team for 10 months under the supervision of C. Marché and J.-J. Lévy (PiR2 team, Inria Paris). She worked on the formal verification of graphs algorithms [25], [17], and also in the context of the CoLiS project on verification of some aspects of the Unix file system and shell scripts [74] [11]

## COMMANDS Project-Team

## 9. Partnerships and Cooperations

### 9.1. Regional Initiatives

- Gaspard Monge Program for Optimization and Operational Research (Fondation Jacques Hadamard)
 

|         |   |  |
|---------|---|--|
| Title   | : | Optimal control of partial differential equations using parameterizing manifolds, model reduction, and dynamic programming,  |
| Funding | : | 10,000 Euro (for 2016-17), 7,000 Euro (for 2017-2018)  |
| PI      | : | Axel Kröner, U. Humboldt and Inria   |
| Period  | : | 2015 – 2018  |
| Members | : | Frédéric Bonnans (Inria Saclay and CMAP, École Polytechnique),<br>Mickaël Chekroun (UCLA, Los Angeles), Martin Gubisch (U. of Konstanz),<br>Honghu Liu (Virginia Tech),<br>Karl Kunisch (University of Graz), Hasnaa Zidani (ENSTA ParisTech). |

### 9.2. National Initiatives

#### 9.2.1. IPL

##### 9.2.1.1. *Cosy*

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

##### 9.2.1.2. *Algae in Silico*

Inria Project Lab ALGAE IN SILICO (started in 2014) is dedicated to provide an integrated platform for numerical simulation of microalgae “from genes to industrial process“. The project has now reached a stage where we can tackle the optimization aspects. Commands is currently joining the IPL, in the following of our previous collaborations with teams Modemic and Biocore on bioreactors, see [35], [23]

### 9.3. International Research Visitors

#### 9.3.1. *Internships*

Joao Miguel Machado, from FGV (Rio de Janeiro), spent his master internship in our team from sept-dec 2017, working with F. Bonnans and M.S. Aronna (EMAP-FGV) on the second order necessary and sufficient optimality conditions for optimal control problems of ODEs with broken extremals, i.e., with discontinuous control. We are currently extending the classical theory to the case of a jump between interior and boundary values for the control.

## **DEFI Project-Team**

# **8. Partnerships and Cooperations**

## **8.1. International Initiatives**

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

#### *8.1.1.1. International Initiatives*

##### **QUASI**

Title: Qualitative Approaches to Scattering and Imaging

International Partner (Institution - Laboratory - Researcher):

University of Rutgers (United States) - Fioralba Cakoni

Duration: 2013 - 2017

Start year: 2013

We concentrate on the use of qualitative methods in acoustic and electromagnetic inverse scattering theory with applications to nondestructive evaluation of materials and medical imaging. In particular, we would like to address theoretical and numerical reconstruction techniques to solve the inverse scattering problems using either time harmonic or time dependent measurements of the scattered field. The main goal of research in this field is to not only detect but also identify geometric and physical properties of unknown objects in real time.

## **8.2. International Research Visitors**

### ***8.2.1. Visits of International Scientists***

- Fioralba Cakoni (2 weeks)
- David Colton (1 week)
- Armin Lechleiter (1 week)
- Rainer Kress (1 week)

#### *8.2.1.1. Internships*

- Marwa Kchaou (ENIT) 6 months
- FatmeMustapha (EDF) 6 months
- DucVu (Inria) 3 months

## **DISCO Project-Team**

# **9. Partnerships and Cooperations**

## **9.1. Regional Initiatives**

DIGITEO Project (DIM LSC) ALMA3

Project title: Mathematical Analysis of Acute Myeloid Leukemia (AML) and its treatments

September 2014 - August 2017

Coordinator: Catherine Bonnet

Other partners: Inria Paris-Rocquencourt, France, L2S, France, UPMC, St Antoine Hospital Paris

Abstract: this project follows the regional projects ALMA (2010-2014) and ALMA2 (2011-2013). Starting from the work of J. L. Avila Alonso's PhD thesis in ALMA the aim of this project was to provide a refined coupled model of healthy and cancer cell dynamics in AML whose (stability) analysis may enable evaluation of polychemiotherapies delivered in the case of AML which have a high level of Flt-3 duplication (Flt-3-ITD).

## **9.2. National Initiatives**

### **9.2.1. Industrial-Academic Institute**

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

## **9.3. European Initiatives**

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

Program: ITN

Project acronym: TEMPO

Project title: Training in Embedded Predictive Control and Optimization

Duration: January 2014 - January 2018

Coordinator: Tor Arne Johanson; with Sorin Olaru (as French PI)

Other partners: U. Freiburg, Oxford, Imperial College; NTNU Trondheim; STUBA Bratislava; EPFL Lausanne; KU Leuven, Renault, ABB, Ampyx Power

Abstract: TEMPO is an international PhD program for highly motivated young scientists, where state-of-the-art research is combined with a comprehensive training program. The network is funded by the European Community's Seventh Framework program. The European Commission wants to make research careers more attractive to young people and therefore offers early-stage researchers (ESRs) a PhD program the opportunity to improve their research skills, join established research teams and enhance their career prospects via the Marie Curie Initial Training Networks (ITN) in the area of Embedded Predictive Control and Optimization.

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

Program: PHC BOSPHORE 2016 (Turkey)

Project title: Robust Control of Time Delayed Linear Parameter Varying Systems via Switched Controllers.

Duration: January 2016 - December 2017

Coordinator: Frédéric Mazenc (France), Hitay Özbay (Turkey).

Abstract: The main goal of this project is to develop computational algorithms for robust controller design for different classes of time delay systems appearing in various engineering applications such as chemical processes, transportation systems and communications networks. The participants will consider control problems of significant practical implications in this area: (i) developing new computational techniques for simple (low order) reliable and scalable decentralized controllers for control of (and control over) networks; and (ii) reducing conservatism in recently developed dwell-time based stability results for the analysis of switched time delay systems. Moreover, design of scalable low order controllers for reducing the effect of time delays is an important problem investigated in this project. One of the objectives of this collaboration is to generalize the design techniques already developed by the French and Turkish teams to larger classes of time delay systems, in particular multi-input-multi-output (MIMO) systems with time varying delays.

Program: **PHC BRANCUSI 2017 (Romania)**

Project acronym: ProCo

Project title: Systems with propagation: New approaches in control design for oscillation quenching

Duration: January 2016 - December 2018

Coordinator: Islam Boussaada (France) et Daniela Danciu (Romania)

Abstract: The project aims to building a unitary framework for the modeling, the analysis and the control of distributed-parameters systems (DPS) described by hyperbolic partial differential equations in one space variable and non-standard boundary conditions. This main objectives are modeling of DPS and the corresponding functional differential equations, the construction of reduced-order models approximating DPS by both numerical and computational modeling, the design of new control methods for oscillations quenching in DPS.

Program: **PHC CARLSO FINLEY 2017 (Cuba)**

Project title: MODELISATION ET COMMANDE POUR LE PROCESSUS DE CRYOCONSERVATION.

Duration: June 2017 - December 2017

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

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

Program: **COST Action**

Project acronym: FRACTAL

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

Duration: November 2016 - October 2020

Coordinator: Jaroslav Koton Czech Republic

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

## 9.4. International Initiatives

Catherine Bonnet is the co-supervisor together with André Fioravanti of a PhD student of Unicamp (Brazil).

Frédéric Mazenc is the co-supervisor together with Hitay Ozbay of a PhD Student of Bilkent University (Turkey).

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

#### **9.4.1.1. Informal International Partners**

- College of Mathematics and Information Science, Shaanxi Normal University, China
- School of Control Science and Engineering, Dalian University of Technology, Dalian, China
- Louisiana State University, Baton Rouge, USA
- School of Electrical Engineering at the Tel-Aviv University, Israel
- The University of Texas at Austin, Dept. of Aerospace Engineering & Engineering Mechanics, USA
- Bilkent University, Turkey
- Universidad de Chile, Chile
- School of Mathematics, University of Leeds, U.K.
- University Federale Rio de Janeiro, Brazil
- UNICAMP, Brazil
- Kyoto University, Japan

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

#### **9.4.2.1. International Initiatives**

##### **STADE**

Title: Stability and Dichotomies in Differential Equations (Ordinary & Delay).

International Partners (Institution - Laboratory - Researcher):

Universidad de Chile (Chile) - Mathematics Department - Gonzalo Robledo

Universidad de la Republica Uruguay (Uruguay) - Faculty of Engineering - Pablo Monzon

Duration: 2016 - 2017

Start year: 2016

See also: <http://www.stade.cl/pages/list.html>

The ship-flags of this project are the concepts of dichotomy and stability in an ODE & DDE framework. We intend to study some theoretical and applied problems involving these concepts and its relations. In particular, converse stability results (expressed in the existence of density functions), feedback stabilization, stability in delay differential equations and some applications to bioprocesses.

## **9.5. International Research Visitors**

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

Stefanella Boatto, Federale University Rio de Janeiro, Brazil, 1 January-31 December.

André Fioravanti, UNICAMP, Sao Paulo, Brazil, 7 January-28 February.

Yutaka Yamamoto, Kyoto University, Japan, 17 May -2 August.

Hitay Ozbay, Bilkent University, Turkey, 15 November 2017 - 18 November 2017.

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

Stefanella Boatto visited the Department of Mathematics, Universidade de Lisboa, Portugal, 19-23 June 2017. Frédéric Mazenc visited the Department of Mathematics of the Louisiana State University, Baton Rouge USA, 2 April - 14 April 2017, the Departamento de Ingeniaria de Control y Robotico of the Universidad Nacional Autonoma de Mexico, Mexico-city 14 August 2017 - 16 August and 18 August - 27 August 2017, the Laboratoire Franco-Mexicain d'Informatique et d'Automatique (LAFMIA), Mexico-City, 17 August 2017, Universidad de Chile, Santiago de Chile, 15 October 2017 to 28 October 2017.



## **GAMMA3 Project-Team**

# **6. Partnerships and Cooperations**

## **6.1. European Initiatives**

### **6.1.1. FP7 & H2020 Projects**

- UMRIDA <https://sites.google.com/a/numeca.be/umrida/>

## **6.2. International Initiatives**

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

#### **6.2.1.1. AM2NS**

Title: Advanced Meshing Methods for Numerical Simulations

International Partner (Institution - Laboratory - Researcher):

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

Start year: 2017

See also: [http://pages.saclay.inria.fr/frederic.alauzet/AssociateTeam\\_AM2NS/AT\\_am2ns.html](http://pages.saclay.inria.fr/frederic.alauzet/AssociateTeam_AM2NS/AT_am2ns.html)

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

#### **6.2.1.2. MODIS**

Title: High-order discrete geometric modeling

International Partner (Institution - Laboratory - Researcher):

Polytechnique Montréal (Canada) - Computer Science - François Guibault

Start year: 2017

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

## **GECO Project-Team**

# **8. Partnerships and Cooperations**

## **8.1. Regional Initiatives**

- Starting from the end of 2015, we have been funded by PGM0 (Gaspard Monge Program for Optimisation and operational research) through a grant on Geometric Optimal Control. The grant is coordinated by Mario Sigalotti.

## **8.2. National Initiatives**

### **8.2.1. ANR**

The ANR SRGI starts at the end of 2015, for a duration of four years. GECO is one of one of the partners of the ANR. The national coordinator is Emmanuel Trélat (UPMC) and the local one Ugo Boscain.

SRGI deals with sub-Riemannian geometry, hypoelliptic diffusion and geometric control.

### **8.2.2. Other initiatives**

Ugo Boscain and Mario Sigalotti are members of the project DISQUO of the program Inphyniti of the CNRS. Coordinator: Thomas Chambrion (Nancy).

## **8.3. European Initiatives**

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

Program: ERC Proof of Concept

Project acronym: ARTIV1

Project title: An artificial visual cortex for image processing

Duration: From April 2017 to September 2018.

Coordinator: Ugo Boscain

Abstract: The ERC starting grant GECOMETHODS, on which this POC is based, tackled problems of diffusion equations via geometric control methods. One of the most striking achievements of the project has been the development of an algorithm of image reconstruction based mainly on non-isotropic diffusion. This algorithm is bio-mimetic in the sense that it replicates the way in which the primary visual cortex V1 of mammals processes the signals arriving from the eyes. It has performances that are at the state of the art in image processing. These results together with others obtained in the ERC project show that image processing algorithms based on the functional architecture of V1 can go very far. However, the exceptional performances of the primary visual cortex V1 rely not only on the particular algorithm used, but also on the fact that such algorithm runs on a dedicated hardware having the following features: 1. an exceptional level of parallelism; 2. connections that are well adapted to transmit information in a non-isotropic way as it is required by the algorithms of image reconstruction and recognition. The idea of this POC is to create a dedicated hardware (called ARTIV1) emulating the functional architecture of V1 and hence having on one hand a huge degree of parallelism and on the other hand connections among the CPUs that reflect the non-isotropic structure of the visual cortex V1. Such a hardware that we plan to build as an integrated circuit with an industrial partner will be a veritable artificial visual cortex. It will be fully programmable and it will be able to perform many biomimetic image processing tasks that we expect to be exceptionally performant. ARTIV1 will come to the marked accompanied by some dedicated software for image reconstruction and image recognition. However we expect that other applications will be developed by customers, as for instance softwares for optical flow estimation or for sound processing.

## **8.4. International Initiatives**

### **8.4.1. Informal International Partners**

SISSA (Scuola Internazionale Superiore di Studi Avanzati), Trieste, Italy.

Sector of Functional Analysis and Applications, Geometric Control group. Coordinator: Andrei A. Agrachev.

We collaborate with the Geometric Control group at SISSA mainly on subjects related with sub-Riemannian geometry. Thanks partly to our collaboration, SISSA has established an official research partnership with École Polytechnique.

## **8.5. International Research Visitors**

### **8.5.1. Visits of International Scientists**

- Andrei Agrachev (SISSA, Italy) has been visiting the GECO team for one year, ending in June 2017.

#### **8.5.1.1. Internships**

Gontran Lance has made an internship in GECO, under the supervision of Mario Sigalotti and Emmanuel Trélat on the turnpike phenomenon in the orbital transfer problem.

## POEMS Project-Team

# 9. Partnerships and Cooperations

## 9.1. Regional Initiatives

The post-doc of Maryna Kachanovska was funded by the Fondation Mathématique Jacques Hadamard (FMJH).

## 9.2. National Initiatives

### 9.2.1. ANR

- ANR project *RAFFINE: Robustesse, Automatisation et Fiabilité des Formulations INTégrales en propagation d'ondes : Estimateurs a posteriori et adaptivité*  
Partners: EADS, IMACS, ONERA, Thales  
Start : January 2013. End : June 2017. Administrator : Inria. Coordinator: Marc Bonnet.
- ANR project *Non-Local Domain Decomposition Methods in Electromagnetism*.  
Partners: Inria Alpines, Inria POEMS, Inria Magique 3D.  
Start : 2015, End : 2019. Administrator : Inria. Coordinator: Xavier Claeys.

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

#### 9.3.1.1. BATWOMAN

Type: FP7 Marie Curie

Objectif: Basic Acoustics Training - & Workprogram On Methodologies for Acoustics - Network

Duration: September 2013 - August 2017

Coordinator: Martin Wifling, VIRTUAL VEHICLE (AT)

Inria contact: P. Joly

Abstract: The BATWOMAN ITN aims at structuring research training in basic and advanced acoustics and setting up a work program on methodologies for acoustics for skills development in a highly diverse research field offering multiple career options.

## 9.4. International Initiatives

### 9.4.1. Inria International Partners

#### 9.4.1.1. Informal International Partners

Wilkins Aquino (Duke University)  
Juan Pablo Borthagaray (Univ. of Maryland, College Park, USA)  
Fioralba Cakoni (University of Rutgers)  
Maxence Cassier (Columbia University)  
Camille Carvalho (UC Merced, Merced, USA)  
Christophe Geuzaine (Université de Liège)  
Bojan Guzina (University of Minnesota)  
Marcus Grote (Universitaet Basel)  
Sergei Nazarov (Saint-Petersburg University)  
Jeronimo Rodriguez (University of Santiago de Compostela)  
Adrien Semin (BTU Cottbus)  
Ricardo Weder (Universidad Nacional Autonoma, Mexico)  
Shravan Veerapaneni (Univ. of Michigan at Ann Arbor, USA)

## RANDOPT Team

# 8. Partnerships and Cooperations

## 8.1. Regional Initiatives

- PGMO project “NumBER: Numerical Black Box Optimization for Energy Applications”, in collaboration with EDF, financing the postdoc of Asma Atamna, project length: 2 years (2016–2018), PI: Anne Auger
- PGMO project “AESOP: Algorithms Expensive Simulation-Based Optimization Problems”, a project involving several researchers from CentraleSupélec, Ecole des Mines de St.-Etienne, INRA Toulouse, JSI (Slovenia), Safran, Ruhr-Universität Bochum (Germany), and TU Dortmund University (Germany), project length: 2 years (2017–2019), PI: Dima Brockhoff

## 8.2. National Initiatives

### 8.2.1. ANR

- ANR project “NumBBO: Analysis, Improvement and Evaluation of Numerical Blackbox Optimizers”, with partners DOLPHIN team (till 2016), Ecole des Mines de St.-Etienne and TU Dortmund University (Germany), Anne Auger was PI of this project which had a total budget of 660kEUR (2012–2017)
- ANR project “Big Multiobjective Optimization (BigMO)”, Dima Brockhoff participates in this project through the Inria team BONUS in Lille (2017–2020)

## 8.3. International Initiatives

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

#### 8.3.1.1. s3-bbo

Title: Threefold Scalability in Any-objective Black-Box Optimization

International Partner (Institution - Laboratory - Researcher):

Shinshu (Japan) - Tanaka-Hernan-Akimoto Laboratory - Hernan Aguirre

Start year: 2015

See also: <http://francejapan.gforge.inria.fr/doku.php?id=associateteam>

This associate team brings together researchers from the TAO and Dolphin Inria teams with researchers from Shinshu university in Japan. Additionally, researchers from the University of Calais are external collaborators to the team. The common interest is on black-box single and multi-objective optimization with complementary expertises ranging from theoretical and fundamental aspects over algorithm design to solving industrial applications. The work that we want to pursue in the context of the associate team is focused on black-box optimization of problems with a large number of decision variables and one or several functions to evaluate solutions, employing distributed and parallel computing resources. The objective is to theoretically derive, analyze, design, and develop scalable black-box stochastic algorithms including evolutionary algorithms for large-scale optimization considering three different axes of scalability: (i) decision space, (ii) objective space, and (iii) availability of distributed and parallel computing resources.

We foresee that the associate team will make easier the collaboration already existing through a proposal funded by Japan and open-up a long term fruitful collaboration between Inria and Shinshu university. The collaboration will be through exchanging researchers and Ph.D. students and co-organization of workshops.

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

#### *8.3.2.1. Declared Inria International Partners*

- We are collaborating with Shinshu University and particularly Youhei Akimoto through our joint associate team.

#### *8.3.2.2. Informal International Partners*

- We are collaborating with Tea Tušar from the Josef-Stefan Institute in Ljubljana, Slovenia for extending and maintaining our COCO platform and on benchmarking in general.
- We are collaborating with Jun.-Prof. Tobias Glasmachers from the Ruhr-Universität Bochum in Germany on runtime analysis of adaptive stochastic algorithms.

## **8.4. International Research Visitors**

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

- Filip Matzner from Charles University Prague (Czech Republic) - Visit of one month in November 2017 to work on Evolution Strategies for reinforcement learning and classification problems.
- Prof. Dr. Youhei Akimoto from Shinshu University (Japan) - Visit of one month in November 2017 to work on several projects related to theory and algorithm design for large-scale optimization.
- Dr. Alexandre Chotard from KTU (Sweden) - Visit of one month in November 2017 to work on adaptive MCMC.
- Dr. Tea Tušar from the Josef-Stefan Institute (Slovenia) - Visit of one week in November 2017 to work on our projects around (multiobjective) blackbox optimization benchmarking.

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

#### *8.4.2.1. Research Stays Abroad*

- Anne Auger and Dimo Brockhoff visited Jun.-Prof. Tobias Glasmachers and Prof. Günter Rudolph in Dortmund from April 10 till April 14, 2017

## **SELECT Project-Team**

# **8. Partnerships and Cooperations**

## **8.1. Regional Initiatives**

Gilles Celeux and Christine Keribin have a collaboration with the Pharmacoepidemiology and Infectious Diseases (PhEMI, INSERM) groups.

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

## **8.2. National Initiatives**

### **8.2.1. ANR**

SELECT is part of the ANR funded MixStatSeq.

## **8.3. International Initiatives**

Gilles Celeux is one of the co-organizers of the international working group on model-based clustering. This year this workshop took place in Perugia, Italy

## **8.4. International Research Visitors**

### **8.4.1. Visits to International Teams**

#### **8.4.1.1. Research Stays Abroad**

Kevin Bleakley stayed at the Pasteur Institute, Cambodia, while working on several collaborations in dengue fever research, from late 2016 until early 2017.

## TAU Team

## 9. Partnerships and Cooperations

### 9.1. National Initiatives

#### 9.1.1. ANR

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

#### 9.1.2. Others

- **ROMModel Reduction and Multiphysics Optimization** 2014-2017 (50 Keuros)  
Coordinator: IRT System X  
Participants: Marc Schoenauer, Michèle Sebag, François Gonard (PhD)
- **MAJOREA Collaborative Filtering Approach to Matching Job Openings and Job Seekers**, 2013-2017 (105 kEuros)  
Thomas Schmitt's PhD (funded by ISN).  
Participants: Philippe Caillou, Michèle Sebag, Thomas Schmitt (PhD)
- **AMIQAP** 2015-2017 (12 months of Postdoctoral fellow). Qualité de vie au travail.  
Project funded by ISN  
Partners: Mines-Telecom SES, RITM (Univ. Paris Sud) and *La Fabrique de l'Industrie*  
Extended for 6 months in 2018 via a donation from *La Fabrique de l'Industrie*  
Participants: Philippe Caillou, Olivier Goudet, Isabelle Guyon, Michèle Sebag, Paola Tubaro, Diviyan Kalainathan (PhD)
- **Nutriperso** 2017-2018, 37 kEuros. Personalized recommendations toward healthier eating practices.  
U. Paris-Saclay IRS (*Initiative de Recherche Stratégique*)  
Partners: INRA (coordinator), INSERM, Agro Paristech, Mines Telecom  
Participants: Philippe Caillou, Flora Jay, Michèle Sebag, Paola Tubaro
- **POST** 2014-2017 (1,220 MEuros, including 500 kEuros for a 'private' cluster). Platform for the optimization and simulation of trans-continental grids  
ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie)  
Coordinator: ARTELYS  
Participants (in 2017, after Olivier Teytaud left): Vincent Berthier (PhD defended in Dec.), Marc Schoenauer
- **E-LUCID** 2014-2017 (194 kEuros)  
Coordinator: Thales Communications & Security S.A.S  
Participants: Marc Schoenauer, Cyril Furtlehner, Luis Marti
- **PIA ADAMME** 2015-2018 (258 kEuros)  
Coordinator: Bull SAS  
Participants (in 2017): Marc Schoenauer, Guillaume Charpiat, Cécile Germain-Renaud, Yasmina Bouzbiba, Etienne Brame



- **CNES contract** 2015-2017 (70 kEuros)  
Coordinator: Manuel Grizonnet (CNES) & Yuliya Tarabalka (Inria Sophia-Antipolis, Titane team)  
Participant: Guillaume Charpiat
- **NEXT** 2017-2021 (675 kEuros). Simulation, calibration, and optimization of regional or urban power grids  
ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie)  
Coordinator: ARTELYS  
Participants Isabelle Guyon, Marc Schoenauer, Michèle Sebag, Victor Berger (PhD), Herilalaina Rakotoarison (PhD), Berna Bakir Batu (Post-doc)
- **BRAINTIME** 2017 (7 kEuros) Défi exploratoire interdisciplinaire de l'appel INFINITE (CNRS) concerning the functional connectome dynamics of the brain.  
Coordinator: Andrea Brovelli (CNRS), Institut de Neurosciences de la Timone (INT)  
Participants Aurélien Decelle, Cyril Furtlehner
- **CDS DeepGenetics** 2017 (6mois, 3k euros), Deep Learning for Population Genetics.  
funded by Center for Data Science  
Coordinators: Flora Jay and Guillaume Charpiat  
Participants: Théophile Sanchez (master internship)

## 9.2. European Initiatives

### 9.2.1. FP7 & H2020 Projects

**See.4C** 2016-2017 (2.7 kEuros). SpatiotEmporal ForEcasting: Coopetition to meet Current Cross-modal Challenges  
Participants: Isabelle Guyon

### 9.2.2. Collaborations with Major European Organizations

**MLSpaceWeather** 2015-2019. Coupling physics-based simulations with Artificial Intelligence.  
Coordinator: CWI  
Participants: Michèle Sebag, Aurélien Decelle, Cyril Furtlehner, Mhamed Hajaiej

**ESA Tender** 2015-2017  
Coordinator: Bart Boonacker (TNO)  
Participant: Marc Schoenauer, Dejan Tusar

## 9.3. International Initiatives

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

#### 9.3.1.1. MDG-TAO

**Title:** Data-driven simulations for Space Weather predictions

**International Partner:** CWI (Netherlands) – **Multiscale Dynamics Group** – Enrico Camporeale  
Start year: 2017

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

### 9.3.2. Inria International Partners

#### 9.3.2.1. Declared Inria International Partners

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

#### 9.3.2.2. Informal International Partners

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

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

## 9.4. International Research Visitors

### 9.4.1. Visits of International Scientists

- **Edgar Galvan Lopez** University College Dublin, April 2015 - April 2017, funded by the ELEVATE Fellowship, the Irish Research Council's Career Development Fellowship co-funded by Marie Curie Actions. Now Lecturer at Maynooth University, Ireland.

#### 9.4.1.1. Internships

- **Tomas Lungenstrass** June 2016 - June 2017, self-funded, collaboration with Inria Chile. Worked on magnetic storm prediction under A. Decelle's, C. Furtlehner's and M. Sebag's supervision.

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## TROPICAL Team

## 9. Partnerships and Cooperations

### 9.1. National Initiatives

#### 9.1.1. ANR

- Projet ANR MALTHY (Méthodes ALgébriques pour la vérification de modèles Temporisés et HYbrides), responsable T. Dang. Partenaires : Verimag, CEA LIST, Inria Rennes, Inria Saclay, VISEO/Object Direct.
- Projet ANR DEMOCRITE ("DEmonstrateur d'un MOteur de Couverture des Risques sur un TERRitoire), responsable Emmanuel Lapébie (CEA). Partenaires : CEA-GRAMAT, BSPP, Inria Saclay (Maxplus), Institut PPRIME - UPR3346 (CNRS, Univ. Poitiers, ISAE-ENSMA), IPSIS, SYSTEL, ARMINES-E.M. Alès-ISR, CERDACC (Univ. de Haute-Alsace).

#### 9.1.2. Programme Gaspard Monge pour l'Optimisation

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

### 9.2. International Initiatives

#### 9.2.1. Inria International Partners

##### 9.2.1.1. Informal International Partners

- Collaboration with Ricardo D. Katz, CIFASIS-CONICET, Rosario (Argentina). Research invitation at CMAP during 2 months.

#### 9.2.2. Participation in International Programs

- Collaboration with Gleb Koshevoy, Poncelet Laboratory, Moscow (research invitation of Gleb Koshevoy at CMAP during 2 months, research invitation of Stéphane Gaubert at Poncelet Laboratory during 1 week).

### 9.3. International Research Visitors

#### 9.3.1. Visits of International Scientists

- Gleb Koshevoy (Russian Academy of Sciences), Feb-March, 2017.
- Shmuel Friedland (University of Illinois at Chicago), one week in May 2017.
- Zheng Qu (Hong Kong University), June-July 2017
- Zheng Hua (Hong Kong University), June-July 2017
- Rajendra Bhatia (Indian Statistical Institute, New Delhi), 1 week in Dec 2017.
- Floris Claassens (University of Kent), 1 week in Dec 2017.

## AMIBIO Team

## 6. Partnerships and Cooperations

### 6.1. National Initiatives

#### 6.1.1. FRM

AMIBio is in charge of Bioinformatics developments in this project on structural prediction from RNA probing data (SHAPE). It involves Biochemists at Université Paris Descartes (France, PI B. Sargueil) and is funded by a "Fondation pour la Recherche Medicale" grant. It also involves partners in Paris-Sud (France) and McGill University (Canada).

Fondation pour la Recherche Medicale – *Analyse Bio-informatique pour la recherche en Biologie* program

- Approche comparatives haut-débit pour la modelisation de l'architecture 3D des ARN à partir de données experimentales
- 2015–2018
- Yann Ponty, A. Denise, M. Regnier, A. Saaidi (PhD funded by FRM)
- B. Sargueil (Paris V – Experimental partner), J. Waldispuhl (Univ. McGill)

### 6.2. European Initiatives

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

Yann Ponty is the French PI for the French/Austrian RNALANDS project, jointly funded by the French ANR and the Austrian FWF, in partnership with the Theoretical Biochemistry Institute (University of Vienna, Austria), LRI (Univ. Paris-Sud) and EPI BONSAI (Inria Lille-Nord Europe).

French/Austrian International Program

RNALANDS (ANR-14-CE34-0011)

Fast and efficient sampling of structures in RNA folding landscapes

01/10/2014–30/09/2018

Coordinated by AMIB (Inria Saclay) and TBI Vienna (University of Vienna)

EPI BONSAI/INRIA Lille - Nord Europe, Vienna University (Austria), LRI, Université Paris-Sud (France)

The main goal of the RNALands project is to provide efficient tools for studying the kinetics of RiboNucleic Acids, based on efficient sampling strategies.

### 6.3. International Initiatives

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

##### 6.3.1.1. ALARNA

Title: Associated Laboratory for the Analysis of RiboNucleic Acids

International Partner (Institution - Laboratory - Researcher):

McGill University (Canada) - REUSSI Program - Jerome Waldispuhl

Start year: 2017

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

RiboNucleic Acids (RNAs) are ubiquitous biomolecules whose structure, adopted as the outcome of a complex folding process, often plays a crucial part in cellular processes. The ALARNA Associate Team (Laboratory for the Analysis of RiboNucleic Acids), which consist of the AMIBio project-team (Inria Saclay/Ecole Polytechnique, France) and the CSB (Computer Science and Biology) group at university McGill (Montreal, Canada), addresses key questions in RNA bioinformatics. More specifically, it dedicates much of its effort to the production and interpretation of chemical probing data generated by SHAPE, an experimental technology which allows to accurately predict, in a high-throughput, one or several secondary structure(s) adopted by an RNA. To that end, the teams contribute their unique combinations of expertise, ranging from combinatorial optimization to sequence algorithmics through structural bioinformatics.

#### 6.3.1.2. Informal International Partners

AMIBio enjoys regular interactions with the following institutions:

- TBI, University of Vienna (Austria). Within the RNALands project funded by the Austrian FWF and the french ANR, we frequently interact with our partners at the TBI, on projects associated with the kinetics of RNAs. Over the course of 2017, we have visited our partners twice, once in Vienna and once in Bled (Slovenia) over the course of the 2017 Winter retreat of the TBI. Additionally, Andrea Tanzer has visited AMIBio for a month in Oct 2018, funded by a visiting scholar program of Ecole Polytechnique;
- Simon Fraser University (Vancouver, Canada). The Mathematics department at SFU has ongoing projects on RNA design, comparative genomics and RNA structure comparison with our team. M. Mishna (SFU) has visited Inria Saclay in January 2017 to push an ongoing collaboration on 2D walks;
- McGill University (Montréal, Canada). Following our productive collaboration with J. Waldispühl (Computer Science Dept, McGill), and the recent defense of V. Reinharz's PhD, whose thesis was co-supervised by AMIBio members, we have increased our interactions on SHAPE data analysis through the ALARNA associate team;
- King's college (London, UK). Our collaboration with L. Mouchard (AMIBio associate) and S. Pissis on string processing and data structures was at the core of Alice Héliou's PhD, defended in July 2017.

#### 6.3.2. Participation in Other International Programs

Title: PHC GRO-algo – Combination of time-course GRO-seq assay, algorithmics and software development for measuring genome-wide transcription elongation rates

International Partner (Institution - Laboratory - Researcher):

Wuhan University (China), College of Life Science – Pr Yu Zhou

Start year: 2017

Participant in a French-Chinese Hubert Curien Partnerships (PHC), supported by CampusFrance and funding bilateral exploratory research exchanges in Bioinformatics. The program involves research scientists from Wuhan University, Ecole Polytechnique and Univ. Paris-Sud.

Title: Computational methods and databases to identify small RNA-binding molecules regulating gene expression

International Partner (Institution - Laboratory - Researcher):

University McGill (Canada), Computer Science & Biochemistry – J. Waldispühl, N. Moitessier; Univ. Strasbourg, IBMC - E. Westhof.

Start year: 2017

The project, headed by N. Moitessier and J. Waldispühl (McGill University, Canada) strives to develop tools to derive a mechanical understanding of riboswitches at the 2D and 3D levels, including chemoinformatics aspects.

## **6.4. International Research Visitors**

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

Andrea Tanzer

Date: Oct 2017 - Nov 2017

Institution: TBI Vienna, Austria

Mathieu Blanchette

Date: June 2017

Institution: Univ. McGill, Canada

#### ***6.4.1.1. Internships***

Paul Arijit

Institution: IISc Bangalore (India)

Supervisor: Mireille Régnier

Chinmay Singhal

Date: May 2017 - July 2017

Institution: IIT Guwahati, India (India)

Supervisor: Yann Ponty

## GALEN Project-Team

# 9. Partnerships and Cooperations

## 9.1. National Initiatives

### 9.1.1. ANR

Program: ANR Blanc International

Project acronym: ADAMANTIUS

Project title: Automatic Detection And characterization of residual Masses in pAtients with lymphomas through fusioN of whole-body diffusion-weighted mrI on 3T and 18F-flUorodeoxyglucoSe pet/ct

Duration: 9/2012-8/2015

Coordinator: CHU Henri Mondor - FR

Program: ANR JCJC

Project acronym: HICORE

Project title: HIERarchical COmpositional REpresentations for Computer Vision

Duration: 10/2010-9/2014

Coordinator: ECP - FR

Program: ANR JCJC

Project acronym: LearnCost

Project title: Learning Model Constraints for Structured Prediction

Duration: 2014-2018

Coordinator: Inria Saclay - FR

Program: ANR JCJC

Project acronym: MajIC

Project title: Majorization-Minimization Algorithms for Image Computing

Duration: 2017-2021

Coordinator: E. Chouzenoux

Program: ITMOs Cancer & Technologies pour la santé d'Aviesan / INCa

Project acronym: CURATOR

Project title: Slice-to-Image Deformable Registration towards Image-based Surgery Navigation & Guidance

Duration: 12/2013-11/2015

Coordinator: ECP - FR

### 9.1.2. Others

Program: CNRS MASTODONS

Projet acronym: TABASCO

Project title: Traitement du bruit non Gaussien en spectroscopie

Duration: 2016-2018

Coordinator: E. Chouzenoux

Program: CNRS-CEFIPRA  
 Project acronym: NextGenBP  
 Project title: Looking Beyond Backpropagation in Deep Learning  
 Duration : 2017-2019  
 Coordinator: E. Chouzenoux

## 9.2. European Initiatives

### 9.2.1. FP7 & H2020 Projects

#### 9.2.1.1. MOBOT

Title: Intelligent Active MObility Aid RoBOT integrating Multimodal Communication

Programm: FP7

Duration: February 2013 - January 2016

Coordinator: Technische Universität München

Partners:

Bartłomiej Marcin Stanczyk (Poland)

Athena Research and Innovation Center in Information Communication & Knowledge Technologies (Greece)

Bethanien Krankenhaus - Geriatisches Zentrum - Gemeinnützige (Germany)

Diaplasia Rehabilitation Center (Greece)

Ecole Centrale des Arts et Manufactures (France)

Institute of Communication and Computer Systems (Greece)

Technische Universitaet Muenchen (Germany)

Ruprecht-Karls-Universitaet Heidelberg (Germany)

Inria contact: Iasonas Kokkinos

Mobility disabilities are prevalent in our ageing society and impede activities important for the independent living of elderly people and their quality of life. The MOBOT project aims at supporting mobility and thus enforcing fitness and vitality by developing intelligent active mobility assistance robots for indoor environments that provide user-centred, context-adaptive and natural support. Our driving concept envisions cognitive robotic assistants that act (a) proactively by realizing an autonomous and context-specific monitoring of human activities and by subsequently reasoning on meaningful user behavioural patterns, as well as (b) adaptively and interactively, by analysing multi-sensory and physiological signals related to gait and postural stability, and by performing adaptive compliance control for optimal physical support and active fall prevention. Towards these targets, a multimodal action recognition system will be developed to monitor, analyse and predict user actions with a high level of accuracy and detail. The main thrust of our approach will be the enhancement of computer vision techniques with modalities such as range sensor images, haptic information as well as command-level speech and gesture recognition. Data-driven multimodal human behaviour analysis will be conducted and behavioural patterns will be extracted. Findings will be imported into a multimodal human-robot communication system, involving both verbal and nonverbal communication and will be conceptually and systemically synthesised into mobility assistance models taking into consideration safety critical requirements. All these modules will be incorporated in a behaviour-based and context-aware robot control framework. Direct involvement of end-user groups will ensure that actual user needs are addressed. Finally, user trials will be conducted to evaluate and benchmark the overall system and to demonstrate the vital role of MOBOT technologies for Europe's service robotics.

#### 9.2.1.2. Strategie



Title: Statistically Efficient Structured Prediction for Computer Vision and Medical Imaging

Programm: FP7

Duration: January 2014 - December 2017

Coordinator: Inria

Inria contact: Matthew Blaschko

'Inference in medical imaging is an important step for disease diagnosis, tissue segmentation, alignment with an anatomical atlas, and a wide range of other applications. However, imperfections in imaging sensors, physical limitations of imaging technologies, and variation in the human population mean that statistical methods are essential for high performance. Statistical learning makes use of human provided ground truth to enable computers to automatically make predictions on future examples without human intervention. At the heart of statistical learning methods is risk minimization - the minimization of the expected loss on a previously unseen image. Textbook methods in statistical learning are not generally designed to minimize the expected loss for loss functions appropriate to medical imaging, which may be asymmetric and non-modular. Furthermore, these methods often do not have the capacity to model interdependencies in the prediction space, such as those arising from spatial priors, and constraints arising from the volumetric layout of human anatomy. We aim to develop new statistical learning methods that have these capabilities, to develop efficient learning algorithms, to apply them to a key task in medical imaging (tumor segmentation), and to prove their convergence to optimal predictors. To achieve this, we will leverage the structured prediction framework, which has shown impressive empirical results on a wide range of learning tasks. While theoretical results giving learning rates are available for some algorithms, necessary and sufficient conditions for consistency are not known for structured prediction. We will consequently address this issue, which is of key importance for algorithms that will be applied to life critical applications, e.g. segmentation of brain tumors that will subsequently be targeted by radiation therapy or removed by surgery. Project components will address both theoretical and practical issues.'

### **9.2.2. I-SUPPORT**

Title: ICT-Supported Bath Robots

Project-Team GALEN 17

Program: FP7

Duration: March 2015 - March 2018

Coordinator: Robotnik Automation S.L.L.

Partners:

Bethanien Krankenhaus - Geriatisches Zentrum - Gemeinnutzige GMBH (Germany)

Fondazione Santa Lucia (Italy)

Institute of Communication and Computer Systems (Greece)

Karlsruher Institut für Technologie (Germany)

Theofanis Alexandridis Kai Sia Ee (OMEGATECH) (Greece)

Robotnik Automation SII (Spain)

Scuola Superiore di Studi Universitari E di Perfezionamento Sant'Anna (Italy)

Frankfurt University of Applied Sciences (Germany)

Inria contact: Iasonas Kokkinos

The I-SUPPORT project envisions the development and integration of an innovative, modular, ICTsupported service robotics system that supports and enhances older adults' motion and force abilities and assists them in successfully, safely and independently completing the entire sequence of bathing tasks, such as properly washing their back, their upper parts, their lower limbs, their buttocks and groin, and to effectively use the towel for drying purposes. Advanced modules of cognition, sensing, context awareness and actuation will be developed and seamlessly integrated into the service robotics system to enable the robotic bathing system to adapt to the frail elderly population' capabilities and the frail elderly to interact in a master-slave mode, thus, performing bathing activities in an intuitive and safe way. Adaptation and integration of state-of-the-art, cost-effective, soft-robotic manipulators will provide the hardware constituents, which, together with advanced human-robot force/compliance control that will be developed within the proposed project, will form the basis for a safe physical human-robot interaction that complies with the most up-to-date safety standards. Human behavioural, sociological, safety, ethical and acceptability aspects, as well as financial factors related to the proposed service robotic infrastructure will be thoroughly investigated and evaluated so that the I-SUPPORT end result is a close-to-market prototype, applicable to realistic living settings.

### 9.3. International Initiatives

#### 9.3.1. Inria International Partners

##### 9.3.1.1. Informal International Partners

Sup'Com Tunis - Collaborative research with Amel Benazza-Benhayia. Collaboration Topic: Multi-spectral imaging.

Universidad Tecnica Federico Santa Maria - Collaborative research with Luis M. Briceno Arias. Collaboration Topics: Variational approaches for monotone inclusions.

University of Patras, Greece - Collaborative research with V. Megalooikonomou. Collaboration Topic: Biosignal analysis.

University of Pennsylvania - Collaborative research with Aristeidis Sotiras. Collaboration Topic: Higher Order Graphs in biomedical image analysis.

### 9.4. International Research Visitors

#### 9.4.1. Visits of International Scientists

##### 9.4.1.1. Internships

The following international students did an internship at CVN in the past year:

Huidong Liu, Stony Brook University, NY (may 2017)

Zhixin Shu, Stony Brook University, NY (may 2017)

Vu Nguyen, Stony Brook University, NY (jul. 2017)

Han Anh Vu Le, Houston University (jul. 2017)

Anisia Florescu, University of Galati Romania (feb. 2017)

Vyacheslav Dudar, Taras Sheuchenko National University of Kyiv (nov. 2017)

Carla Bertolocchi, Universita degli studi di Modena e Reggio Emilia (dec. 2017)

Yana Vedel, Taras Sheuchenko National University of Kyiv (dec. 2017)

## LIFEWARE Project-Team

## 8. Partnerships and Cooperations

### 8.1. National Initiatives

#### 8.1.1. ANR Projects

- ANR-MOST **BIOPSY** (2016-2020) on “Biochemical Programming System”, coordinated by F. Molina (CNRS, Sys2diag, Montpellier) and J.H. Jiang (National Taiwan University), with F. Fages.
- ANR **MEMIP** (2016-2020) on “Mixed-Effects Models of Intracellular Processes”, coordinated by G. Batt, with P. Hersen, (CNRS/Paris7), E. Cinquemani (Inria EPI IBIS) and M. Lavielle (Inria/CNRS/Polytechnique, EPI XPOP).
- ANR **COGEX** (2016-2019) on “Computer Aided Control of Gene Expression” coordinated by P. Hersen (MSC lab, CNRS/Paris7), with G. Batt and G. Truan (LISBP, CNRS/INSA).
- ANR Blanc **HYCLOCK** (2014-2018) on “Hybrid modeling of time for Circadian Clock Biology and Chronopharmacology”, coordinated by F. Delaunay (CNRS, Nice), with F. Lévi (INSERM Paris-Sud), G. Bernot (CNRS I3S, Nice), O. Roux (Ecole Centrale Nantes), F. Fages and S. Soliman.
- ANR Blanc **STOCH-MC** (2014-2018) on “Stochastic Models: Scalable Model Checking”, coordinated by Blaise Genest (Inria Rennes), with Grégory Batt, Wieslaw Zielonka (LIAFA), and Hugo Gimbert (LaBRI).
- ANR Investissement Avenir **ICEBERG** project (2011-2017) “From population models to model populations”, coordinated by Grégory Batt, with Pascal Hersen (MSC lab, Paris Diderot Univ./CNRS), Reiner Veitia (Institut Jacques Monod, Paris Diderot Univ./CNRS), Olivier Gandrillon (BM2A lab, Lyon Univ./CNRS), Cédric Lhoussaine (LIFL/CNRS), and Jean Krivine (PPS lab, Paris Diderot Univ./CNRS).

#### 8.1.2. Inria Project Lab

- IPL **COSY** (2017-2021) “real-time control of synthetic microbial communities”, coordinated by Eugenio Cinquemani (Ibis, Inria), with Jean-Luc Gouzé (Biocore, Inria), Gregory Batt, Frédéric Bonnans (Commands, Inria), Efimov Denis (Non-A, Inria), and Hans Geiselmann (BIOP, Université Grenoble-Alpes), Beatrice Laroche (Maïage, Inra Jouy-en-Josas), and Hyun Youk (Youk lab, TU Delft).

### 8.2. European Initiatives

#### 8.2.1. FP7 & H2020 Projects

- H2020 FET-OPEN **COSY-BIO** (2017-2020), “Control Engineering of Biological Systems for Reliable Synthetic Biology Applications”, coordinated by Diego di Bernardo (Tigem), with Filippo Menolascina (Edinburgh U), Mario di Bernardo (Naples U), Pascal Hersen (Paris7 U), Mustafa Khammash (ETHZ), Gregory Batt, Guy-Bart Stan (Imperial College), and Lucia Marucci (Bristol U).

### 8.3. International Initiatives

#### 8.3.1. Participation in International Programs

- French-German PROCOPE (2015-2017) grant on “Réduction de modèle et analyse de grands réseaux biochimiques par des méthodes stoechiométriques et tropicales”, coord. Prof. Andreas Weber, University of Bonn, Germany, and Prof. Ovidiu Radulescu, Univ. Montpellier, France.

## **M3DISIM Project-Team**

## **9. Partnerships and Cooperations**

### **9.1. National Initiatives**

#### **9.1.1. ANR**

ANR METIS(ANR-13-BS09-0004-02). Title: “Mechanics of Tissues: multiscale structural approach of Ehlers-Danlos Syndrome”. Involved research groups: LMS (Ecole Polytechnique, CNRS, Mines ParisTech, PI: Jean-Marc ALLAIN), LOB - Optics and Biosciences Laboratory (Ecole Polytechnique, CNRS, INSERM), IGFL - Institut de Génétique Fonctionnelle de Lyon (ENS Lyon, Université Lyon 1, CNRS, INRA). Total amount of the grant: 200k€ for the team. The METIS project is dedicated to the study of the biomechanics of connective tissues. Soft connective tissues such as skin, tendon or cornea are made of more than 90% of extracellular matrix proteins, fibrillar collagens being by far the predominant component. The rationale of this project is to understand the link between the microstructure of connective tissues and their macroscopic mechanical properties. To achieve this, observations of the fibrillar collagen will be done at different levels of stretch, while recording the mechanical properties. The consequences of change in the microstructure will also be explored through mutants mimicking the Ehler-Danlos syndrome, but also aging or wound-healing experiments. The project was completed on September 30th 2017 (4 years project).

#### **9.1.2. Other funding**

IPM-MS project (for Imagerie Polarimétrique de Mueller pour la réalisation d'un système original de caractérisation des propriétés mécaniques des Matériaux Structurés). 50k€ funded by the LABEX Lasips. This project, which involves the LPICM laboratory (Ecole Polytechnique, CNRS), the LMS (Ecole Polytechnique, CNRS, Mines ParisTech) and the Centre des Matériaux (Mines ParisTech), aims at developing an optical tool to study the link between the mechanical properties of a material and its hierarchical organization. Despite the development of new methods to observe the microstructure, one of the limitations is the number of observations that can be obtained on a given sample in a realistic experimental time. To overcome this difficulty, we are planning to use the Mueller polarimetry to obtain at a fast rate (a few frames per second, compared to a few frames per half-hour) relevant information on the local anisotropy of biological (heart, skin) and composite (short fibers composite) samples.

G. Bureau, software engineer in the team, is funded by an Inria Reo industrial contract with Kephalios, a startup working on innovative artificial valves devices.

### **9.2. European Initiatives**

#### **9.2.1. FP7 & H2020 Projects**

##### **9.2.1.1. VP2HF**

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

Programm: FP7

Duration: October 2013 - March 2017

Coordinator: King's College London (UK)

Inria contact: Dominique Chapelle

Abstract: Heart failure (HF) is one of the major health issues in Europe affecting 6 million patients and growing substantially because of the aging 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 the 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.

### **9.3. International Initiatives**

#### **9.3.1. Inria International Partners**

##### *9.3.1.1. Informal International Partners*

We have started a collaboration with the University of Texas Southwestern Medical Center in Dallas. A joint PhD student based at Inria and funded by UTSW is starting in October 2017. An associated team proposal has been submitted in October 2017.

### **9.4. International Research Visitors**

#### **9.4.1. Visits of International Scientists**

##### *9.4.1.1. PhD exchange program*

J. Albella, PhD student at University of Santiago de Compostela, has spent 3 months in M3DISIM, working with S. Imperiale on numerical methods for elastodynamics wave propagation.

E. Bertoberoglu, PhD Student at ETH Zurich, has spent multiple weeks in M3DISIM to work with M. Genet on computational models of growth and remodeling of the heart, validated on MRI data acquired at ETH Zurich.

## PARIETAL Project-Team

## 9. Partnerships and Cooperations

### 9.1. Regional Initiatives

#### 9.1.1. *CoSmic project*

**Participants:** Philippe Ciuciu [Correspondant], Carole Lazarus, Loubna El Gueddari.

This is a collaborative project with Jean-Luc Stark, (CEA) funded by the DRF-impulsion CEA program.

Compressed Sensing is a recent theory in maths that allows the perfect recovery of signals or images from compressive acquisition scenarios. This approach has been popularized in MRI over the last decade as well as in astrophysics (noticeably in radio-astronomy). So far, both of these fields have developed skills in CS separately. The aim of the COSMIC project is to foster collaborations between CEA experts in MRI (Parietal team within NeuroSpin) and in astrophysics (CosmoStat lab within the Astrophysics Department). These interactions will allow us to share different expertise in order to improve image quality, either in MRI or in radio-astronomy (thanks to the interferometry principle). In this field, given the data delivered by radio-telescopes, the goal consists in extracting high temporal resolution information in order to study fast transient events.

#### 9.1.2. *BrainAMP project*

**Participants:** Bertrand Thirion [Correspondant], Gaël Varoquaux, Antonio Andre Monteiro Manoel.

This is a collaborative project with Lenka Zdeborová, Theoretical Physics Institute (CEA) funded by the DRF-impulsion CEA program.

In many scientific fields, the data acquisition devices have benefited of hardware improvement to increase the resolution of the observed phenomena, leading to ever larger datasets. While the dimensionality has increased, the number of samples available is often limited, due to physical or financial limits. This is a problem when these data are processed with estimators that have a large sample complexity, such as multivariate statistical models. In that case it is very useful to rely on structured priors, so that the results reflect the state of knowledge on the phenomena of interest. The study of the human brain activity through high-field MRI belongs among these problems, with up to  $10^6$  features, yet a set of observations limited by cost and participant comfort.

We are missing fast estimators for multivariate models with structured priors, that furthermore provide statistical control on the solution. Approximate message passing methods are designed to work optimally with low-sample-complexity, they accommodate rather generic class of priors and come with an estimation of statistical significance. They are therefore well suited for our purposes.

We want to join forces to design a new generation of inverse problem solvers that can take into account the complex structure of brain images and provide guarantees in the low-sample-complexity regime. To this end, we will first adapt AMP to the brain mapping setting, using first standard sparsity priors (e.g. Gauss-Bernoulli) on the model. We will then consider more complex structured priors that control the variation of the learned image patterns in space. Crucial gains are expected from the use of the EM algorithm for parameter setting, that comes naturally with AMP. We will also examine the estimators provided by AMP for statistical significance. BrainAMP will design a reference inference toolbox released as a generic open source library. We expect a 3- to 10-fold improvement in CPU time, that will benefit to large-scale brain mapping investigations.

#### 9.1.3. *iConnectom project*

**Participants:** Bertrand Thirion [Correspondant], Gaël Varoquaux, Elvis Dohmatob.

This is a Digiteo project (2014-2017).

Mapping brain functional connectivity from functional Magnetic Resonance Imaging (MRI) data has become a very active field of research. However, analysis tools are limited and many important tasks, such as the empirical definition of brain networks, remain difficult due to the lack of a good framework for the statistical modeling of these networks. We propose to develop population models of anatomical and functional connectivity data to improve the alignment of subjects brain structures of interest while inferring an average template of these structures. Based on this essential contribution, we will design new statistical inference procedures to compare the functional connections between conditions or populations and improve the sensitivity of connectivity analysis performed on noisy data. Finally, we will test and validate the methods on multiple datasets and distribute them to the brain imaging community.

#### 9.1.4. *MetaCog project*

**Participants:** Bertrand Thirion [Correspondant], Gaël Varoquaux, Jérôme Dockès.

This is a Digicosme project (2016-2019) and a collaboration with Fabian Suchanek (Telecom Paritech).

Understanding how cognition emerges from the billions of neurons that constitute the human brain is a major open problem in science that could bridge natural science –biology– to humanities –psychology. Psychology studies performed on humans with functional Magnetic Resonance Imaging (fMRI) can be used to probe the full repertoire of high-level cognitive functions. While analyzing the resulting image data for a given experiment is a relatively well-mastered process, the challenges in comparing data across multiple datasets poses serious limitation to the field. Indeed, such comparisons require to pool together brain images acquired under different settings and assess the effect of different *experimental conditions* that correspond to psychological effects studied by neuroscientists.

Such meta-analyses are now becoming possible thanks to the development of public data resources –OpenfMRI <http://openfmri.org> and NeuroVault <http://neurovault.org>. As many others, researchers of the Parietal team understand these data sources well and contribute to them. However, in such open-ended context, the description of experiments in terms of cognitive concepts is very difficult: there is no universal definition of cognitive terms that could be employed consistently by neuroscientists. Hence meta-analytic studies loose power and specificity. On the other hand, <http://brainspell.org> provide a set of curated annotation, albeit on much less data, that can serve as a seed or a ground truth to define a consensual ontology of cognitive concepts. Relating these terms to brain activity poses another challenge, of statistical nature, as brain patterns form high-dimensional data in perspective with the scarcity and the noise of the data.

The purpose of this project is to learn a semantic structure in cognitive terms from their occurrence in brain activation. This structure will simplify massive multi-label statistical-learning problems that arise in brain mapping by providing compact representations of cognitive concepts while capturing the imprecision on the definition these concepts.

#### 9.1.5. *HighDimStat project*

**Participants:** Bertrand Thirion [Correspondant], Jérôme-Alexis Chevalier, Joseph Salmon.

This is a Digicosme project (2017-2020) and a collaboration with Joseph Salmon (Telecom Paritech).

The HiDimStat project aims at handling uncertainty in the challenging context of high dimensional regression problem. Though sparse models have been popularized in the last twenty years in contexts where many features can explain a phenomenon, it remains a burning issue to attribute confidence to the predictive models that they produce. Such a question is hard both from the statistical modeling point of view, and from a computation perspective. Indeed, in practical settings, the amount of features at stake (possibly up to several millions in high resolution brain imaging) limit the application of current methods and require new algorithms to achieve computational efficiency. We plan to leverage recent developments in sparse convex solvers as well as more efficient reformulations of testing and confidence interval estimates to provide several communities with practical software handling uncertainty quantification. Specific validation experiments will be performed in the field of brain imaging.

### 9.1.6. AMPHI project

**Participants:** Bertrand Thirion [Correspondant], Joseph Salmon, Antonio Andre Monteiro Manoel.

This is a Digicosme project (2017-2020) and a collaboration with Joseph Salmon (Telecom Paritech) and Lenka Zdeborova (CEA, IPHT).

In many scientific fields, the data acquisition devices have benefited of hardware improvement to increase the resolution of the observed phenomena, leading to ever larger datasets. While the dimensionality has increased, the number of samples available is often limited, due to physical or financial limits. This is a problem when these data are processed with estimators that have a large sample complexity, such as multivariate statistical models. In that case it is very useful to rely on structured priors, so that the results reflect the state of knowledge on the phenomena of interest. The study of the human brain activity through neuroimaging belongs among these problems, with up to  $10^6$  features, yet a set of observations limited by cost and participant comfort. We are missing fast estimators for multivariate models with structured priors, that furthermore provide statistical control on the solution. Approximate message passing (AMP) methods are designed to work optimally with low- sample-complexity, they accommodate rather generic class of priors and come with an estimation of statistical significance. They are therefore well suited for our purposes. We want to join forces to design a new generation of inverse problem solvers that can take into account the complex structure of brain images and provide guarantees in the low-sample-complexity regime. To this end, we will first adapt AMP to the brain mapping setting, using first standard sparsity priors (e.g. Gauss-Bernoulli) on the model. We will then consider more complex structured priors that control the variation of the learned image patterns in space. Crucial gains are expected from the use of the EM algorithm for parameter setting, that comes naturally with AMP. We will also examine the estimators provided by AMP for statistical significance. AMPHI will design a reference inference toolbox released as a generic open source library. We expect a 3- to 10-fold improvement in CPU time, that will benefit to large-scale brain mapping investigations.

### 9.1.7. CDS2

**Participants:** Bertrand Thirion [Correspondant], Gaël Varoquaux, Guillaume Lemaître, Joris Van Den Bossche.

CDS2 is an "Strategic research initiative" of the Paris Saclay University Idex <http://datascience-paris-saclay.fr>. Although it groups together many partners of the Paris Saclay ecosystem, Parietal has been deeply involved in the project. It currently funds a post-doc for Guillaume Lemaître and an engineer position for Joris van den Bossche.

## 9.2. National Initiatives

### 9.2.1. ANR

#### 9.2.1.1. MultiFracs project

**Participants:** Philippe Ciuciu [Correspondant], Daria La Rocca.

The scale-free concept formalizes the intuition that, in many systems, the analysis of temporal dynamics cannot be grounded on specific and characteristic time scales. The scale-free paradigm has permitted the relevant analysis of numerous applications, very different in nature, ranging from natural phenomena (hydrodynamic turbulence, geophysics, body rhythms, brain activity,...) to human activities (Internet traffic, population, finance, art,...).

Yet, most successes of scale-free analysis were obtained in contexts where data are univariate, homogeneous along time (a single stationary time series), and well-characterized by simple-shape local singularities. For such situations, scale-free dynamics translate into global or local power laws, which significantly eases practical analyses. Numerous recent real-world applications (macroscopic spontaneous brain dynamics, the central application in this project, being one paradigm example), however, naturally entail large multivariate data (many signals), whose properties vary along time (non-stationarity) and across components (non-homogeneity), with potentially complex temporal dynamics, thus intricate local singular behaviors.



These three issues call into question the intuitive and founding identification of scale-free to power laws, and thus make uneasy multivariate scale-free and multifractal analyses, precluding the use of univariate methodologies. This explains why the concept of scale-free dynamics is barely used and with limited successes in such settings and highlights the overriding need for a systematic methodological study of multivariate scale-free and multifractal dynamics. The Core Theme of MULTIFRACS consists in laying the theoretical foundations of a practical robust statistical signal processing framework for multivariate non homogeneous scale-free and multifractal analyses, suited to varied types of rich singularities, as well as in performing accurate analyses of scale-free dynamics in spontaneous and task-related macroscopic brain activity, to assess their natures, functional roles and relevance, and their relations to behavioral performance in a timing estimation task using multimodal functional imaging techniques.

This overarching objective is organized into 4 Challenges:

1. Multivariate scale-free and multifractal analysis,
2. Second generation of local singularity indices,
3. Scale-free dynamics, non-stationarity and non-homogeneity,
4. Multivariate scale-free temporal dynamics analysis in macroscopic brain activity.

#### 9.2.1.2. *NiConnect project*

**Participants:** Bertrand Thirion, Gaël Varoquaux [Correspondant], Kamalaker Reddy Dadi, Darya Chyzyk, Mehdi Rahim.

- **Context:** The NiConnect project (2012-2017) arises from an increasing need of medical imaging tools to diagnose efficiently brain pathologies, such as neuro-degenerative and psychiatric diseases or lesions related to stroke. Brain imaging provides a non-invasive and widespread probe of various features of brain organization, that are then used to make an accurate diagnosis, assess brain rehabilitation, or make a prognostic on the chance of recovery of a patient. Among different measures extracted from brain imaging, functional connectivity is particularly attractive, as it readily probes the integrity of brain networks, considered as providing the most complete view on brain functional organization.
- **Challenges:** To turn methods research into popular tool widely usable by non specialists, the NiConnect project puts specific emphasis on producing high-quality open-source software. NiConnect addresses the many data analysis tasks that extract relevant information from resting-state fMRI datasets. Specifically, the scientific difficulties are *i)* conducting proper validation of the models and tools, and *ii)* providing statistically controlled information to neuroscientists or medical doctors. More importantly, these procedures should be robust enough to perform analysis on limited quality data, as acquiring data on diseased populations is challenging and artifacts can hardly be controlled in clinical settings.
- **Outcome of the project:** In the scope of computer science and statistics, NiConnect pushes forward algorithms and statistical models for brain functional connectivity. In particular, we are investigating structured and multi-task graphical models to learn high-dimensional multi-subject brain connectivity models, as well as spatially-informed sparse decompositions for segmenting structures from brain imaging. With regards to neuroimaging methods development, NiConnect provides systematic comparisons and evaluations of connectivity biomarkers and a software library embedding best-performing state-of-the-art approaches. Finally, with regards to medical applications, the NiConnect project also plays a support role in on going medical studies and clinical trials on neurodegenerative diseases.
- **Consortium**
  - Parietal Inria research team: applied mathematics and computer science to model the brain from MRI
  - LIF INSERM research team: medical image data analysis and modeling for clinical applications

- CATI center: medical image processing center for large scale brain imaging studies
- Henri-Mondor hospital neurosurgery and neuroradiology: clinical teams conducting research on treatments for neurodegenerative diseases, in particular Huntington and Parkinson diseases
- Logilab: consulting in scientific computing

## 9.3. European Initiatives

### 9.3.1. FP7 & H2020 Projects

#### 9.3.1.1. HBP

Title: The Human Brain Project

Programm: FP7

Duration: October 2013 - September 2016

Coordinator: EPFL

Partners:

- Inria contact: Olivier Faugeras
- 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.

## 9.4. International Initiatives

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

#### 9.4.1.1. MetaMRI

Title: Machine learning for meta-analysis of functional neuroimaging data

International Partner (Institution - Laboratory - Researcher):

Stanford (United States) - Department of Psychology - Russ Poldrack

Start year: 2015

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

Neuroimaging produces huge amounts of complex data that are used to better understand the relations between brain structure and function. Observing that the neuroimaging community is still largely missing appropriate tools to store and organize the knowledge related to the data, Parietal team and Poldrack's lab, have decided to join forces to set up a framework for functional brain image meta-analysis, i.e. a framework in which several datasets can be jointly analyzed in order to accumulate information on the functional specialization of brain regions. MetaMRI will build upon Poldrack's lab expertise in handling, sharing and analyzing multi-protocol data and Parietal's recent developments of machine learning libraries to develop a new generation of meta-analytic tools.

#### 9.4.1.2. *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: 2016

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.

## 9.5. International Research Visitors

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

Parietal has welcome François Meyer, Univ Colorado at Boulder, for a six months visit (Jan-June 2017), funded by a D'Alembert fellowship of Paris Saclay University. The project of François is to assess novel statistical models of functional connectivity based on the generalized resistivity model he has developed within a graph theoretical framework.

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

#### *9.5.2.1. Research Stays Abroad*

##### **9.5.2.1.1. Denis Engemann**

has spent two months in Boston (April-May) with the MEG Core lab, Athinoula A. Martinos Center (MGH/Harvard-MIT) working on functional connectivity methods and population analysis for MEG.

##### **9.5.2.1.2. Arthur Mensch**

has spent 3 months in Japan (Sept-Dec) with NTT, working on dynamic time warping problems with Mathieu Blondel.

##### **9.5.2.1.3. Jérôme Dockès**

has spent two months with Poldracklab at Stanford, as part of the MetaMRI associated team. He has worked on the statistical relationships between neuroscientific concepts (whether anatomical or cognitive) and brain activation loci.

## **XPOP Project-Team**

# **9. Partnerships and Cooperations**

## **9.1. National Initiatives**

### **9.1.1. ANR**

*Mixed-Effects Models of Intracellular Processes: Methods, Tools and Applications (MEMIP)*

Coordinator: Gregory Batt (InBio Inria team)

Other partners: InBio and IBIS Inria teams, Laboratoire Matière et Systèmes Complexes (UMR 7057; CNRS and Paris Diderot Univ.)

### **9.1.2. Institut National du Cancer (INCa)**

*Targeting Rac-dependent actin polymerization in cutaneous melanoma - Institut National du Cancer*

Coordinator: Alexis Gautreau (Ecole Polytechnique)

Other partners: Laboratoire de Biochimie (Polytechnique), Institut Curie, INSERM.

## **9.2. International Initiatives**

### **9.2.1. Informal International Partners**

Marc Lavielle is Adjunct Professor at the Faculty of Pharmacy of Florida University.

Marc Lavielle is Adjunct Professor at the Faculty of Pharmacy of Buffalo University.

Julie Josse collaborates with Susan Holmes, Stanford University.

Eric Moulines regularly collaborates with Sean P. Meyn, University of Florida.

Geneviève Robin was recipient of a *Visiting Student Researcher Fellowship* from the France Stanford Centre for a research fellowship in the Department of Statistics at Stanford University. She worked on imputation of missing data to medical databases in a distributed framework.

## **9.3. International Research Visitors**

### **9.3.1. Visits of International Scientists**

Ricardo Rios, Universidad Central de Venezuela, Caracas: September 2017.

## INFINE Project-Team

# 8. Partnerships and Cooperations

## 8.1. National Initiatives

### 8.1.1. Equipex FIT

**Participants:** Cedric Adjih, Emmanuel Baccelli, Alexandre Abadie, Philippe Lubrano, Ichrak Amdouni, Alaeddine Weslati, Vincent Ladeveze.

**Partners:** Inria (Lille, Sophia-Antipolis, Grenoble), INSA, UPMC, Institut Telecom Paris, Institut Télécom Evry, LSIT Strasbourg.



*Figure 3. FIT IoT-LAB site in Saclay*

FIT (Future Internet of Things) aims to develop an experimental facility, a federated and competitive infrastructure with international visibility and a broad panel of customers. It provides this facility with a set of complementary components that enable experimentation on innovative services for academic and industrial users. The project gives french internet stakeholders a means to experiment on mobile wireless communications at the network and application layers thereby accelerating the design of advanced networking technologies for the future internet. FIT was one of 52 winning projects from the first wave of the French Ministry of Higher Education and Research's "Équipements d'Excellence" (Equipex) research grant program, in 2011.

One component of the FIT platform is the sets of IoT-LAB testbeds (see [the IoT-LAB web site](#)). These were motivated by the observation that the world is moving towards an "Internet of Things", in which most communication over networks will be between objects rather than people.

The Infine team is more specifically managing the FIT IoT-LAB site formerly at Rocquencourt, which recently moved to Saclay (on-going re-deployment), and is participating in the deployment of an additional IoT-lab testbed in Berlin (at Freie Universitaet Berlin).

## 8.2. European Initiatives

### 8.2.1. FP7 & H2020 Projects

#### 8.2.1.1. AGILE (H2020 project)

**Participants:** Emmanuel Baccelli, Cedric Adjih.

Program: H2020 ICT-30-2015 Topic: Internet of Things and Platforms for Connected Smart Objects

Project acronym: AGILE

Project title: Adoptive Gateways for dIverse muLtipLe Environments

Duration: 2015-2017

Coordinator: Emmanuel Baccelli

Other partners: Canonical (UK), Eclipse IoT Foundation (IE), Mobistar (BE), Libelium (ES), Startupbootcamp IoT (SP), CREATE-NET (IT), iMinds (BE), Atos (SP), Rulemotion (UK), Jolocom (DE), Passau University (DE), Sky-Watch (DN), BioAssist (GR), Graz Technical University (AT), Eurotech (IT), IoTango (US).

Abstract:

The AGILE project is a 3-year H2020 project started in January 2016, which will deliver an integrated framework of open source tools and platforms that interoperate for enabling the delivery of adaptive, self-configurable and secure IoT elements (both software and hardware) that can be utilized in a variety of scenarios. Such tools target actors with heterogeneous skills, including entrepreneurs, researchers, and individuals, aiming to enable the realization of IoT applications respecting user privacy and data ownership.

#### 8.2.1.2. ARMOUR (H2020 project)

**Participants:** Emmanuel Baccelli, Cedric Adjih.

Program: H2020 ICT-12-2015 Topic: Integrating experiments and facilities in FIRE+

Project acronym: ARMOUR

Project title: Large-Scale Experiments of IoT Security Trust

Duration: 2016-2018

Coordinator: Serge Fdida (UPMC)

Other partners: UPMC (France), Synelixis (Greece), SMA (France), UI (Portugal), JRC (Belgium), EGM (France), OdinS (Spain).

Abstract: The ARMOUR project is a 2-year H2020 project started in February 2016. The ARMOUR project is aimed at providing duly tested, benchmarked and certified Security & Trust technological solutions for large-scale IoT using upgraded FIRE large scale IoT/Cloud testbeds properly-equipped for Security & Trust experimentations. To this, ARMOUR will: (1) Enhance two outstanding FIRE testbeds (> 2700 nodes; 500 users) with the ARMOUR experimentation toolbox for enabling large-scale IoT Security & Trust experiments; (2) Deliver six properly experimented, suitably validated and duly benchmarked methods and technologies for enabling Security & Trust in the large-scale IoT; and (3) Define a framework to support the design of Secure & Trusted IoT applications as well as establishing a certification scheme for setting confidence on Security & Trust IoT solutions.

### 8.2.2. Collaborations with Major European Organizations

#### 8.2.2.1. EU CHIST-ERA MACACO

**Participants:** Aline Carneiro Viana, Emmanuel Baccelli, Eduardo Mucelli.

Program: EU CHIST-ERA, topic Context- and Content-Adaptive Communication Networks

Project acronym: MACACO

Project title: Mobile context-Adaptive CAching for COntent-centric networking

Duration: 2013-2017 (extended until December 2017)

Coordinator: Aline Carneiro Viana

Other partners: INPT-ENSEEIH at University of Toulouse, University of Birmingham (UK), SUPSI (Switzerland), CNR (Italy) and Federal University of Minas Gerais (Brazil)

Abstract:

MACACO (Mobile context-Adaptive CACHing for Content-centric networking ) is a 3-year CHIST-ERA European Project addressing the topic Context- and Content-Adaptive Communication Networks. Due to delay in funding access and data collection campaign we got an extension until December 2017. It is funded by ANR in France, SNSF in Switzerland, and ESPRC in UK. It focus on data offloading mechanisms that take advantage of context and content information. Our intuition is that if it is possible to extract and forecast the behaviour of mobile network users in the three dimensional space of time, location and interest (i.e. what, when and where users are pulling data from the network), it is possible to derive efficient data offloading protocols. Such protocols would pre-fetch the identified data and cache it at the network edge at an earlier time, preferably when the mobile network is less charged, or offers better quality of service. This project has officially started in November 2013.

## 8.3. International Initiatives

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

#### 8.3.1.1. EMBRACE

Title: Leveraging Human Behavior and Uncertainty in 5G Networks to Build Robust Resource Allocation and Services Orchestration Models

International Partners (Institution - Laboratory - Researcher):

UTFPR (Brazil) - Departamento Academico de Informatica (DAINF) Curso de Pos-Graduacao em Engenharia Eletrica e Informatica Industrial (CPGEI) - Anelise Munaretto

UFG (Brazil) - Institute of Computational Mathematics and Scientific / Engineering Computing - Kleber Vieira Cardoso

UFMG (Brazil) - Dpt of Statistics - Antonio A. F. Loureiro

Start year: 2017

See also: <https://team.inria.fr/infine/embrace/>

EMBRACE propose une architecture novatrice pour gérer des ressources et des services opérationnels hétérogènes. EMBRACE se concentre sur les défis scientifiques liés des ensembles de données collectées dans le monde réel et décrivant le comportement du réseau des utilisateurs. En particulier, EMBRACE exploite la modélisation du comportement humain en termes de mobilité, de demande de contenu, d'intérêts communs et des interactions entre-utilisateurs. En construisant des modèles d'allocation des ressources tenant compte de l'utilisateur, EMBRACE a pour objectif de diminuer l'incertitude et mieux cerner les profils humains dans les réseaux 5G. La communication D2D sera également utilisée comme service opérationnel pour gérer la croissance du trafic mobile en libérant des ressources des réseaux cellulaires, sans augmenter les coûts. La nouveauté de l'architecture réside dans les algorithmes conçus qui exploiteront les caractérisations tirés de l'analyse du comportement des utilisateurs, l'hétérogénéité du réseau, et de l'incertitude. L'évaluation par simulation et l'émulation sera également l'un des thèmes clés. Enfin, les équipes concernées (Inria Infine, UFMG, UFG, UTFPR) ont un long historique de coopération sur ces thèmes.

### 8.3.2. Inria International Partners

#### 8.3.2.1. Declared Inria International Partners

1. Renewed IOTPUSH collaboration with Freie Universitaet Berlin around the long-term stay of Emmanuel Baccelli in Berlin, on research topics about the Internet of Things, RIOT and Information-Centric Networking.

#### 8.3.2.2. Informal International Partners

1. On-going collaboration with Freie Universitaet Berlin and Hamburg University of Applied Science around RIOT.
2. Informal collaborations with UIUC and UMass.



3. Informal collaborations with ENSI Tunis and Sesame Tunis.
4. On-going strong collaboration with Sapienza University of Rome, Italy.
5. On-going strong collaboration with CNR Torino, Italy.
6. On-going collaboration with University of Porto, Portugal.
7. On-going collaboration with ENSAE/CNRS, France.
8. On-going collaboration with University of Edinburgh, UK.

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

#### 8.3.3.1. *Indo-French project*

The Inria teams Infine and Eva are part of the "D2D Communication for LTE Advanced Cellular Network", a project funded by the Indo-French Centre for the Promotion of Advanced Research (CEFIPRA). With industrial partners, and also with Indian partners, this project is focusing on the evolution of cellular networks towards 5G: this includes exploration of device-to-device (D2D) communication, and more generally IoT communication in a cellular context. Research directions include efficient access for IoT devices (massive numbers of devices with low volume communication); combination of random access protocols/error coding/physical layer ; efficient neighbor discovery, ....

#### 8.3.3.2. *STIC AmSud MOTIf 2017*

**Participant:** Aline Carneiro Viana.

Program: STIC AmSud

Project title: Mobile phone sensing of human dynamics in techno-social environment

Duration: 2017-2019

Coordinators: Marton Karsai (ENS/Inria) and Jussara M. Almeida (UFMG) and Alejo Salles (Univ. of Buenos Aires)

**Abstract:** Information and Communication Technology (ICT) is becoming increasingly social, as demonstrated by the multitude of emerging technologies and technology platforms that facilitate social interactions, taking place as communication via telephone, text message, email, online social networks etc. At the same time, our social activities are increasingly embedded in the ICT environments that enable and enhance our ability to transact, share experiences, and maintain social relationships. One of the best ways to explore these developments is through the mining and analysis of data, which are collected through mobile phones and allow us to investigate how individuals act when embedded in a technology-enabled environment. The MOTIf project builds on the analysis and modeling of geo-localized temporally detailed but fully anonymised mobile phone call networks. These datasets allow us to address the two scientific objectives about spatiotemporal patterns of service usage of anonymised individuals to learn when, where, and what people are doing; and about the fine-grained sociodemographic structure of society and its effect on the the individual social behaviour. In other words our goal in general is to understand how individuals behave in a dynamic techno-social environment.

## 8.4. International Research Visitors

### 8.4.1. *Visits of International Scientists*

**Rik Sarkar** was Visiting Researcher at Infine for 3 days. He worked with Aline C. Viana and the internship Maria Astefanoaei on predicting new places to visit in human mobility decision.

**Julinda Stefa** was Visiting Researcher at Infine for 3 months. She worked with Aline C. Viana and the internship Adriano Di Luzio on the inference of human personality from mobile phones datasets.

**Ana Aguiar** was Visiting Researcher at Infine for 3 days. She worked with Aline C. Viana and the internship Emanuel Lima on data offloading decision via mobile crowdsensing.

#### 8.4.1.1. Internships

**Panagiota Katsikouli** did an internship of 5 months at Infine working with Aline C. Viana and Marco Fiore on sampling frequency of human mobility.

**Maria Astefanoaei** did an internship of 5 months at Infine working with Aline C. Viana and Rik Sarkar on predicting new places to visit in human mobility decision.

**Adriano Di Luzio** did an internship of 4 months at Infine working with Aline C. Viana and Julinda Stefa on the inference of human personality from mobile phones datasets.

**Emanuel Lima** did an internship of 3 months at Infine working with Aline C. Viana and Ana Aguiar on data offloading decision via mobile crowdsensing.

**Ayat Zaki Hindi** did an internship of 6 months at Infine working with Cedric Adjih, Michel Kieffer and C. Weidmann on synchronization strategy in Information-Centric Networks.

#### 8.4.2. Visits to International Teams

##### 8.4.2.1. Research Stays Abroad

**Emmanuel Baccelli** is Visiting Professor at Freie Universitaet (FU) Berlin, within the context of the formal collaboration IOTPUSH with this university on research topics about the Internet of Things, RIOT and Information-Centric Networking.

## AVIZ Project-Team

## 7. Partnerships and Cooperations

### 7.1. European Initiatives

#### 7.1.1. FP7 & H2020 Projects

##### 7.1.1.1. CENDARI

Title: Collaborative European Digital/Archival Infrastructure

Programm: FP7

Duration: February 2012 - January 2016

Coordinator: Trinity College - Dublin

Partners:

Consortium of European Research Libraries (United Kingdom)

Koninklijke Bibliotheek (Netherlands)

Fondazione Ezio Franceschini Onlus (Italy)

Freie Universitaet Berlin (Germany)

King's College London (United Kingdom)

"matematicki Institutnu, Beograd" (Serbia)

Narodni Knihovna Ceske Republiky (Czech Republic)

Societa Internazionale Per Lo Studio Del Medioevo Latino-S.I.S.M.E.L.Associazione (Italy)

The Provost, Fellows, Foundation Scholars & The Other Members of Board of The College of The Holy & Undivided Trinity of Queen Elizabeth Near Dublin (Ireland)

Georg-August-Universitaet Goettingen Stiftung Oeffentlichen Rechts (Germany)

The University of Birmingham (United Kingdom)

Universitaet Stuttgart (Germany)

Universita Degli Studi di Cassino E Del Lazio Meridionale (Italy)

Inria contact: L. Romary

'The Collaborative European Digital Archive Infrastructure (CENDARI) will provide and facilitate access to existing archives and resources in Europe for the study of medieval and modern European history through the development of an 'enquiry environment'. This environment will increase access to records of historic importance across the European Research Area, creating a powerful new platform for accessing and investigating historical data in a transnational fashion overcoming the national and institutional data silos that now exist. It will leverage the power of the European infrastructure for Digital Humanities (DARIAH) bringing these technical experts together with leading historians and existing research infrastructures (archives, libraries and individual digital projects) within a programme of technical research informed by cutting edge reflection on the impact of the digital age on scholarly practice. The enquiry environment that is at the heart of this proposal will create new ways to discover meaning, a methodology not just of scale but of kind. It will create tools and workspaces that allow researchers to engage with large data sets via federated multilingual searches across heterogeneous resources while defining workflows enabling the creation of personalized research environments, shared research and teaching spaces, and annotation trails, amongst other features. This will be facilitated by multilingual authority lists of named entities (people, places, events) that will harness user involvement to add intelligence to the system. Moreover, it will develop new visual paradigms for the exploration of patterns generated by the system, from knowledge transfer and dissemination, to language usage and shifts, to the advancement and diffusion of ideas.'

## 7.2. International Initiatives

### 7.2.1. *Informal International Partners*

- University of Calgary. Pierre Dragicevic and Petra Isenberg collaborate with Wesley Willett on situated data visualization.
- University of Washington, Chicago University and University of Zurich. Pierre Dragicevic collaborates with Matthew Kay, Steve Haroz and Chat Wacharamanatham on transparent statistical reporting and efficient statistical communication
- Stanford University. Pierre Dragicevic and Jean-Daniel Fekete collaborate with Sean Follmer on swarm user interfaces.
- Chicago University and University of Maryland, Evanthia Dimara and Pierre Dragicevic collaborate with Steven Franconeri and Catherine Plaisant on a taxonomy of cognitive biases.

## 7.3. International Research Visitors

### 7.3.1. *Visits of International Scientists*

- Catherine Plaisant (June–July): Invited professor from University of Maryland, USA. Invited through a DigiCosme grant, Catherine Plaisant has spent two months with Aviz. We have launched two research projects, one on hypergraph visualization and one on tracing users to understand their use of visualization. Catherine Plaisant has interacted with all of the Aviz students and post-doctoral fellows, as well as with the permanent researchers.
- Paolo Buono, from University of Bari, Italy. Paolo Buono has spent two months with Aviz working on the visualization of dynamic networks. He has collaborated with Paoa Valdivia, Catherine Plaisant, and Jean-Daniel Fekete for that project. He has also interacted with all the members of Aviz.

#### 7.3.1.1. *Internships*

- Jaemin Jo (March–April): intern from Seoul National University, Korea. Worked on converting a KNN algorithm into a progressive form.
- Nicola Pezzotti (April–May): intern from University of Delft, The Netherlands. Worked on data structures and algorithms for managing very large (out of core) datasets in the context of progressive algorithms.

## CEDAR Team

## 8. Partnerships and Cooperations

### 8.1. National Initiatives

#### 8.1.1. ANR

- AIDE (“A New Database Service for Interactive Exploration on Big Data”) is an ANR “Young Researcher” project led by Y. Diao, started at the end of 2016.
- CBOD (“Cloud-Based Organizational Design”) is a 4-year ANR started in 2014, coordinated by prof. Ahmed Bounfour from UPS. Its goal is to study and model the ways in which cloud computing impacts the behavior and operation of companies and organizations, with a particular focus on the cloud-based management of data, a crucial asset in many companies.
- ContentCheck (2015-2018) is an ANR project in collaboration with U. Rennes 1 (F. Goasdoué), INSA Lyon (P. Lamarre), the LIMSI lab from U. Paris Sud, and the Le Monde newspaper, in particular their fact-checking team Les Décodeurs. Its aim is to investigate content management models and tools for journalistic fact-checking.

#### 8.1.2. LabEx, IdEx

- CloudSelect is a three-years project started in October 2015. It is financed by the *Institut de la Société Numérique* (ISN) of the IDEX Paris-Saclay; it funds the PhD scholarship of S. Cebiric. The project is a collaboration with A. Bounfour from the economics department of Université Paris Sud. The project aims at exploring technical and business-oriented aspects of data mobility across cloud services, and from the cloud to outside the cloud.

#### 8.1.3. Others

- ODIN is a four-year project started in 2014, funded by the Direction Générale de l’Armement, between the SemSoft company, IRISA Rennes and Cedar. The project aims to develop a complete framework for analytics on Web data, in particular taking into account uncertainty, based on Semantic Web technologies such as RDF.
- The goal of the iCODA project is to develop the scientific and technological foundations for knowledge-mediated user-in-the-loop collaborative data analytics on heterogeneous information sources, and to demonstrate the effectiveness of the approach in realistic, high-visibility use-cases. The project stands at the crossroad of multiple research fields—content analysis, data management, knowledge representation, visualization—that span multiple Inria themes, and counts on a club of major press partners to define usage scenarios, provide data and demonstrate achievements. This is a project funded directly by Inria (“Inria Project Lab”), and is in collaboration with GraphIK, ILDA, LINKMEDIA (coordinator), as well as the press partners AFP, Le Monde (Les Décodeurs) and Ouest-France.

### 8.2. International Initiatives

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

##### 8.2.1.1. WebClaimExplain

Title: Mining for explanations to claims published on the Web

International Partner (Institution - Laboratory - Researcher):

AIST (Japan) - Julien Leblay

Start year: 2017

See also: <https://team.inria.fr/cedar/projects/webclaimexplain/>

The goal of this research is to create tools to find explanations for facts and verify claims made online. While this process cannot be fully automated, the main focus of our work will be explanation finding via trusted sources, based on the observation that one can only trust a statement if he/she can explain it through rules and proofs that can themselves be trusted.

## **8.3. International Research Visitors**

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

#### *8.3.1.1. Internships*

Lars Kegel, a PhD student at the university of Dresden, is visiting the team since September 2017. He is working on the systematic description of time series with features that capture the global, structural characteristics of a series in a lower dimensional space.

## **EX-SITU Project-Team**

## **8. Partnerships and Cooperations**

### **8.1. Regional Initiatives**

#### ***8.1.1. MoveIT – Modeling the Speed/Accuracy Trade-Off of Human Aimed Movement with the Tools of Information Theory***

Type: Ph.D. grant

Funding: DigiCosme Labex

Duration: 2015-2018

Coordinator: Olivier Rioul (Institut Mines Telecom)

Partners: Univ. Paris-Sud, Inria, CNRS, Institut Mines-Telecom

Inria contact: Michel Beaudouin-Lafon

Abstract: The goal of this project is to conduct fundamental studies of aimed movements based on information theory. The project studies the interaction phenomena involved in pointing, in order to discover novel, more effective pointing techniques. This project funds Wanyu Liu, a joint Ph.D. student between the COMELEC and VIA groups at Institut Mines Telecom and ExSitu.

#### ***8.1.2. SensoMotorCVE – Sensor-motor Interface for Collaborative Virtual Environments with Heterogeneous Devices: Application to Industrial Design***

Type: Ph.D. grant

Funding: DigiCosme Labex

Duration: 2014-2017

Coordinator: Patrick Bourdot (LIMSI-CNRS)

Partners: Univ. Paris-Sud, Inria, CNRS

Inria contact: Cédric Fleury

Abstract: In the context of collaborative virtual environments, the goal of this project is to develop a sensorimotor interface model for CAD data manipulation that supports heterogeneous interactive systems such as wall-sized displays or immersive virtual reality rooms. This project funds Yujiro Okuya, a joint Ph.D. student between the VENISE group at LIMSI and ExSitu.

#### ***8.1.3. An Augmented-Reality System for Collaborative Physical Modeling and Design***

Type: Equipment

Funding: STIC Paris-Saclay

Duration: 2017-2018

Coordinator: Theophanis Tsandilas

Partners: Univ. Paris-Sud, Inria

Inria contact: Theophanis Tsandilas

Abstract: The goal of the project is to develop an augmented-reality system to support collaboration over 3D models and enhance digital-fabrication approaches. It is a collaboration with the AVIZ group and provides funding (8k) for equipment.

#### ***8.1.4. Le Plateau des Recherches Infinies***

Type: Equipment and subcontracting

Funding: Learning Center Paris-Saclay

Duration: 2017-2018

Coordinator: Michel Beaudouin-Lafon

Partners: Univ. Paris-Sud

Inria contact: Michel Beaudouin-Lafon

Abstract: The goal of this project (30k) is to create an interactive installation presenting the portraits of a hundred researchers from Université Paris-Saclay. It is a collaboration with portrait photographer Didier Goupy. The installation is designed to be exhibited in various sites of Université Paris-Saclay until it is permanently installed in the Learning Center of Université Paris-Saclay. This project supported Shubhangi Gupta, an intern, for two months over the summer.

## 8.2. National Initiatives

### 8.2.1. *Investissements d'Avenir*

#### 8.2.1.1. *Digiscope - Collaborative Interaction with Complex Data and Computation*

Type: EQUIPEX (Equipement d'Excellence)

Duration: 2011-2021

Coordinator: Michel Beaudouin-Lafon

Partners: FCS Paris-Saclay (coordinator), Université Paris-Sud, CNRS, CEA, Inria, Institut Mines-Telecom, Ecole Centrale Paris, Université Versailles - Saint-Quentin, ENS Cachan, Maison de la Simulation

Overall budget: 22.5 Meuros, including 6.7 Meuros public funding from ANR

Abstract: The goal of the project is to create ten high-end interactive rooms interconnected by high-speed networks and audio-video facilities to support remote collaboration across interactive visualization environments. The equipment will be open to outside users and targets four main application areas: scientific discovery, product lifetime management, decision support for crisis management, and education and training. Digiscope includes the existing WILD room, and funded the WILDER room. ExSitu contributes its expertise in the design and evaluation of advanced interaction techniques and the development of distributed software architectures for interactive systems. At the end of 2017, all ten rooms and the telepresence network are operational. The project was successfully evaluated by an international jury in June, 2017.

## 8.3. European Initiatives

### 8.3.1. *European Research Council (ERC)*

#### 8.3.1.1. *Creating Human-Computer Partnerships*

Program: ERC Advanced Grant

Project acronym: CREATIV

Project title: Creating Human-Computer Partnerships

Duration: mois année début - mois année fin

Coordinator: Wendy Mackay



Abstract: CREATIV explores how the concept of co-adaptation can revolutionize the design and use of interactive software. Co-adaptation is the parallel phenomenon in which users both adapt their behavior to the system's constraints, learning its power and idiosyncrasies, and appropriate the system for their own needs, often using it in ways unintended by the system designer. A key insight in designing for co-adaptation is that we can encapsulate interactions and treat them as first class objects, called interaction instruments. This lets us focus on the specific characteristics of how human users express their intentions, both learning from and controlling the system. By making instruments co-adaptive, we can radically change how people use interactive systems, providing incrementally learnable paths that offer users greater expressive power and mastery of their technology. The initial goal of the CREATIV project is to fundamentally improve the learning and expressive capabilities of advanced users of creative software, offering significantly enhanced methods for expressing and exploring their ideas. The ultimate goal is to radically transform interactive systems for everyone by creating a powerful and flexible partnership between human users and interactive technology.

#### 8.3.1.2. Unified Principles of Interaction

Program: ERC Advanced Grant

Project acronym: ONE

Project title: Unified Principles of Interaction

Duration: October 2016 - September 2020

Coordinator: Michel Beaudouin-Lafon

Abstract: The goal of ONE is to fundamentally re-think the basic principles and conceptual model of interactive systems to empower users by letting them appropriate their digital environment. The project addresses this challenge through three interleaved strands: empirical studies to better understand interaction in both the physical and digital worlds, theoretical work to create a conceptual model of interaction and interactive systems, and prototype development to test these principles and concepts in the lab and in the field. Drawing inspiration from physics, biology and psychology, the conceptual model combines *substrates* to manage digital information at various levels of abstraction and representation, *instruments* to manipulate substrates, and *environments* to organize substrates and instruments into digital workspaces.

## 8.4. International Initiatives

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

#### 8.4.1.1. DECibel

Title: Discover, Express, Create – Interaction Technologies For Creative Collaboration

International Partner (Institution - Laboratory - Researcher):

University of California Berkeley (United States) - Electrical and Computer Engineering,  
Center for Magnetic Resonance Research - Bjoern Hartmann

Start year: 2016

See also: <https://www.inria.fr/en/associate-team/decibel>

The DECibel associated team includes Inria's ExSitu and the CITRIS Connected Communities Initiative (CCI) at UC Berkeley. ExSitu explores extreme interaction, working with creative professionals and scientists who push the limits of technology to develop novel interactive technologies that offer new strategies for creative exploration. ExSitu's research activities include: developing underlying theory (co-adaptive instruments and substrates), conducting empirical studies (participatory design with creative professionals), and implementing interactive systems (creativity support tools). The CITRIS Connected Communities Initiative investigates collaborative discovery and design through new technologies that enhance education, creative work, and public engagement. It develops interactive tools, techniques and materials for the rapid design and prototyping of novel interactive products, expertise sharing among designers, and citizen science investigations. DECibel will combine the strengths of these two groups to investigate novel tools and technologies that support Discovery, Expressivity, and Creativity.

## **8.5. International Research Visitors**

### ***8.5.1. Visits of International Scientists***

- Mobile Life research team (KTH, Sweden) 20 researchers visited ExSitu in January, 2017.
- Susanne Bødker (Aarhus University, Denmark) visited ExSitu in April, 2017.
- Joanna McGrenere (University of British Columbia, Canada) Inria Chair, visited ExSitu in June-July, 2017.

#### ***8.5.1.1. Internships***

- Alessandro Silacci, Haute Ecole d'Ingenierie et d'Architecture de Fribourg (Suisse), "Cross-Surface Expressive Gesture Interactions in Collaboration Scenarios": Michel Beaudouin-Lafon
- Shubhangi Gupta, "Design and Prototyping of Web Interface to the 'Plateau des Recherches Infinies' Installation": Michel Beaudouin-Lafon
- Alexander Eiselmayer, University of Zurich, "Touchstone II": Wendy Mackay and Michel Beaudouin-Lafon

## ILDA Project-Team

## 9. Partnerships and Cooperations

### 9.1. Regional Initiatives

**ScaleGest. Surface Gestures for Advanced Graphical Interfaces: Which Gesture for What.** (2014-2017) Funded by Digiteo. In collaboration with Telecom ParisTech: **109Keuros**. Participants: Caroline Appert (PI), Rafael Morales Gonzalez, Emmanuel Pietriga.

The project aims at designing gesture-based interaction for expert users who navigate and manipulate large datasets. In the context of advanced graphical applications, the number of gestures should be large-enough to cover the set of controls (*i.e.*, commands and parameter settings) but remain simple-enough to avoid exceeding human abilities. Making gesture-based interaction scale with graphical applications' growing complexity can be achieved only by understanding the foundational aspects of this input modality. This project is about characterizing and structuring both the space of application controls and the space of surface gestures in order to establish guidelines for appropriate control-gesture mappings. It is also about the definition of a sound and systematic evaluation methodology that will serve as a reference benchmark for evaluating these mappings. The resulting control-gesture mappings are demonstrated in the specific application domains of cartography and astronomy.

### 9.2. National Initiatives

#### 9.2.1. ANR

**MapMuxing - Multi-dimensional Map Multiplexing.** (2014-2018) Funded by the French National Research Agency (ANR). In collaboration with IGN (Institut National de l'Information Géographique et Forestière): **208Keuros/499Keuros**. Participants: Emmanuel Pietriga (PI), Caroline Appert, Olivier Chapuis, Maria Jesus Lobo Gunther, Vit Rusnak. <http://mapmuxing.ign.fr>

The project explores novel ways of combining different maps and data layers into a single cartographic representation, and investigates novel interaction techniques for navigating in it. The project aims at going beyond the traditional pan & zoom and overview+detail interface schemes, and at designing and evaluating novel cartographic visualizations that rely on high-quality generalization, *i.e.*, the simplification of geographic data to make it legible at a given map scale, and symbol specification.

#### 9.2.2. Inria - Ministère de la Culture

**Visual Exploration of Linked Data on BnF's data portal** (2017-2018) Funded by the French Ministère de la Culture and Inria. **65Keuros**. Participants: Emmanuel Pietriga (PI), Caroline Appert, Hande Gözükan, Marie Destandau, Dylan Lebout.

The project explores novel ways of visually navigating the data exposed by the Bibliothèque Nationale de France as linked data on <http://data.bnf.fr>.

#### 9.2.3. Inria Project Lab

ILDA participates to Inria Project Lab iCODA : Data Journalism : knowledge-mediated Content and Data Interactive Analytics, that started in 2017. A key issue in data science is the design of algorithms that enable analysts to infer information and knowledge by exploring heterogeneous information sources, structured data, or unstructured content. With journalism data as a landmark use-case, iCODA aims to develop the scientific and technological foundation for collaborative, heterogeneous data analysis, guided by formalized, user-centric knowledge. The project relies on realistic scenarios in data-journalism to assess the contribution of the project to this area. iCODA is at the crossroads of several research areas (content analysis, data management, knowledge representation, visualization) and is part of a club of partners of the world of the press. Equipes-projets Inria : Graphik, Ilda, Linkmedia, Cedar. Press partners: Le Monde, OuestFrance, AFP. Participants: Anastasia Bezerianos (PI) and Emmanuel Pietriga.

## 9.3. European Initiatives

### 9.3.1. Collaborations with Major European Organizations

- Deutsches Elektronen-Synchrotron (DESY): Scientific collaboration on the design and implementation of user interfaces for array operations monitoring and control for the Cherenkov Telescope Array (CTA) project, to be built in the Canary Islands (Spain) and in the Atacama desert (Chile).

## 9.4. International Initiatives

### 9.4.1. Inria International Labs

Inria Chile / CIRIC. From 2012 to 2015, Emmanuel Pietriga was the scientific leader of the Massive Data team at Inria Chile, working on projects in collaboration with the ALMA radio-telescope and the Millenium Institute of Astrophysics. He is now scientific advisor to Inria Chile's visualization lab, and is actively involved in the collaboration between Inria Chile and the LSST on the design and development of user interfaces for operations monitoring and control.

### 9.4.2. Inria International Partners

#### 9.4.2.1. Informal International Partners

- KISTI (Korea). 2017. We investigated the potential of ultra-high-resolution wall-sized displays for the visualization of stream IOT data in the field of air quality monitoring in large and dense urban areas in Korea. The goal of the project was to design and implement an interactive multi-scale visualization of streamed data collected from vehicles (taxis) equipped with a battery of sensors and geolocation devices. The project focused on how to design effective visualizations that take advantage of the specific characteristics of large surfaces featuring a very high pixel density ; and on how to handle streams of IOT data, in this case the sensor data from all taxis, both live data streams and historical data retrieved from a database.
- University of Konstanz: Daniel Keim and Johannes Fuchs on mapping out the design space for visualization glyphs [16]. Participants: Anastasia Bezerianos.

## 9.5. International Research Visitors

### 9.5.1. Visits of International Scientists

- Iftach Sadeh, DESY/CTA Observatory, February 2017

#### 9.5.1.1. Internships

- María Grazia Prato, Inria Chile, October 2017
- Amanda Ibsen, Sebastian Pereira, María Grazia Prato, Inria Chile, June 2017

## PETRUS Project-Team

## 8. Partnerships and Cooperations

### 8.1. National Initiatives

#### 8.1.1. ANR PerSoCloud (Jan 2017 - Jan 2020)

Partners: Orange Labs (coordinator), PETRUS (Inria-UVSQ), Cozy Cloud, U. of Versailles.

PETRUS funding: 170k€. The objective of PerSoCloud is to design, implement and validate a full-fledged Privacy-by-Design Personal Cloud Sharing Platform. One of the major difficulties linked to the concept of personal cloud lies in organizing and enforcing the security of the data sharing while the data is no longer under the control of a central server. We identify three dimensions to this problem. Devices-sharing: assuming that the primary copy of user U1's personal data is hosted in a secure place, how to share and synchronize it with U1's multiple (mobile) devices without compromising security? Peers-sharing: how user U1 could exchange a subset of his-her data with an identified user U2 while providing to U1 tangible guarantees about the usage made by U2 of this data? Community-sharing: how user U1 could exchange a subset of his-her data with a large community of users and contribute to personal big data analytics while providing to U1 tangible guarantees about the preservation of his-her anonymity? In addition to tackling these three scientific and technical issues, a legal analysis will guarantee compliance of this platform with the security and privacy French and UE regulation, which firmly promotes the Privacy by Design principle, including the current reforms of personal data regulation.

#### 8.1.2. PIA - PDP SECSi (May 2016 - Dec 2017)

Partners: Cozy Cloud (coordinator), Qwant, Inria (Inria-UVSQ), FING.

SMIS funding: 149k€. The objective of this PIA-PDP (Programme Investissement d'Avenir - Protection des Données Personnelles) SECSi project is to build a concrete Personal Cloud platform which can support a large scale deployment of Self Data services. Three major difficulties are identified and will be tackled in this project: (1) how to implement and enforce a fine control of the data flow when personal data are exploited by third party applications, (2) how to protect these same applications when processing is delegated to the personal cloud platform itself and (3) how to implement personalized search on the web without hurting user's privacy.

#### 8.1.3. CityLab@Inria, Inria Project Lab (May 2014 -).

Inria Partners: ARLES-MIMOVE, CLIME, DICE, FUN, MYRIADS, OAK, PETRUS, URBANET, WILLOW. External partners: UC Berkeley.

Funding: not associated to individual project teams. CityLab@Inria studies ICT solutions toward smart cities that promote both social and environmental sustainability. A strong emphasis of the Lab is on the undertaking of a multi-disciplinary research program through the integration of relevant scientific and technology studies, from sensing up to analytics and advanced applications, so as to actually enact the foreseen smart city Systems of Systems. SMIS contributes to Privacy-by-Design architectures for trusted smart objects so as to ensure privacy to citizens, which is critical for ensuring that urbanscale sensing contributes to social sustainability and does not become a threat. The PhD Thesis of Dimitris Tsoulovas, co-directed by MIMOVE and PETRUS, is funded by CityLab. <http://citylab.inria.fr/>