RESEARCH CENTER

FIELD
Digital Health, Biology and Earth

Activity Report 2013

Section Partnerships and Cooperations

Edition: 2014-03-20

ABS Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. Projets Exploratoires Pluridisciplinaires from CNRS/Inria/INSERM

Title: Modeling Large Protein Assemblies with Toleranced Models

Type: Projet Exploratoire Pluri-disciplinaire (PEPS) CNRS / Inria / INSERM

Duration: two years

Coordinator: F. Cazals (Inria, ABS)

Others partners: V.Doye (Inst. Jacques Monod)

Abstract: Reconstruction by Data Integration (RDI) is an emerging paradigm to reconstruct large protein assemblies, as discussed in section 5.1.3 .

Elaborating on our Toleranced Models framework, a geometric framework aiming at inherently accommodating uncertainties on the shapes and positions of proteins within large assemblies, we ambition within the scope of the two year long PEPS project entitled *Modeling Large Protein Assemblies with Toleranced Models* to (i) design TOM compatible with the flexibility of proteins, (ii) develop graph-based analysis of TOM, and (iii) perform experimental validations on the NPC.

7.2. European Initiatives

7.2.1. FP7 Projects

7.2.1.1. CG-Learning

Title: Computational Geometric Learning (CGL)

Type: COOPERATION (ICT)

Defi: FET Open

Instrument: Specific Targeted Research Project (STREP)

Duration: November 2010 - October 2013

Coordinator: Friedrich-Schiller-Universität Jena (Germany)

Others partners: Jena Univ. (coord.), Inria (Geometrica Sophia, Geometrica Saclay, ABS), Tech. Univ. of Dortmund, Tel Aviv Univ., Nat. Univ. of Athens, Univ. of Groningen, ETH Zürich, Freie Univ. Berlin.

See also: http://cglearning.eu/

Abstract: *The Computational Geometric Learning project aims at extending the success story of geometric algorithms with guarantees to high-dimensions. This is not a straightforward task. For many problems, no efficient algorithms exist that compute the exact solution in high dimensions. This behavior is commonly called the curse of dimensionality. We try to address the curse of dimensionality by focusing on inherent structure in the data like sparsity or low intrinsic dimension, and by resorting to fast approximation algorithms.*

7.3. International Initiatives

7.3.1. Inria International Partners

7.3.1.1. Declared Inria International Partners

ABS has regular international collaboration, in particular with the members of the FP7 project *Computational geometric learning* mentioned in section 7.2.1 .

7.4. International Research Visitors

7.4.1. Internships

- Angeliki Kalamara, from the University of Athens, performed a 5 month internship under the dual supervision of F. Cazals and I. Emiris (Univ. of Athens). The topic was *Modeling cryo-electron microscopy density maps*.

AMIB Project-Team

6. Partnerships and Cooperations

6.1. Regional Initiatives

A. Denise is the coordinator of the "Japarin-3D" Digiteo project 2012-2016. This project, in collaboration with PRISM at Versailles, aims to develop new efficient approaches for predicting the 3D structure of large RNA molecules, by applying game theory and graph algorithms.

6.2. National Initiatives

6.2.1. ANR

A. Denise is involved in the NSD-NGD ANR project 2010-2014. Y. Ponty is involved in the MAGNUM ANR project (BLAN program, 12/2010–12/2014).

6.2.2. PEPS

Ch. Froidevaux was responsible for the CNRS-INSERM-INRIA Peps grant *Identification of metabolic capabilities of fungi by comparative genomic* involving IGM, Paris-Sud and UMR GV, CNRS.

6.3. European Initiatives

Program: Partenariat Hubert Curien (PHC) Procope (Jointly funded by Egide and DAAD)

Project acronym: SOSW

Project title: Sharing and Optimizing Scientific Workflows

Duration: 2013 - 2015

Coordinator: Sarah Cohen-Boulakia

International Partner

U. Humboldt (Berlin, Allemagne)

Institute for Computer Science

Ulf Leser

Abstract : Considerable effort has been put into the development of scientific workflow management systems. They support scientists in developing, running, and monitoring chains of data analysis programs. A variety of systems have reached a level of maturity that allows them to be used by scientists for their bioinformatics experiments, especially including analysis of NGS data. However, each scientific group has its own way of analyzing NGS data, using a particular set of tools, in a particular order. The aim of this project is to exploit the complementary skills of the two European groups involved to develop approaches promoting exchange of (optimized) workflows.

6.4. International Initiatives

6.4.1. Inria Associate Teams

6.4.1.1. ITSNAP

Title: Intelligent Techniques for Structure of Nucleic Acids and Proteins

Inria principal investigator: Julie Bernauer

International Partner (Institution - Laboratory - Researcher):

Stanford University (United States) - Computational Structural Biology, School of Medicine, Structural Biology - Julie Bernauer

Duration: 2012 - 2014

See also: http://www.lix.polytechnique.fr/~bernauer/EA_ITSNAP/

The ITSNAP Associated Team project is dedicated to the computational study of RNA 3D structure and interactions. By developing new molecular hierarchical models for knowledge-based and machine learning techniques, we can provide new insights on the biologically important structural features of RNA and its dynamics. This knowledge of RNA molecules is key in understanding and predicting the function of current and future therapeutic targets.

6.4.2. Inria International Partners

6.4.2.1. Declared Inria International Partners

CARNAGE

Program: Inria-Russia

Title: CARNAGE: Combinatorics of Assembly and RNA in GEnomes

Inria principal investigator: Mireille Régnier

International Partner (Institution - Laboratory - Researcher):

State Research Institute of Genetics and Selection of Industrial Microorganisms (Russia (Russian Federation)) - Bioinformatics laboratory - Mireille Régnier

Duration: 2012- 2014

See also: https://team.inria.fr/amib/carnage

CARNAGE addresses two main issues on genomic sequences, by combinatorial methods.

Fast development of high throughput technologies has generated a new challenge for computational biology. The recently appeared competing technologies each promise dramatic breakthroughs in both biology and medicine. At the same time the main bottlenecks in applications are the computational analysis of experimental data. The sheer amount of this data as well as the throughput of the experimental dataflow represent a serious challenge to hardware and especially software. We aim at bridging some gaps between the new "next generation"sequencing technologies, and the current state of the art in computational techniques for whole genome comparison. Our focus is on combinatorial analysis for NGS data assembly, interspecies chromosomal comparison, and definition of standard pipelines for routine large scale comparison.

This project also addresses combinatorics of RNA and the prediction of RNA structures, with their possible interactions.

6.4.2.2. Informal International Partners

Polytechnique/UPSud and McGill/U. Montréal

Program: CFQCU

Title: Réseau franco-québecois de recherche sur l'ARN

Inria principal investigator: Jean-Marc Steyaert

International Partner (Institution - Laboratory - Researcher):

Mc Gill and Université de Montréal (Canada)

Computer Science Department

Jérôme Waldispühl

Duration: 2012 - 2014

Résumé : The partners have developped complementary expertise on RNA : bioinformatics, combinatorics and algorithms. machine learning, physics and genomics. Methodologies will be developed that combine theoretical simulations and new (high throughput) experimental data. A common high level training at Master and PhD level is organized.

6.4.3. Inria International Labs

R. Fonseca spent 5 months at SLAC in Stanford to work with Henry van den Bedem. J. Bernauer spent two weeks at SLAC. The associated team members also presented their work at the Inria BIS 2013 Workshop in Stanford https://project.inria.fr/inria-siliconvalley/workshops/bis2013/.

6.4.4. Participation In other International Programs

6.4.4.1. NII International Internship Program

Adrien Rougny has been an intern at NII from February to August 2013 with a support of "NII International Internship Program. He worked on the topic "Inference and Learning for Systems Biology and Network Dynamics" in Pr. Katsumi Inoue's group, a long-term collaboration of Ch. Froidevaux.

6.4.4.2. PHC Procore

J. Bernauer is coordinator with Pr. X. Huang at the Hong-Kong University of Science and Technology of a Partenariat Hubert Curien (PHC) Procore project (2012-2013). The project is entitled *Computational studies of conformational dynamics of the RNA-induced silencing complex and design of miRNAs to target oncogenes*.

6.5. International Research Visitors

6.5.1. Visits of International Scientists

H.K. Hwang

Subject: Probabilistic Analysis of A Simple Evolutionary Algorithm

Institution:Taipeh University (Taiwan)

V. Reinharz

Subject: RNA 3D structure analysis

Institution: McGill University (Canada)

E. Furletova

Subject: word enumeration

Institution: Institute of Mathematical Problems in Biology (Russia)

6.5.1.1. Internships

- C. Moutet (May and June 2013)

  Subject: Poor mappability regions in assembly

  Institution: ENS Lyon and Ecole Polytechnique Fédérale de Lausanne

  Funding: INRIA

  Supervision: M. Régnier
- F. Pirot (May and June 2013)

  Subject: Exceptional words in *Archae* genomes

  Institution: ENS Lyon

  Funding: INRIA

  Supervision: M. Régnier
- B. Fang (May to July 2013)

  Subject: Clumps combinatorics, automata and word asymptotics

  Institution: Princeton University (United States)

  Funding: Ecole Polytechnique

  Supervision: M. Régnier
- J. Moussu (April to July 2013)

Subject: Repeats in genomic sequences
Institution: Rennes University
Funding: INRIA
Supervision: M. Régnier

- M. Pichene (April to July 2013)
  Subject: Graph algorithms and protein-protein interactions
  Institution: Paris-Sud University
  Funding: INRIA
  Supervision: J. Bernauer
- L. Uroshlev (June 2013)
  Subject: Reference state for RNA KB potentials
  Institution: IOGEN (Moscou, (Russia))
  Funding: INRIA (CARNAGE)
  Supervision: J. Bernauer
- O. Berillo (January and december 2013)
  Subject: miRNAs and oncogenes.
  Institution: El Farabi University (Almaty, (Kazakhstan))
  Funding: El Farabi University
  Supervision: M. Régnier
- A. Bari (March 2013)
  Subject: stress-inducible miRNAs
  Institution:El Farabi University (Almaty, (Kazakhstan))
  Funding: El Farabi University
  Supervision: M. Régnier

6.5.2. Visits to International Teams

- Sep. 2013–Sep. 2014: Y. Ponty is visiting PIMS and Simon Fraser University (Vancouver, Canada)

BAMBOO Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

- Title: Inférence de graphes de régulations génétiques à partir de données d'expression
- Coordinator: H. Charles
- BAMBOO participant(s): H. Charles, L. Brinza, M.-F. Sagot
- Type: Pré-Projet de Recherche de l'IXXI (2012-2013)
- Web page: Not available

7.2. National Initiatives

7.2.1. ABS4NGS

- Title: Solutions Algorithmiques, Bioinformatiques et Logicielles pour le Séquençage Haut Débit
- Coordinator: E. Barillot
- BAMBOO participant(s): V. Lacroix
- Type: ANR (2012-2015)
- Web page: Not available

7.2.2. Colib'read

- Title: Methods for efficient detection and visualization of biological information from non assembled NGS data
- Coordinator: P. Peterlomgo
- BAMBOO participant(s): V. Lacroix, A. Julien-Lafferière, C. Marchet, G. Sacomoto, M.-F. Sagot, B. Sinaimeri
- Type: ANR (2013-2016)
- Web page: http://colibread.inria.fr/

7.2.3. Exomic

- Title: Functional annotation of the transcriptome at the exon level
- Coordinator: D. Auboeuf (Inserm, Lyon)
- BAMBOO participant(s): V. Lacroix, M.-F. Sagot
- Type: INSERM Systems Biology Call (2012-2015)
- Web page: Not available

7.2.4. ImmunSymbArt

- Title: Immunity and Symbiosis in Arthropods
- Coordinator: D. Bouchon
- BAMBOO participant(s): F. Vavre
- Type: ANR Blanc (2010-2014)
- Web page: Not available

7.2.5. Metagenomics of Bemisia tabaci

- Title: Metagenomics of *Bemisia tabaci* symbiotic communities

- Coordinator: L. Mouton (LBBE, UCBL)
- BAMBOO participant(s): F. Vavre, M.-F. Sagot
- Type: Genoscope Project
- Web page: Not available

7.2.6. SpeciAphid

- Title: Evolutionary genetics and mechanisms of plant adaptation in aphids
- Coordinator: Jean-Christophe Simon (IGEPP, INRA, Rennes)
- BAMBOO participant(s): H. Charles, Y. Rahbé
- Type: ANR (2012-2014)
- Web page: Not available

7.3. European Initiatives

7.3.1. FP7 Projects

7.3.1.1. BacHBerry

- Title: BACterial Hosts for production of Bioactive phenolics from bERRY fruits
- Coordinator: Jochen Förster (Novo Nordisk Foundation Center for Biosustainability (CFB), Copenhagen, Danemark)
- BAMBOO participant(s): V. Lacroix, Alice J. Lafferière, M.-F. Sagot, A. Viari, M. Wannagat
- Type: KBBE (2013-2016)
- Web page: Not yet available.

7.3.1.2. DroParCon

- Title: Drosophila parasitoid consortium
- Coordinator: Jochen Förster (Novo Nordisk Foundation Center for Biosustainability (CFB), Copenhagen, Danemark)
- BAMBOO participant(s): F. Vavre
- Type: PHC (2012-2014)
- Web page: http://www.droparcon.org.

7.3.1.3. Microme

- Title: The Microme Project: A Knowledge-Based Bioinformatics Framework for Microbial Pathway Genomics
- Coordinator: P. Kersey (EBI)
- European partners: Amabiotics (France), CEA (France), CERTH (Greece), CSIC (Spain), CNIO (Spain), DSMZ (Germany), EBI (UK), HZI (Germany), Isthmus (France), Molecular Nertwork (Germany), SIB (Switzerland), Tel Aviv Univ. (Israel), Université Libre de Bruxelles (Belgium), WTSI (UK), Wageningen Univ. (The Netherlands)
- BAMBOO participant(s): Anne Morgat
- Type: Collaborative Project. Grant Agreement Number 222886-2
- Web page: http://www.microme.eu

7.3.1.4. SISYPHE

- Title: Species Identity and SYmbiosis Formally and Experimentally explored
- Coordinator: M.-F. Sagot
- BAMBOO participant(s): Whole BAMBOO team

- Type: ERC Advanced Grant (2010-2015)
- Web page: http://pbil.univ-lyon1.fr/members/sagot/htdocs/team/projects/sisyphe/sisyphe.html

7.3.1.5. SWIPE

- Title: Predicting whitefly population outbreaks in changing environments
- Coordinator: E. Zchori-Fein
- BAMBOO participant(s): F. Vavre
- Type: European ERA-NET program ARIMNET (2012-2015)
- Web page: http://www.arimnet.net/index.php?p=fp_swipe

7.3.1.6. Symbiox

- Title: Role of the oxidative environment in the stability of symbiotic associations
- Coordinator: F. Vavre
- BAMBOO participant(s): F. Vavre
- Type: Marie Curie IOF for Natacha Kremer (2011-2014)
- Web page: http://www.2020-horizon.com/SYMBIOX-Role-of-the-oxidative-environment-in-the-stability-of-symbiotic-associations%28SYMBIOX%29-s4673.html

7.4. International Initiatives

7.4.1. Inria International Partners

Bamboo has an Inria International Partnership, called AMICI (see http://team.inria.fr/bamboo/amici/), with three partners in Italy (Universities of Rome “La Sapienza", Florence, and Pisa) and one in the Netherlands (Free University of Amsterdam / CWI). There are two unifying interests to all the projects of AMICI: algorithmics, and biology. At the present time, mostly because the current work of BAMBOO is centered on the ERC project SISYPHE (“Species Identity and SYmbiosis Formally and Experimentally explored"), the biology is very oriented to the general study, at the molecular level, of the symbiotic relation (genomics and other associated “omics", evolution, biochemical and interaction networks). This should evolve in future to extend the symbiotic study to either the ecological or a more health-oriented level, or to address new biology-related problems using mathematical modelling and techniques, and algorithmics.

7.4.2. Inria International Labs

BAMBOO participates in a project within the Inria-Chile CIRIC (Communication and Information Research and Innovation Center) titled “Omics Integrative Sciences”. The main objectives of the project are the development and implementation of mathematical and computational methods and the associated computational platforms for the exploration and integration of large sets of heterogeneous omics data and their application to the production of biomarkers and bioidentification systems for important Chilean productive sectors. The project started in 2011 and is coordinated in Chile by Alejandro Maass, Mathomics, University of Chile, Santiago.

7.4.3. Participation In other International Programs

BAMBOO is member of a CNRS-UCBL-Inria Laboratoire International Associé (LIA) with the Laboratório Nacional de Computação Científica (LNCC), Petrópolis, Brazil. The LIA has for acronym LIRIO (“Laboratoire International de Recherche en bIOinformatique") and is coordinated by Ana Tereza Vasconcelos from the LNCC and Marie-France Sagot from BAMBOO. The LIA was created in January 2012 for 4 years, renewable once. A preliminary web page for the LIA LIRIO is available at this address: http://team.inria.fr/bamboo/en/cnrs-lia-laboratoire-international-associe-lirio/.

BAMBOO has two other projects with Brazil. One is the Inria-Faperj project RAMPA (“Bioinformatics for the Reconstruction and Analysis of the Metabolism of PArasites") whose coordinators are M.-F. Sagot (France) and A. T. Vasconcelos (LNCC, Brazil). This project will finish at the end of 2013. Its main objective was to computationally and experimentally study the dialog between the trypanosomatids *Angomonas deanei* and *Strigomonas culicis* and their respective endosymbiont mainly at the metabolic level. The second project is the CAPES-COFECUB project titled: “Multidisciplinary Approach to the Study of the Biodiversity, Interactions and Metabolism of the Microbial Ecosystem of Swines". The coordinators are M.-F. Sagot (France) and A. T. Vasconcelos (LNCC, Brazil) with also the participation of Arnaldo Zaha (Federal University of Rio Grande do Sul. The project started in 2013 for 2 years, renewable once. The main objective of this project is to experimentally and mathematically explore the biodiversity of the bacterial organisms living in the respiratory tract of swines, many of which are pathogenic.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

During 2013, the team had 4 international scientists visiting our group for at least one week. These included:

- Carlos Norberto Fischer, São Paulo State University, Rio Claro, Brazil, visit 3 months;
- Maria Cristina Motta, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil, visit 15 days;
- Susana Vinga, INESC-ID, IST Lisbon, Portugal, visit of 1 week;
- Arnaldo Zaha, Federal University of Rio Grande do Sul, Porto Alegre, Brazil, visit 15 days.

The above does not count the frequent visits of our external collaborators, members of the Inria International Partnership AMICI or of the LIA LIRIO.

7.5.2. Visits to International Teams

The visits to international teams were done mostly in the context of the Inria International Partnership AMICI, the LIA LIRIO, or the CIRIC project with Chile. Besides those, there were also visits of at least one week to Susana Vinga, INESC-ID, IST Lisbon, Portugal.

BEAGLE Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

- Stochagene (2011-2014). Objective: identify the molecular basis of the stochasticity of gene expression in eukaryotic cells. Partners: CGPhyMC (Olivier Gandrillon, Lyon, Leader), Genethon (Andras Paldi, Evry). Participants: G Beslon, H Berry, Gael Kaneko
- Ancestrome: phylogenetic reconstruction of ancestral "-omes", a five-year project (2012-2016), call "Bioinformatics" of the "Investissements d'avenir". Supervisor: V. Daubin (CNRS, LBBE, Lyon) ; with Institut Pasteur, ENS Paris, ISEM (Univ Montpellier 2) Participant: Eric Tannier.
- Foster: Spatiotemporal data mining: application to the understanding and monitoring of soil erosion (2011-2014). Supervisor: Nazha Selmaoui and Frédéric Flouvat (PPME Univ. Nouvelle Caledonie); with LISTIC Univ. Savoie, ICube Univ. Strasbourg, BlueCham Company. Participant: Christophe Rigotti.

7.1.2. CNRS

- E Tannier participates to a PEPS (Projet exploratoire premier soutien) called C1P: algorithmics of 1D structures, 2012-2013. Supervisor: M. Raffinot (CNRS, LIAFA, Paris), involved teams from Marne-la-Vallée, Nantes, Marseille, Bordeaux, Lyon.

7.2. European Initiatives

7.2.1. FP7 Projects

7.2.1.1. EvoEvo

Type: COOPERATION
Defi:
Instrument: Specific Targeted Research Project
Objectif: NC
Duration: November 2013 - October 2016
Coordinator: Guillaume Beslon (Inria)
Partners: Université Joseph Fourier (France, D. Schneider), Utrecht University (Nederland, P. Hogeweg), University of York (UK, S. Stepney) and CSIC (Spain, S. Elena)
Inria contact: Guillaume Beslon
Abstract: Evolution is the major source of complexity on Earth, at the origin of all the species we can observe, interact with or breed. On a smaller scale, evolution is at the heart of the adaptation process for many species, in particular micro-organisms (e.g. bacteria, viruses). Microbial evolution results in the emergence of the species itself, and it also contributes to the organisms' adaptation to perturbations or environmental changes. These organisms are not only organised by evolution, they are also organised to evolve. The EvoEvo project will develop new evolutionary approaches in information science and will produce algorithms based on the latest understanding of molecular and evolutionary biology. Our ultimate goal is to address open-ended problems, where the specifications are either unknown or too complicated to express, and to produce software able to operate in unpredictable, varying conditions. We will start from experimental observations of micro-organism evolution, and abstract this to reproduce EvoEvo, in biological models, in computational models, and in application software. Our aim is to observe EvoEvo in action, to model EvoEvo, to understand EvoEvo and, ultimately, to implement and exploit EvoEvo in software and computational systems. The EvoEvo project will have impact in ICT, through the development of new technologies. It will also have impact in biology and public health, by providing a better understanding of micro-organism adaptation (such as the emergence of new pathogens or the development of antibiotic resistances).

7.2.1.2. Neuron-Astro-Nets

Type: PEOPLE

Defi:

Instrument: ERCIM and Marie Curie International Outgoing Fellowships for Career Development

Objectif: NC

Duration: Juin 2013-Mai 2017 (ERCIM Juin 2013-mai 2014 puis IOF Marie Curie Juin 2014-mai 2017)

Coordinator: Hugues Berry

Partner: N. Brunel, Statistics Dept, University of Chicago (USA)

Inria contact: Maurizio DE PITTA

Abstract: Healthy functionality in the brain relies on intricate neuron-glia networks. Recent data suggest that glial, including astrocytes, play a crucial role in the processing and storing on by the brain. In particular, synapses might not be bipartite, but rather tripartite structures, comprised of the pre- and the postsynaptic terminals and the surrounding astrocyte. Moreover, astrocytes, like neurons, form intricate interconnected networks that afford long-range communication via the propagation of calcium waves. Therefore, neurons and astrocytes form intertwined neuron-glial networks supporting active partnership between the two cell populations. Hence, understanding the nature of neuron-glia interactions is essential to understand how the brain functions, and will serve as a stepping stone for deciphering brain disorders. Our long-term goal is to reveal the mechanisms that control and regulates the activity of combined neuron-glia networks. The specific objectives of this application, which are fundamental in the pursuit of that goal, are (1) to determine the properties of astrocytic modulation of synaptic transmission; and (2) to characterize how such modulation shapes neuronal activity in neuron-glia networks of the brain. To pursue these aims we will employ a comprehensive theoretical investigation to develop mathematical and biophysical models in support to experiments, at the many levels and scales of action of neuron-astrocyte signaling. The significance of understanding glia-neuron interactions is several-fold as it pertains to a very wide range of applications, from basic understanding of neuronal activity, to developing therapeutic strategies toward the treatment of neurological disorders. Here, we will focus on how modulations of synaptic transmission by astrocytes could favor the emergence of synchronized neuronal, leveraging the predictions of our theoretical approach in the perspective of brain disorders, and epilepsy in particular.

7.2.2. Collaborations with Major European Organizations

European PRACE 7th regular call.

Allocation of 34 million hours computing on the Curie super-computer for the project "Thousands of trees for 4 billon years of life evolution on Earth" led by Bastien Boussau (LBBE, UMR CNRS 5558, Lyon) and involving Eric Tannier from the Beagle team.

7.3. International Initiatives

7.3.1. Inria International Partners

7.3.1.1. Informal International Partners

- Ecole Polytechnique Fédérale de Lausanne (EPFL). We collaborate with Marion Leleu and Jacques Rougemont of the Bioinformatics and Biostatistics Core Facility of the EPFL. The general objective of this exploratory work is to investigate the relationships between epigenetic profiles and 3D structure of the genome. More precisely, we currently compare the clustering of DNA intervals based on descriptors computed from epigenetic profiles in two cases: with and without making use of information about the 3D structure of the genome. We have co-supervised a Master student (Duc Thanh Phan) in 2012-2013 on this topic.

7.3.2. Participation In other International Programs

7.3.2.1. Research Networks Program of the High Council for Scientific and Technological Cooperation between France-Israel: Astrocytic regulation of neuronal network activity (2012-2013)

The specific objectives of this joint project with groups from Tel Aviv University are to determine the properties of astrocytic calcium wave propagation and to reveal how astrocyte signals dynamically affect synaptic information transfer, thus regulating neuronal network activity. To this aim, we combine theoretical and experimental investigations of small neuron-glial networks.

Beagle (H. Berry) is coordinator of the project for the French side and supervises the modeling aspects. The coordinator for the Israeli group is Pr. Y. Hanein (Tel Aviv University Institute for Nanoscience and Nanotechnology, http://nano.tau.ac.il/hanein), who is responsible for the experimental parts. The other partner is Pr. E. Ben-Jacob (School of Physics and Astronomy, Tel Aviv University, http://tamar.tau.ac.il/~eshel/EBJG/). The project also gathers 4 PhD or Master students in Tel Aviv and Lyon.

Total amount funded : 160 k€.

7.3.2.2. ANR/NSF Bilateral programme for Collaborative Research in Computational Neuroscience (CRCNS): Modelling the vocal apparatus of birds (2013-2016)

This joint project with F. Theunissen (UC Berkeley, USA) aims at modelling the vocal apparatus of birds (Zebra Finches) to recreate vocal range of this bird using a sparser representation than the spectrum. This new representation can be used as a new parameter space to test acoustic neural coding.

This collaboration has been granted by ANR/NSF Bilateral program for Collaborative Research in Computational Neuroscience (CRCNS)(CRCNS 2012), which promotes collaborations between French and American teams. Beagle (H. Soula) is coordinator of the project for the French side and supervises the modeling aspects.

7.3.2.3. France Berkeley Fund: User-friendly phylogenomics: Bayesian simultaneous reconstruction of gene trees and species trees

We obtained a grant for a common project with J. Huelsenbeck's lab (UC Berkeley, USA) on the development of probabilistic models of genome and sequence evolution to simultaneously reconstruct gene trees and species trees, and thus study how species and their genomes have changed through time.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

7.4.1.1. Visiting Professors

Participant: Sergei Fedotov.

Dates: 3 weeks in March 2013 and 3 weeks in September 2013

Institution: Mathematical School, University of Manchester (UK)

Funded by the "Lyon Mathematics Labex MiLyon, and by Inria's visiting professor's program.

Participant: Nadia El-Mabrouk.

Dates: April 2013

Institution: Département d'Informatique et de Recherche Opérationnelle in Montréal (Canada)

Funded by Inria's visiting professor's program.

7.4.1.2. Internships

Osama Khalil

Subject: Computational systems biology of signal transduction in living cells: synaptic plasticity of striatum neurons

Date: from Feb 2013 until May 2013

Institution: American University in Cairo (Egypt)

7.4.2. Visits to International Teams

During the whole 2012-2013 academic year, Hédi Soula was an Invited Professor at UC Berkeley (USA) in F. Theunissen's lab.

BIGS Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

- *Optique-PDT* (2012-2014), mOdélisation et oPTimisation de l'Irradiance dans les tissus biologiQUEs hétérogènes traités par Thérapie PhotoDynamique interstitielle, Funding organism: *PEPS CNRS-INSERM-Inria*, Leader: M. Thomassin (CRAN, U. Lorraine).
- *Nano-Xrays* (2011-2014), Nanoparticles-based X ray-induced photodynamic therapy in glioblastoma multiforme, Funding organism: *Institut National du Cancer (INCa)*, Leader: M. Barberi-Heyob (CRAN, U. Lorraine).
- *PDTX* (2010-2013), Active Nanoplatforms for Photodynamic Therapy, Funding organism: *French National Agency for Research (ANR)*, Leader: M. Verelst (U. Paul Sabatier, Toulouse).
- *MASTERIE* (2010-2013), Malliavin Stein Random Irregular Equation, Funding organism: *French National Agency for Research (ANR)*, Leader: F. Russo (ENSTA, Paris).

8.2. European Initiatives

8.2.1. FP7 Projects

- *Target-PDT* (2009-2013), Photodynamic Therapy using photosensitizer-doped targeted organic nanoparticles, Funding organism: FP7 ERA-NET EuroNanoMed: **European Innovative RTD Projects Proposals in Nanomedicine**, Leader: P. Boisseau (CEA LETI, Grenoble).

BONSAI Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

- Projet émergent call 2011. "Scénarios d'évolution génomique basés sur les régions de cassure des réarrangements génomiques" involving GEPV (UMR CNRS 8198, Université Lille 1) and BONSAI.
- Projet émergent call 2011. "ABILES – Algorithmes bioinformatiques pour le diagnostic de leucémie résiduelle par séquenceurs haut-débit" involving IRCL (Institut de recherche sur le cancer de Lille, Inserm, Université Lille 2), Hematology department of Lille Hospital and BONSAI (see the Vidjil software, Section 5.7).

7.2. National Initiatives

7.2.1. ANR

- ANR Mappi (2010-2013): National funding from the French Agency Research (call *Conception and Simulation*). This project involves four partners: LIAFA (Université Paris 7), Genescale (Inria Rennes), Genoscope (French National Center for Sequencing) and BONSAI. The topic is *Nouvelles approches algorithmiques et bioinformatiques pour l'analyse des grandes masses de données issues des séquenceurs de nouvelle génération*.
- PIA France Génomique: National funding from Investissements d'Avenir (call *Infrastructures en Biologie-Santé*). France Génomique is a shared infrastructure, whose goal is to support sequencing, genotyping and associated computational analysis, and increase French capacities in genome and bioinformatics data analysis. It gathers 9 sequencing platforms and 8 bioinformatics platforms. Within this consortium, we are responsible for the workpackage devoted to the computational analysis of sRNA-seq data, in coordination with the bioinformatics platform of Génopole Toulouse-Midi-Pyrénées
- Mastodons (2012): National funding from CNRS (call *Scientific big data*). This call targets the management, analysis and exploitation of massive scientific data sets. We have a collaborative project for Next Generation Sequencing data analysis with LIRMM (Montpellier) and Genscale (Inria Rennes).
- PEPS Bio-Math-Info *Silenes* (2012-2013): National funding from CNRS. This project involves the GEPV (P. Touzet) and the IBMP [8] (J. Gualberto, L. Maréchal-Drouard). The topic is *Etude comparative de l'architecture du génome mitochondrial chez les Caryophyllacées et les Poacées*. It aims to sequence and analyze the genome structure of a number of *Silene* ecotypes and to compare them to other species.
- PEPS Bio-Math-Info *ReSeqVar* (2013-2014): National funding from CNRS. This new project aims at designing new read mapping algorithms in the context of human genome resequencing, taking into account known variants. We are two partners: UMR 8199 (Génomique et maladie métabolique, Ph Froguel, O. Sand, part of the LIGAN sequencing platform) and BONSAI.

[8] Institut de Biologie Moléculaire des Plantes - UPR2357, Strasbourg

7.2.2. PEPS

- PEPS Biology-Mathematics-Computer science: “Etude comparative de l’architecture du génome mitochondrial chez les Caryophyllacées et les Poacées”. This project involves three partners: IBMP (Institut de Biologie Moléculaire des Plantes), GEPV (UMR CNRS 8198, Université Lille 1) and BONSAI.
- PEPS Biology-Mathematics-Computer science: “Algorithmes pour l’alignement des lectures et la découverte de variants dans les projets de reséquençage”. This project involves two partners: UMR 8199 Génomique et Maladies Métaboliques and BONSAI.

7.2.3. ADT

- ADT biosciences resources (2011-2013): this ADT aims to build a portal of available applications in bioinformatics at Inria. The projects involves all the 8 teams from theme Bio-A and is more specifically developed by BONSAI and Rennes. An engineer was hired from 2011 to 2013 and worked in Rennes and another one was hired in 2012 and works in Lille.

7.3. International Initiatives

7.3.1. Inria International Partners

7.3.1.1. Informal International Partners

- *Universität Tübingen :* We have a collaboration with Tilmann Weber on the topic of computational biology for nonribosomal peptides. We co-organized a workshop in Lille with him.
- We have a collaboration with Martin C. Frith from the *Computational Biology Research Center* (Tokyo) on the topic of transition spaced seeds.
- *LaCIM (Laboratoire de Combinatoire et d’Informatique Mathématique):* Since 2009, we have been collaborating with Anne Bergeron (Univ. du Québec à Montréal), Krister Swenson (Univ. de Montréal), and Cédric Chauve (Simon Fraser Univ.) on theroretical and applied aspects of gene orders evolution. In 2011, we began a new project on the analysis of exonic gene structure evolution.
- *Universität Bielefeld (Germany)*: This collaboration started through a PHC Procope bilateral cooperation project with the team of Pr. Robert Giegerich (2010-2011). The goal was to work on a generic parallelization of the Algebraic Dynamic Programming methodology. This partnership is still ongoing, with several visits of Robert Giegerich these last few months. It is the source of our recent work for an extension of Algebraic Dynamic Programming [9].

7.4. International Research Visitors

7.4.1. Visits of International Scientists

The following scientists visited the team and gave a talk at the team or the laboratory seminar:

- Mihai Pop, University of Maryland (28 may)
- Veli Mäkinen, university of Helsinki (11 december)
- Krister M. Swenson, UQAM (12 november)

DYLISS Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. Regional partnership with computer science laboratories in Nantes

Participants: Anne Siegel, Jérémie Bourdon, Damien Eveillard, François Coste, Jacques Nicolas, Oumarou Abdou-Arbi, Vincent Picard, Santiago Videla, Sven Thiele.

Methodologies are developed in close collaboration with university of Nantes (LINA) and Ecole centrale Nantes (Irccyn). This is acted through the Biotempo and Idealg ANR projects and co-development of common software toolboxes within the Renabi-GO platform process. The Ph-D students V. Picard and J. Laniau are also co-supervised with members of the LINA laboratory.

7.1.2. Regional partnership in Marine Biology

Participants: Anne Siegel, Catherine Belleannée, Jérémie Bourdon, Jeanne Cambefort, François Coste, Damien Eveillard, Jacques Nicolas, Guillaume Collet, Clovis Galiez, Gaëlle Garet, Julie Laniau, Vincent Picard, Sylvain Prigent.

A strong application domain of the Dyliss project is marine Biology. This application domain is co-developped with the station biologique de Roscoff and their three UMR and involves several contracts. The IDEALG consortium is a long term project (10 years, ANR Investissement avenir) aiming at the development of macro-algae biotechnology. Among the research activities, we are particularly interested in the analysis and reconstruction of metabolism and the characterization of key enzymes. Other research contracts concern the modeling of the initiation of sea-urchin translation (former PEPS program Quantoursin, Ligue contre le cancer and ANR Biotempo), the analysis of extremophile archebacteria genomes and their PPI networks (former ANR MODULOME and PhD thesis of P.-F. Pluchon) and the identification of key actors implied in competition for light in the ocean (PELICAN ANR project).

7.1.3. Regional partnership with Inra and Health

Participants: Oumarou Abdou-Arbi, Geoffroy Andrieux, Aymeric Antoine-Lorquin, Catherine Belleannée, Charles Bettembourg, François Coste, Olivier Dameron, Michel Le Borgne, Jacques Nicolas, Anne Siegel, Valentin Wucher.

We have a strong and long term collaboration with biologists of INRA in Rennes : PEGASE and IGEEP units. This partnership is acted by the co-supervision of one post-doctorant and the co-supervision of several PhD students. The Ph-D thesis of O. Abdou-Arbi [11] and C. Bettembourg were supported by collaborations with the PEGASE laboratory [14]. This collaboration is also reinforced by collaboration within ANR contracts (Lepidolf, MirNadapt, FatInteger).

We also have a strong and long term collaboration with the IRSET laboratory at Univ. Rennes 1, acted by the defense of the co-supervised Ph-D thesis of G. Andrieux [12]. This partnership is reinforced by the ANR contract Biotempo. It was also supported in the framework of the previous CPER by a project, BasicLab, on a lab on chip for cell assays. Future studies will focus on the understanding of the metabolism of xenobiotics, funded by Anses.

7.2. National Initiatives

7.2.1. Long-term contracts

7.2.1.1. "Omics"-Line of the Chilean CIRIC-Inria Center

Participants: Anne Siegel, Jérémie Bourdon, François Coste, Damien Eveillard, Gaëlle Garet, Jacques Nicolas, Andres Aravena, Sven Thiele, Santiago Videla.

Cooperation with Univ. of Chile (MATHomics, A. Maass) on methods for the identification of biomarkers and software for biochip design. It aims at combining automatic reasoning on biological sequences and networks with probabilistic approaches to manage, explore and integrate large sets of heterogeneous omics data into networks of interactions allowing to produce biomarkers, with a main application to biomining bacteria. Co-funded by Inria and CORFO-chile from 2012 to 2022, the program includes a co-advised Ph-D student (A. Aravena) [13] and a post-doc (S. Thiele). In this context, IntegrativeBioChile is an Associate Team between Dyliss and the Laboratory of Bioinformatics and Mathematics of the Genome hosted at Univ. of Chile funded from 2011 to 2013.

7.2.1.2. ANR Idealg

Participants: Anne Siegel, Catherine Belleannée, Jérémie Bourdon, Jeanne Cambefort, François Coste, Olivier Dameron, Damien Eveillard, Jacques Nicolas, Guillaume Collet, Clovis Galiez, Gaëlle Garet, Sylvain Prigent.

IDEALG is one of the five laureates from the national call 2010 for Biotechnology and Bioresource and will run until 2020. It gathers 18 different partners from the academic field (CNRS, IFREMER, UEB, UBO, UBS, ENSCR, University of Nantes, INRA, AgroCampus), the industrial field (C-WEED, Bezhin Rosko, Aleor, France Haliotis, DuPont) as well as a technical center specialized in seaweeds (CEVA) in order to foster biotechnology applications within the seaweed field. It is organized in ten workpackages. We are participating to workpackages 1 (establishment of a virtual platform for integrating omics studies on seaweed) and 4 (Integrative analysis of seaweed metabolism) in cooperation with SBR Roscoff. Major objectives are the building of brown algae metabolic maps, flux analysis and the selection extraction of important parameters for the production of targeted compounds. We will also contribute to the prediction of specific enzymes (sulfatases) within workpackage 5 .[details]

7.2.2. Methodology: ANR Biotempo

Participants: Anne Siegel, Jérémie Bourdon, François Coste, Damien Eveillard, Jacques Nicolas, Michel Le Borgne, Geoffroy Andrieux, Andres Aravena, Vincent Picard, Sylvain Prigent, Santiago Videla.

The BioTempo projects aims at developing some original methods for studying biological systems. The goal is to introduce partial quantitative information either on time or on component observations to gain in the analysis and interpretation of biological data. Three biological applications are considered regulation systems used by biomining bacteria, TGF-$beta$ signaling and initiation of sea-urchin translation. It is funded by ANR Blanc (SIMI2) and coordinated by A. Siegel from 2011 to 2014. Teams involved include LINA (Nantes), I3S (Nice), DIMPP (Montpellier), Contrainte project team (Inria), IRSET (Rennes) and Station biologique de Roscoff [details]

7.2.3. Proof-of-concept on dedicated applications

7.2.3.1. ANR Fatinteger

Participants: Aymeric Antoine-Lorquin, Catherine Belleannée, Jacques Nicolas, Olivier Quenez, Anne Siegel.

This project (ANR Blanc SVE7 "biodiversité, évolution, écologie et agronomie" from 2012 to 2015) is leaded by INRA UMR1348 PEGASE (F. Gondret). Its goal is the identification of key regulators of fatty acid plasticity in two lines of pigs and chickens. To reach these objectives, this project has for ambition to test some combination of statistics, bioinformatics and phylogenetics approaches to better analyze transcriptional data of high dimension. Data and methods integration is a key issue in this context. We work on the recognition of specific common cis-regulatory elements in a set of differentially expressed genes and on the regulation network associated to fatty acid metabolism with the aim of extracting some key regulators.

7.2.3.2. ANR Lepidolf

Participants: François Coste, Jacques Nicolas.

The LEPIDOLF project aims at better understanding olfactory mechanisms in insects. The goal is to establish the antennal transcriptome of the cotton leafworm Spodoptera littoralis, a noctuid representative of crop pest insects. It is funded by ANR call Blanc and coordinated by E. Jacquin-Joly from UMR PISC (INRA Versailles) from 2009 to 2013. Our contribution is to use grammatical inference to build characteristic signatures of the Olfactory Receptor family, which will be used to scan directly 454-sequencing reads and available partial cDNAs of genes expressed in the antenna of Lepidoptera or deduced proteins.

7.2.3.3. ANR Mirnadapt

Participants: Jacques Nicolas, Catherine Belleannée, Anne Siegel, Valentin Wucher.

This ANR project is coordinated by UMR IGEPP, INRA Le Rheu (D. Tagu) and funded by ANR SVSE 6 "Génomique, génétique, bioinformatique, biologie systémique" from 2012 to 2014. This cooperation is strengthened by a co-tutored PhD thesis (V. Wucher). It proposes an integrative study between bioinformatics, genomics and mathematical modeling focused on the transcriptional basis of the plasticity of the aphid reproduction mode in response to the modification of environment. An important set of differentially expressed mRNAs and microRNAs are available for the two modes, asexual parthenogenesis and sexual reproduction. Our work is to combine prediction methods for the detection of putative microRNA/mRNA interactions as well as transcription factor binding sites from the knowledge of genomic sequences and annotations available on this and other insects. The results will be integrated within a coherent putative interaction network and serve as a filter for the design of new targeted experiments with the hope to improve functional annotations of implied genes.

7.2.3.4. ANR Pelican

Participant: François Coste.

The PELICAN project addresses competition for light in the ocean. It proposes an integrative genomic approach of the ecology, diversity and evolution of cyanobacterial pigment types in the marine environment, which arises from differences in the composition of the light-harvesting complexes (PBS). Our work is to build characteristic signatures of targeted PBS enzymes. This ANR project (génomique et biotechnologies végétales) is coordinated by F. Partensky (CRNS Roscoff) from 2010 to 2013.

7.2.4. Programs funded by research institutions

7.2.4.1. Inria Bioscience Ressource

Participants: Claudia Hériveau, Jacques Nicolas.

This project started in november 2011 and aims at promoting bioinformatics software and resources developed by Inria teams and their partners. A web portal will be deployed to allow users to test the software online. A tool is also developed to enhance the search of a specific resource using different criteria. The project is funded by Inria ADT program from 2011 to 2013, involves 8 research teams and is coordinated by the GenOuest platform and the Dyliss team (J. Nicolas and O. Collin).

7.2.4.2. PEPS VAG

Participants: François Coste, Jacques Nicolas, Clovis Galiez.

PEPS VAG started a collaboration between IMPMC UMR 7590, Institut de biologie de l'Ecole Normale Supérieure (IBENS) UMR8197, Atelier de Bioinformatique UPMC and Dyliss. It aims at defining the needs and means for a larger project about viruses in marine ecosystems. Indeed, we aim at developing new methods based on both sequential and structural information of proteins to improve the detection of viral sequences in marine metagenomes, to identify new viruses and to compare the viral populations specifically associated with different environment parameters (temperature, acidity, nutriments...) and ultimately to connect them with the potential hosts identified by population sequencing.

7.3. European Initiatives

7.3.1. Collaborations with Major European Organizations

Partner: EBI (Great-Britain)

Title: Modeling the logical response of a signalling network with constraints-programming.

Partner: Potsdam university (Germany)

Title: Constraint-based programming for the modelling and study of biological networks.

7.4. International Initiatives

7.4.1. Inria Associate Teams

7.4.1.1. INTEGRATIVEBIOCHILE

Title: Bioinformatics and mathematical methods for heterogeneous omics data

Inria principal investigator: Anne Siegel

International Partner (Institution - Laboratory - Researcher):

University of Chile (Chile) - Center for Mathematical Modeling - Alejandro Maass

Duration: 2011 - 2013

See also: http://www.irisa.fr/dyliss/public/EA/index.html

IntegrativeBioChile is an Associate Team between Inria project-team "Dyliss" and the "Laboratory of Bioinformatics and Mathematics of the Genome" hosted at CMM at University of Chile. The Associated team is funded from 2011 to 2013. The project aims at developing bioinformatics and mathematical methods for heterogeneous omics data. Within this program, we funded long and short stay visitings in France.

7.4.2. Inria International Labs

The Dyliss team is strongly involved in the Inria CIRIC center, and the research line "Omics integrative center": the associated team "IntegrativeBioChile", the post-doc of S. Thiele and the co-supervised of A. Aravena contribute to reinforce the complementarity of both Chilean and French teams. In 2013, a workshop was organized in Chile to develop new French-Chilean collaboration within the framework of the CIRIC center. See Sec. 7.2.1 for details.

7.4.3. Participation In other International Programs

7.4.3.1. Argentina - MinCYT-Inria 2011-13

Partner: Universidad Nacional de Cordoba, *Grupo de Procesamiento de Lenguaje Natural (PLN)*, Argentina.

Title: Modélisation linguistique de séquences génomiques par apprentissage de grammaires

Financial support: MinCYT-Inria program 2011-13

The projects aims at developing new grammatical inference methods to learn automatically linguistic models of genomic sequences.

7.4.3.2. International joint supervision of PhD

Title: Introduction des approches combinatoires dans des modèles probabilistes pour la découverte d'évènements de régulation d'un système biologique à partir de données hétérogènes [*A. Aravena*]

Inira principal investigator: Anne Siegel

International Partners (Institution - Laboratory - Researcher):

University of Chile (Chile) - Center of Mathematical Modelling - Alejandro Maass

Duration: Jul 2011 - Dec 2013

Title: Analyse automatisée et générique de réseaux métaboliques en nutrition [*O. Abdou-Arbi*]

Inria principal investigator: Anne Siegel

International Partner (Institution - Laboratory - Researcher):

University of Ouagadougou (Burkina Faso) - Department of mathematics - T. Tabsoba.

Duration: October 2010 - September 2013

Title: Applying logic programming to the construction of robust predictive and multi-scale models of bioleaching bacteria [*S. Videla*]

Inria principal investigator: Anne Siegel

International Partner (Institution - Laboratory - Researcher):

University of Postdam (Germany). Department of computer science. T. Schaub.

Duration: October 2011 - September 2014

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- **Germany**. Department of Computer Science, Potsdam [T. Schaub]
- **Chile**. Centro de Modelimiento Matematico, Santiago [A. Maass, N. Loirà]
- **Burkina-Faso**. Laboratoire de mathématiques, Ouagadougou [T. Tabsoba]

7.5.1.1. Internships

Andres Aravena

Subject: Programmation par Ensemble-Réponse pour l'identification de régulateur clés en biologie des systèmes

Date: from Jan 2013 until Jul 2013

Institution: University of Chile (Chile)

7.5.2. Visits to International Teams

- **Burkina-Faso**. Department of Computer Science, Ouagadougou. *Multi-objective methods for the static analysis of metabolic network*. Jan. 2013 (1 month) [O. Abdou-Arbi]
- **Niger**. University of Maradi. *Multi-objective methods for the static analysis of metabolic network*. Feb. 2013 (1 month) [O. Abdou-Arbi]
- **UK** EMBL-European Bioinformatics Institute. *Learning logical rules for protein signaling networks*. Feb. 2013 (2 days) [A. Siegel, S. Thiele, S. Videla]
- **UK** Brunel University *Learning logical rules for protein signaling networks*. Feb. 2013 (3 days) [A. Siegel, S. Thiele, S. Videla]
- **Germany**. Max Planck Institute (Klamt lab), Magdeburg. *Application of ASP to the control of signaling networks*. June 2013 (2 days) [S Thiele, S. Videla]
- **Argentina**. Departamento Universitario de Informática, Cordoba. *Collaboration on grammatical inference*. Jul. 2013 (14 days) [F. Coste]

- **Argentina**. Departamento Universitario de Informática, Cordoba. *Collaboration on grammatical inference*. Jul. 2013 (1 month) [G. Garet]
- **Germany**. Department of Computer Science, Potsdam. *Application of ASP to biology, meeting with Klamt and Schaub labs*. Oct 2013 (3 days) [A. Siegel, S. Videla]
- **Germany**. Department of Computer Science, Potsdam. *Application of ASP for sequence annotation*. Oct. Nov. Dec. 2013 (3 months) [G. Garet]
- **Chile**. Centro de Modelimiento Matematico, Santiago. *Applications of ASP*. Nov. & Dec 2013 (2 monthes) [S. Videla]
- **Chile**. Centro de Modelimiento Matematico, Santiago. *Metabolic modeling of bacteria*. Dec. 2013 (14 days) [D. Eveillard]
- **Chile**. Centro de Modelimiento Matematico, Santiago. *Data integration*. Dec. 2013 (7 days) [A. Siegel, S. Prigent, J. Laniau, V. Picard, F. Coste]

GENSCALE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Program from Région Bretagne : MIRAGE

Participants: Liviu Ciortuz, Claire Lemaitre, Pierre Peterlongo.

The MIRAGE project is funded by Région Bretagne in the framework of the SAD call (Stratégie Attractivité Durable) which aims at attracting international post-doctorant for one year. The MIRAGE project was funded from Sept. 2012 until August 2013 and coordinated by C. Lemaitre. It enabled to hire Liviu Ciortuz as a postdoctoral student for 12 months, for developping new methods to detect complex variation (structural variations) in non-assembled NGS data.

8.1.2. Program from Région Bretagne : DGASP

Participants: Antonio Mucherino, Douglas Goncalves.

This project is funded by Région Bretagne in the framework of the SAD call (Stratégie Attractivité Durable), from April 2013 to March 2014 and coordinated by A. Mucherino. It enabled to hire Douglas Goncalves as a postdoctoral student for 12 months for working on a discretizable class of distance geometry problems. The project is in collaboration with Carlile Lavor (IMECC-UNICAMP, Brazil) and Jacques Nicolas (équipe Dyliss, IRISA).

8.1.3. Poly-BNF

Participants: Dominique Lavenier, Claire Lemaitre, Pierre Peterlongo, Erwann Scaon.

This projects aims to develop bioinformatics strategies for studying polyploid genomes. It is a one year project (09/2012 – 09/2013) funded by the University of Rennes 1. It is a joined project with CNRS/EcoBio lab and INRA/IGEPP lab in Rennes.

8.1.4. Partnership with IGDR

Participants: Dominique Lavenier, Claire Lemaitre, Pierre Peterlongo, Guillaume Rizk, Fabrice Legeai, Charles Deltel.

We collaborate with several teams of the Genomic and Development Institute of Rennes (IGDR) : Genetics of dog (detection of long non coding RNAs in collaboration with Thomas Derrien and Christophe Hitte) and Integrated Fonctional Genomics and Biomarkers (NGS analyses of glioblastoma cancer, project funded by INCa in collaboration with Marie de Tayrac and Jean Mosser).

8.1.5. Partnership with INRA

Participants: Dominique Lavenier, Claire Lemaitre, Pierre Peterlongo, Guillaume Rizk, Anaïs Gouin, Fabrice Legeai, François Moreews, Susete Alves Carvalho.

We have a strong and long term collaboration with biologists of INRA in Rennes : IGEPP and PEGASE units. This partnership concerns both service and research activities and is acted by the hosting of two ingineers (F. Legeai, F. Moreews) and by the co-supervision of two non permanent engineers (A. Gouin, S. Alves Carvalho). In particular, the collaboration with the IGEPP team includes several research projects in which Genscale is formally a partner : an INRA project PEAPOL including an industrial partner, Biogemma, and an ANR project SPECIAPHID. These projects fund the non-permanent INRA members.

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. MAPPI

Participants: Dominique Lavenier, Claire Lemaitre, Nicolas Maillet, Pierre Peterlongo.

The MAPPI project aims to develop new algorithms and Bioinformatics methods for processing high trougthput genomic data. It is funded by ANR call COSINUS and coordinated by M. Raffinot (LIAFA, Paris VII) from Oct 2010 to Dec. 2013.

8.2.1.2. FATINTEGER

Participants: Dominique Lavenier, François Moreews.

The FatInteger project aims to identify some of the transcriptional key players of animal lipid metabolism plasticity, combining high throughput data with statistical approaches, bioinformatics and phylogenetic. It is funded by ANR call BLANC and coordinated by F. Gondret from 2012 to 2015.

8.2.1.3. SPECIAPHID

Participants: Anaïs Gouin, Fabrice Legeai, Claire Lemaitre.

The SPECIAPHID project aims to understand the adaptation and speciation of pea aphids by re-sequencing and comparing the genomes of numerous aphid individuals. Genscale's task, as associate partner, is to apply and develop new methods to detect variation between re-sequenced genomes, and in particular complex variants such as structural ones. It is funded by ANR call BLANC and coordinated by J-C Simon (Inra, Rennes) from January 2012 to Dec. 2014.

8.2.1.4. ADA-SPODO

Participants: Rumen Andonov, Dominique Lavenier, Fabrice Legeai, Claire Lemaitre, François Moreews, Pierre Peterlongo.

The ADA-SPODO project aims at identifying all sources of genetic variation between two strains of an insect pest : Lepidoptera Spodoptera frugiperda in order to correlate them with host-plant adaptation and speciation. Genscale's task is to develop new efficient methods to compare complete genomes along with their post-genomic and regulatory data. It is funded by ANR call BLANC and coordinated by E. d'Alençon (Inra, Montpellier) from October 2012 to Dec. 2015.

8.2.1.5. RAPSODYN

Participants: Dominique Lavenier, Claire Lemaitre, Pierre Peterlongo, Erwann Scaon.

RAPSODYN is a long term project funded by the IA French program (Investissement d'Avenir) for 7.5 years (07/2012-12/2019). The objective is the optimisation of the rapeseed oil content and yield under low nitrogen input. GenScale is involved in the bioinformatics workpackage to elaborate advanced tools dedicated to polymorphism.

8.2.1.6. COLIB'READ

Participants: Pierre Peterlongo, Claire Lemaitre, Dominique Lavenier, Fabrice Legeai, Guillaume Rizk.

The main goal of the Colib'Read project is to design new algorithms dedicated to the extraction of biological knowledge from raw data produced by High Throughput Sequencers (HTS). The project proposes an original way of extracting information from such data. Usually, a generic assembly (pre-treatment) is applied to the data, and then, in a second step, any information of interest is extracted. Our aim is to avoid this protocol that leads to a significant loss of information, or generates chimerical results because of the heuristics used in the assembly. Instead, the project will propose a set of innovative approaches for extracting information of biological interest from HTS data, with methods that bypass any costly and often inaccurate assembly phase, not requiring the availability of a reference genome. It is funded by ANR call BLANC and coordinated by P. Peterlongo from March 2013 to February 2016. https://colibread.inria.fr/

8.2.1.7. GATB

Participants: Dominique Lavenier, Erwan Drezen, Pierre Peterlongo, Claire Lemaitre, Guillaume Rizk.

GATB (Genome Assembly Tool Box) is a project that aims to provide algorithms and tools for genome assembly. The strength of these algorithms comes from the underlying structure that has a low memory footprint, which enables to assemble genomes on a simple desktop computer. The GATB project will provide several software components, such as low level libraries, binaries and pipelines providing a full spectrum of tools for genome assembly. It is a 2 years ANR project started in February 2013. http://gatb.inria.fr

8.2.2. Programs from research institutions

8.2.2.1. Mapsembler

Participants: Alexan Andrieux, Dominique Lavenier, Claire Lemaitre, Pierre Peterlongo.

The Mapsembler project aims at finalizing and to distributing the Mapsembler tool. It is funded by Inria ADT call (2012) and coordinated by P. Peterlongo from oct. 2012 to sept. 2014. http://alcovna.genouest.org/mapsembler/

8.2.2.2. Mastodons

Participants: Dominique Lavenier, Claire Lemaitre, Pierre Peterlongo.

This project, funded by the CNRS Big Data program in 2012 and 2013, aims do investigate the challenge brought by the processing of high throughput sequencing genomic data. It is coordinated by D. Lavenier from June 2012 to December 2013.

8.2.2.3. Barcoding de nouvelle génération

Participants: Dominique Lavenier, Claire Lemaitre, Pierre Peterlongo.

This project is a join initiative between Genscale and LECA (Laboratoire d'Ecologie Alpine in Grenoble). It aims at developping new algorithmic approaches for the species identification from low coverage NGS data. It is funded by a PEPS program at CNRS/Inria and coordinated by C. Lemaitre from Sept. 2012 to Dec. 2013.

8.2.2.4. Structuring of NGS for diagnostic purpose in cancer

Participants: Dominique Lavenier, Claire Lemaitre, Pierre Peterlongo.

This 18 months project is funded by the national institute of cancer (INCa). Genscale is involved in the optimization of bioinformatics workflows to detect variants in glioblastoma cancer.

8.2.3. Cooperations

8.2.3.1. Inria Bamboo Team

Participants: Claire Lemaitre, Pierre Peterlongo.

We maintain a long term collaboration with Inria Bamboo Team on the problems of finding biological information, such as variants, in NGS raw data.

8.2.3.2. LIGM, Paris

Participant: Pierre Peterlongo.

P. Peterlongo collaborates with the LIGM lab in Paris (UMR 8049), on problems of large NGS raw data indexation.

8.2.3.3. LIX

Participant: Antonio Mucherino.

A. Mucherino collaborates since 5 years with LIX, Ecole Polytechnique, in Palaiseau on the distance geometry problem. We reformulated the problem as a combinatorial optimization problem and we conceived an ad-hoc algorithm for the solution of this class of problems.

8.3. European Initiatives

8.3.1. Collaborations with Major European Organizations

Partner: CWI, University of Amsterdam, (Netherland)

Subject of cooperation: Optimization algorithms for protein structures alignments.

8.4. International Initiatives

8.4.1. Inria International Partners

8.4.1.1. Informal International Partners

Partner: IMECC, UNICAMP, Campinas-SP (Brazil)

Subject: distance geometry, bioinformatics.

Partner:COPPE, Federal University of Rio de Janeiro (Brazil)

Subject: distance geometry, bioinformatics.

Partner: Los Alamos National Laboratory (lanl), Los Alamos (USA)

Subjects: Combinatorial algorithms (shortest paths, graph partitioning, combinatorial optimization) and algorithm engineering (efficient implementation of combinatorial algorithms)

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Van-Hoa Nguyen from University of Angiang, Viet Nam, visited GenScale for 3 months (nov. 2012 - feb. 2013). The visit was funded by the French Mastodons program from CNRS to research focusing on bioinformatics big data problem.
- Fatima Sapundzhi and Boyana Garkova, PhD students from South-West University, Neofit Rilski, Blagoevgrad (Bulgaria), visited the team for one month in October 2013. The visit was funded by the bulgarian ministery and focused on ligand-protein interaction structure problems in collaboration with R. Andonov and M. Le Boudic-Jamin.

8.5.2. Visits to International Teams

- R. Andonov has been invited by the Information Sciences Group (CCS-3) from Los Alamos National Laboratory (LANL) for one month (15 July - 15 August 2013).

IBIS Project-Team

7. Partnerships and Cooperations

7.1. Regional initiatives

Project name	Identification structurelle et paramétrique des réseaux de régulation bactériens
Coordinator	E. Cinquemani
IBIS participants	E. Cinquemani, J. Geiselmann, H. de Jong, D. Stefan
Type	Funding PhD grant, Cluster ISLE, Région Rhône-Alpes
Web page	http://cluster-isle.grenoble-inp.fr/

Project name	Motilité ou adhésion : comment les entérobactéries choisissent entres ces deux états physiologiques déterminants pour la virulence
Coordinator	S. Lacour
IBIS participants	J. Demol, J. Geiselmann, S. Lacour, C. Pinel
Type	Grant, Cluster Infectiologie, Région Rhône-Alpes

Project name	Séminaire grenoblois des systèmes complexes
Coordinators	S. Achard, O. François, A. Maignan, E. Prados, S. Rafai, D. Ropers
IBIS participants	D. Ropers
Type	Funding by Institut des Systèmes Complexes de Lyon (IXXI)
Web page	http://www.ixxi.fr/?page_id=114&lang=fr

Project name	Séminaire de modélisation du vivant
Coordinators	O. Gandrillon
IBIS participants	D. Ropers
Type	Funding by GdR BIM
Web page	http://cgphimc.univ-lyon1.fr/CGphiMC/Semovi/Semovi.php

7.2. National initiatives

Project name	ColAge – Lifespan control in bacteria: Natural and engineering solutions
Coordinator	H. Berry
IBIS participants	E. Cinquemani, J. Geiselmann, H. de Jong, S. Lacour, C. Pinel, D. Ropers
Type	Inria-Inserm Project Lab (2009-2013)
Web page	http://colage.saclay.inria.fr

Project name	AlgeaInSilico: Prédire et optimiser la productivité des microalgues en fonction de leur milieu de croissance
Coordinator	O. Bernard
IBIS participants	H. de Jong
Type	Inria Project Lab (2013-)

Project name	GeMCo – Model reduction, experimental validation, and control for the gene expression machinery in *E. coli*
Coordinator	M. Chaves
IBIS participants	E. Cinquemani, J. Geiselmann, C. Gomez Balderas-Barillot, E. Grac, H. de Jong, S. Lacour, C. Pinel, D. Ropers
Type	ANR Blanc (2010-2014)
Web page	http://www-sop.inria.fr/members/Madalena.Chaves/ANR-GeMCo/main.html

Project name	RESET – Arrest and restart of the gene expression machinery in bacteria: from mathematical models to biotechnological applications
Coordinator	H. de Jong
IBIS participants	E. Cinquemani, J. Geiselmann, C. Gomez Balderas-Barillot, E. Grac, H. de Jong, S. Lacour, Y. Markowicz, C. Pinel, D. Ropers
Type	Bioinformatics call, Investissements d'Avenir program (2012-2016)
Web page	https://project.inria.fr/reset/

Project name	Fonction du système de régulation post-transcriptionnel CSR dans la dynamique de l'adaptation métabolique chez la bactérie modèle Escherichia coli
Coordinators	M. Cocaign-Bousquet (Inra, LISBP), B. Enjalbert (INSA, LISBP), D. Ropers
IBIS participants	M. Morin, D. Ropers
Type	Contrat Jeune Scientifique Inra-Inria (2012-2016)
Web page	http://www.inra.fr/les_hommes_et_les_femmes/rejoignez_nous/completer_sa_formation/le_recrutement_de_doctorants/cjs__1/inra_inria

7.3. International projects

Project name	French bioinformatics contribution to ICGC
Coordinator	G. Thomas
IBIS participants	F. Rechenmann
Type	International Cancer Genome Consortium (ICGC)
Web page	http://www.icgc.org/

The goal of ICGC (International Cancer Genome Consortium) is to obtain a comprehensive description of genomic, transcriptomic and epigenomic changes in 50 different cancer types. In France, INCa (French

National Cancer Institute) contributes to this project and focuses on two types of cancer. The main idea is to sequence the human genome of normal and tumoral cells of a large set of patients and to compare these genomic sequences to identify the mutations which may explain the development of the cancers. Bioinformatics is clearly involved in the management, the analysis and the visualization of the huge sets of data and results. Bioinformatics of the French contribution is carried out at Lyon, in the context of the Synergie Lyon Cancer Foundation. Until this year, François Rechenmann was part of the bioinformatics team and contributed to the organization of the data management and analysis workflow, under the leadership of prof. Gilles Thomas.

7.4. International collaborations

IBIS has strong collaborations with the group of Giancarlo Ferrari-Trecate at the Computer Engineering & Systems Science Department of the University of Pavia (Italy) and the group of John Lygeros at the Automatic Control Lab at ETH Zürich (Switzerland). This collaboration started with the FP6 project Hygeia, in which the above groups and IBIS (then HELIX) participated. Over the years, it has resulted in a dozen of co-authored papers and the co-supervision of a PhD thesis by Hidde de Jong and Giancarlo Ferrari-Trecate. Eugenio Cinquemani was a post-doctoral fellow at ETH in the framework of the Hygeia project, and joined the IBIS group as a research scientist in the fall of 2009. Andres Gonzales-Vargas, PhD student of Giancarlo Ferrari-Trecate, will spend six months in IBIS in 2014.

7.5. International research visitors

Invited professor	Andreas Kremling (Technische Universität Münich)
Subject	Modeling of carbon catabolite repression in *E. coli*

Invited professor	Alberto Soria-Lopéz (Centro de Investigación y de Estudios Avanzados of Instituto Politécnico Nacional (IPN), Mexico)
Subject	Development of an automatically-controlled system of parallel mini-bioreactors

MAGNOME Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Aquitaine Region "SAGESS" comparative genomics for wine starters.

This project is a collaboration between the company BioLaffort, specialized in the selection of industrial yeasts with distinct technological abilities, with the ISVV and MAGNOME. The goal is to use genome analysis to identify molecular markers responsible for different physiological capabilities, as a tool for selecting yeasts and bacteria for wine fermentation through efficient hybridization and selection strategies. This collaboration has obtained the INNOVIN label.

8.2. National Initiatives

8.2.1. ANR MYKIMUN.

Signal Transduction Associated with Numerous Domains (STAND) proteins play a central role in vegetative incompatibility (VI) in fungi. STAND proteins act as molecular switches, changing from closed inactive conformation to open active conformation upon binding of the proper ligand. Mykimun, coordinated by Mathieu Paoletti of the IBGC (Bordeaux), studies the postulated involvement of STAND proteins in heterospecific non self recognition (innate immune response).

In MYKIMUN we extend the notion of fungal immune receptors and immune reaction beyond the *P. anserina* NWD gene family. We develop *in silico* machine learning tools to identify new potential PRRs based on the expected characteristics of such genes, in *P. anserina* and beyond in additional sequenced fungal genomes. This should contribute to extend concept of a fungal immune system to the whole fungal branch of the eukaryote phylogenetic tree.

8.3. European Initiatives

8.3.1. FP7 Projects

A major objective of the "post-genome" era is to detect, quantify and characterise all relevant human proteins in tissues and fluids in health and disease. This effort requires a comprehensive, characterised and standardised collection of specific ligand binding reagents, including antibodies, the most widely used such reagents, as well as novel protein scaffolds and nucleic acid aptamers. Currently there is no pan-European platform to coordinate systematic development, resource management and quality control for these important reagents.

MAGNOME is an associate partner of the FP7 "Affinity Proteome" project coordinated by Prof. Mike Taussig of the Babraham Institute and Cambridge University. Within the consortium, we participate in defining community for data representation and exchange, and evaluate knowledge engineering tools for affinity proteomics data.

8.3.2. Collaborations with Major European Organizations

Prof. Mike Taussig: Babraham Institute & Cambridge University
Knowledge engineering for Affinity Proteomics
Henning Hermjakob: European Bioinformatics Institute
Standards and databases for molecular interactions

8.4. International Initiatives

8.4.1. Inria Associate Teams

MAGNOME participates in the CARNAGE associated team, coordinated by AMIB, with the Russian Academy of Sciences.

8.4.2. Inria International Partners

8.4.2.1. Declared Inria International Partners

AMAVI

Program: Inria International Partner

Title: Combinatorics and Algorithms for the Genomic sequences

Inria principal investigators: David Sherman

International Partner (Institution - Laboratory - Researcher):

Vavilov Institute of General Genetics (Russia (Russian Federation)) - Department of Computational Biology - Vsevolod Makeev

Duration: 2010 - present

VIGG and AMIB teams has a more than 12 years long collaboration on sequence analysis. The two groups aim at identifying DNA motifs for a functional annotation, with a special focus on conserved regulatory regions. In the current 3-years project CARNAGE, our collaboration, that includes Inrai-team MAGNOME, is oriented towards new trends that arise from Next Generation Sequencing data. Combinatorial issues in genome assembly are addressed. RNA structure and interactions are also studied.

The toolkit is pattern matching algorithms and analytic combinatorics, leading to common software.

8.4.2.2. Informal International Partners

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

8.4.3. Participation in other International Programs

MAGNOME and the VIGG of the Russian Academy of Sciences (RAS) in Moscow are partners in a project funded by the CNRS and the RAS entitle “Séquençage profond de organismes biotechnologiques : des régulons à l’adaptation ”.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Vsevolod MAKEEV November 8-22 2013

Artëm KASIANOV November 8-22 2013

8.5.1.1. Internships

Joaquin FERNANDEZ September-November 2013

MORPHEME Project-Team

6. Partnerships and Cooperations

6.1. Regional Initiatives

- We started a collaboration with the team TIRO (Transporteurs en Imagerie et Radiothérapie en Oncologie), CEA/UNS/Centre Antoine Lacassagne, Nice, concerning the detection of tumorous cells in kidney histopathology (see Fig. 17). Although the images have a very high resolution, the problem is extremely difficult due to the similarity between different type of cells.

  A coarse-to-fine approach seems perfectly adapted since the acquisitions are performed at several resolutions. Typically, six resolutions are available (see Table 1). However, contrarily to what is usually done, we do not plan to develop a unique approach, to apply it to the coarser resolution, and to use the corresponding result projected onto the following resolution as the initialization of the next step. Our idea is to think of which approach to take at each resolution level, and to gradually improve the detection confidence from "this broad area might contain tumorous cells" to "with high confidence, this small, finely delineated region is a tumorous cell". For example, we might start with histogram analysis or simple thresholding methods on the coarser resolution. Then, texture analysis could be performed in intermediate resolutions. Finally, fine radiometric and shape analyses could be done on the full resolution image to achieve object-level detection.
- We have a collaboration with the Laboratoire d'Océanographie de Villefranche (LOV), CNRS/Université Pierre et Marie Curie, concerning automatic classification of zooplankton organisms for an embedded system called UVP for Underwater Vision Profiler (see Section 4.12).
- We have a collaboration with IPMC (H. Barelli) on vesicules tracking for characterizing cell membrane properties (see Section 4.7).

Table 1. Typical resolutions of the acquisitions in kidney histopathology.

	Full res.	Res. 1	Res. 2	Res. 3	Res. 4	Low res.
Width (rounded)	95 000	25 000	6000	1500	370	90
Height (rounded)	70 000	18 000	4500	1100	275	70
1-D downsampling factor	1	4	16	64	256	1024

6.2. National Initiatives

6.2.1. LABEX SIGNALIFE

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

6.2.2. ANR DIAMOND

Participants: Laure Blanc-Féraud [PI], Saima Ben Hadj.

In collaboration with the Pasteur Institute (Jean-Chritophe Olivo Marin) , the MIPS laboratory of Université de Haute Alsace (Alain Dieterlen, Bruno Colicchio) , the LIGM of Université Paris-Est (Jean-Christophe Pesquet, Caroline Chaux, Hugues Talbot), and INRA Sophia-Antipolis (Gilbert Engler). Details on the (website)

6.2.3. ANR MOTIMO

Participants: Laure Blanc-Féraud, Xavier Descombes, Eric Debreuve, Huei Fang Yang, Ana Rita Lopes Simoes.

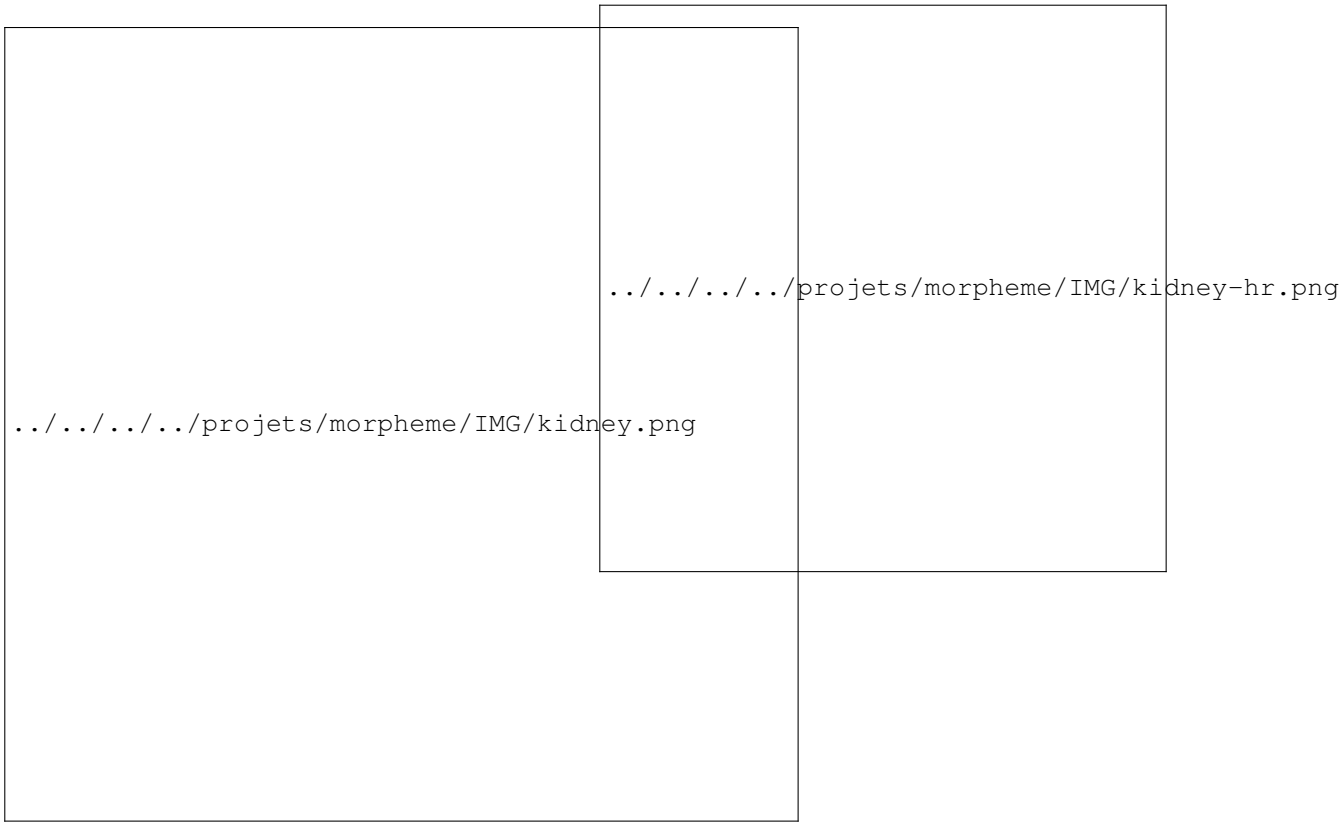

Figure 17. An example of image acquired for kidney histopathology. Left: low resolution; Right: intermediate resolution.

In collaboration with Institut de Mathématiques de Toulouse, INRA, Institut de Mécanique des Fluides de Toulouse, Laboratoire J-A Dieudonné, et IMV Technologies (PME). Details on the (website)

6.2.4. ANR POXADRONO

Participants: Florence Besse [PI], Xavier Descombes, Laure Blanc-Féraud.

The young researcher ANR project POXADRONO is in collaboration with Caroline Medioni, Hélène Bruckert, Giovanni Marchetti, Charlène Perrois and Lucile Palin from iBV. It aims at studying ARN regulation in the control of growth and axonal guidance by using a combination of live-imaging, quantitative analysis of images, bio-informatic analysis and genetic screening.

6.2.5. Inria Large-scale initiative Morphogenetics

Participants: Grégoire Malandain, Xavier Descombes, Gaël Michelin.

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

6.2.6. PEPII 1

Participants: Laure Blanc-Féraud, Xavier Descombes [PI], Alejandro Mottini.

This project aims at studying graphs in biological context (axons, vascular networks ...). In collaboration with Institut de Mécanique des Fluides de Toulouse, CerCo (Toulouse) .

6.2.7. PEPII 2

Participants: Laure Blanc-Féraud [PI], Xavier Descombes, Eric Debreuve.

In collaboration with Institut de Mathématiques de Toulouse, INRA, Institut de Mécanique des Fluides de Toulouse, Laboratoire J-A Dieudonné, et IMV Technologies (PME).

6.3. International Research Visitors

6.3.1. Visits of International Scientists

- Evgueny Pechersky from IITP Moscow (Russian Academy of Science) was invited one week in december.

6.3.1.1. Internships

- Vladimir Gutov : Master BioComp, UNS, Curves and Trees classification using SVM. Supervisors: E. Debreuve, X. Descombes.
- Gael Michelin : ENSEEIHT, Planar structures detection and tracking in biological images. Supervisor: Grégoire Malandain.
- Emmanuel Soubies : INSA Toulouse, Numerical methods for 3D biological structures reconstruction in fluorescent microscopy. Supervisors: L. Blanc-Féraud, Gilles Aubert.
- Nektaria Pappa : Master BioComp, UNS, Lobule detection from confocal microscopy images. Supervisor X. Descombes (with F. Plouraboué from IMFT)
- Anirudh Chakravarthi : Master BioComp, UNS, Dendrties dection from confocal microscopy images. Supervisor X. Descombes (with M. Studer from iBV).

6.3.2. Visits to International Teams

- Xavier has visited the Bristol University during one week in december. He was a Benjamin Maeker invited professor.

SERPICO Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. RTR SISCom project

Participant: Charles Kervrann.

In this project, we developed new statistical restoration algorithms for fluorescence and electron imaging and PSF (point-spread function) and CTF (contrast transfer function) correction, respectively. An integrated highly focused approach combing the efforts of three teams in image processing (Serpico), in-vivo light microscopy (IGDR-CeDRE) and cryo-electron tomography (IGDR-TIPs) has been studied to produce novel computational strategies for biological imaging.

Funding: RTR Syscom, European University of Brittany (UEB): 12 months
Partners: UMR 6290 – IGDR (Institut de Génétique et Développement de Rennes)

8.2. National Initiatives

8.2.1. Quaero project

Participants: Charles Kervrann, Patrick Bouthemy, Denis Fortun, Pierre Allain, Thibault Geffroy.

Quaero is a European collaborative research and development program with the goal of developing multimedia and multi-lingual indexing and management tools for professional and public applications. SERPICO team participates in the Work Package 9 on Video Processing (WP9) of QUAERO Core Technology Cluster Project (CTC). Within WP9, former Vista project-team leaded three tasks: “Motion Recognition”, “Object Tracking” and “Event Recognition”. Since October 2010, SERPICO has conducted activities in object tracking and indexing for video-microscopy analysis (Denis Fortun PhD grant) and Thibault Geffroy (Master 1 INSA Rouen).

Funding: Quaero (no. Inria Alloc 3184), duration: 60 months
Partners: 24 academic and industrial partners leaded by Technicolor

8.2.2. ANR GreenSwimmers project

Participant: Charles Kervrann.

Biofilms are composed of spatially organized microorganisms (possibly including pathogens) embedded in an extracellular polymeric matrix. A direct time-lapse confocal microscopic technique was recently developed to enable the real-time visualization of biocide activity within the biofilm. It can provide information on the dynamics of biocide action in the biofilm and the spatial heterogeneity of bacteria-related susceptibilities that are crucial for a better understanding of biofilm resistance mechanisms. The approach is here to characterize the spatial and temporal exploration of the biofilm by microorganisms.

In this project, SERPICO develop methods and software for the computation of mean velocity as well as other descriptors of swimmers bacteria dynamics inside biofilm image sequences. We investigate spatio-temporal features and descriptors for comparison, classification, indexing and retrieval.

Funding: ANR, duration: 24 months
Partners: INRA, AgroParisTech, Naturatech company

8.2.3. France-BioImaging project

Participants: Charles Kervrann, Patrick Bouthemy, Tristan Lecorgne, Tinaherinantenaina Rakotoarivelo, Thierry Pécot.

The goal of the project is to build a distributed coordinated French infrastructure for photonic and electronic cellular bioimaging dedicated to innovation, training and technology transfer. High computing capacities are needed to exhaustively analyse image flows. We address the following problems: i/ exhaustive analysis of bioimaging data sets; ii/ deciphering of key steps of biological mechanisms at organ, tissular, cellular and molecular levels through the systematic use of time-lapse 3D microscopy and image processing methods; iii/ storage and indexing of extracted and associated data and metadata through an intelligent data management system. SERPICO is co-head of the IPDM (Image Processing and Data Management) node of the FBI network composed of 6 nodes.

Funding: Investissement d'Avenir - Infrastructures Nationales en Biologie et Santé (2011-2016)
Partners: CNRS, Institut Jacques Monod, Institut Pasteur, Institut Curie, ENS Ulm, Ecole Polytechnique, INRA, INSERM

8.3. European Initiatives

8.3.1. Collaborations with Major European Organizations

ESFRI Euro-BioImaging initiative: SERPICO participates in the ESFRI Euro-BioImaging project, one of the four new biomedical science projects in the roadmap of the European Strategic Forum on Research Infrastructures (ESFRI). The mission of Euro-BioImaging is to provide access, service and training to state-of-the-art imaging technologies and foster the cooperation and networking at the national and European level including multidisciplinary scientists, industry regional, national and European authorities. (3-year Preparatory Phase / start: December 2010). SERPICO also participates in the French counterpart, the so-called "France-BioImaging" (FBI) network which gathers several outstanding cellular imaging centers (microscopy, spectroscopy, probe engineering and signal processing) as described in Section 8.2.3 .

8.4. International Research Visitors

8.4.1. Visits to International Teams

- Collaboration with Harvard Medical School (Boston, MA), Prof. G. Danuser, on object tracking in video-microscopy (P. Roudot's visit in 2012-2013, 3 months, Inria & CNRS grant).
- Collaboration with University of California - San Francisco (USA), J. Sedat and D. Agard, on image denoising in cryo-electron microscopy.

VIRTUAL PLANTS Project-Team

6. Partnerships and Cooperations

6.1. Regional Initiatives

6.1.1. OpenAlea

Participants: Christophe Pradal, Christophe Godin, Christian Fournier [INRA, LEPSE].

Funding: Agropolis foundation (Contractors for Virtual Plants: CIRAD and Inria from 2009 to 2013)

The aim of this project is to foster the development and the national and international diffusion of the platform OpenAlea. This opensource platform provides an easy-to-use environment for plant modelers through a visual programming interface to efficiently use and combine models or computational methods from different scientific fields in order to represent, analyze and simulate complex plant systems at different scales, from meristems to plant canopy. Work comprises the development of standard data structures, deployment tools, documentation, training, software engineering, user interface, interfaces with other platform, ...

6.1.2. Agropolis computational plant seminar

Participants: Yann Guédon, Thierry Fourcaud [CIRAD, AMAP], Christine Granier [INRA, LEPSE], Soazig Guyomarc'H [Montpellier 2 University, DIADE], Laurent Laplaze [IRD, DIADE].

Funding: Agropolis foundation (Contractor for Virtual Plants: CIRAD. From 2013 to 2016)

In the context of the creation of a world-level pole on plant science in the region Languedoc-Roussillon, we created a monthly seminar on plant modeling and its applications. The seminar is organized by Yann Guédon, Thierry Fourcaud (CIRAD, AMAP), Christine Granier (INRA, LESPE), Soazig Guyomarc'h (Montpellier 2 University, DIADE) and Laurent Laplaze (IRD, DIADE) with the support of Agropolis International and Agropolis Foundation.

6.1.3. Fruit3D

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

Funding: Agropolis foundation (Contractor for Virtual Plants: INRA, from 2009 to 2012)

The project gathers the competences of plant modelers, physicists and ecophysiologists for developing a virtual tomato model. The model contains the geometrical description of a growing fruit, physical and biological laws involved in tissue differentiation and cell growth, physiological models (for sugar and hormone transfers) and mechanical model. Magnetic Resonance Imaging (MRI) techniques are used to provide an in vivo validation of the model by non invasive measurements.

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

6.1.4. Rhizopolis

Participants: Frédéric Boudon, Christophe Godin, Yann Guédon, Christophe Pradal.

Funding: Agropolis foundation (Contractor for Virtual Plants: INRA, from 2011 to 2013)

Rhizopolis is a multidisciplinary project on the biology and ecology of the plant root that addresses the broad roles of this organ in mineral nutrient and water acquisition. The consortium adresses central issues such as the coupling of membrane transport activity and structure-function relationships in roots and root symbioses, the integration of root-soil interactions in the rhizosphere at the whole root system level, and the development of key tools for imaging root development. Virtual Plants is mainly involved in the developement of a software for automatically reconstructing root systems from 2D images.

Partners: DAR Team, UMR AGAP, UMR BPMC and UMR LEPSE (Montpellier).

6.1.5. RhizoScanHT

Participants: Julien Diener, Frédéric Boudon, Christophe Godin, Yann Guédon, Christophe Pradal.

Funding: Labex Numev (Contractor for Virtual Plants: UM2, from 2013 to 2014)

In this project, we extend the pipeline of 2D root system reconstruction developed in the project RhizoPolis to deal with high-thoughput data. For this we develop the project in two directions: i) make the pipeline software components more robust to various acquisition conditions and root system complexities ii) use techniques coming from the big data community to upscale the indexing and reconstruction methods.

Partners: Zenith Inria Project Team, UMR AGAP, UMR BPMC and UMR LEPSE (Montpellier).

6.2. National Initiatives

6.2.1. ANR

6.2.1.1. Morpholeaf

Participants: Christophe Godin, Maryam Aliee.

Funding: ANR (Contractor for Virtual Plants: Inria, From 2011 to 2014)

The goal of this project is to apply a systems biology approach combining biological investigation and modeling on leaf margin development to elucidate how gene networks and hormone signalling are translated into specific growth patterns and generate complex shapes. This project brings together three groups that have complementary expertises in biology, image analysis and modeling to provide new insights into the mechanisms of leaf margin development. We will specifically determine the dynamics of CUC/miR164A/auxin activities during leaf development and their interrelations, establish the contributions of cell proliferation and cell expansion to leaf serration and leaf shape and address the contribution of auxin and CUC2 to differential growth and hence to leaf serration and leaf shape.

Partners: RDP ENS-Lyon; INRA Versailles.

6.2.1.2. HydroRoot

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

Funding: ANR (Contractor for Virtual Plants: Cirad, From 2012 to 2014)

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

6.2.2. Other national grants

6.2.2.1. OpenAlea 2.0

Participants: Julien Coste, Christophe Pradal, Christophe Godin, Didier Parigot [Inria, Zenith].

Funding: Inria ADT (Contractors for Virtual Plants: Inria from 2012 to 2014)

The goal of this project is to develop an integrated multi-paradigm software environment for plant modeling. This environnement will allow the user to draw, model, program or combine models interactively. In a first step, the component architecture of OpenAlea1 .0 will be extended to dynamically add plugin application. In a second step, we move to a decentralized architecture, capable of distributing simulations in the cloud and share virtual experiments on the web. Finally, the modeling environment to be adapted to run in a web browser using HTML5 and WebGL technology

Partners: EPI Zenith

6.2.2.2. MARS-ALT

Participants: Guillaume Baty, Christophe Pradal, Christophe Godin.

Funding: Inria ADT (Contractors for Virtual Plants: Inria from 2012 to 2014)

The goal of this project is to integrate in a single software platform all the software tools and algorithms that have been developed in various projects about meristem modeling in our teams. More precisely, we aim at building 3D models of meristem development at cellular resolution based on images obtained with confocal or multiphoton microscopy. This set of components will be used by biologists and modelers making it possible to build such meristem structures, to explore and to program them. This platform is embedded in the OpenAlea framework and is based on the imaging components of the platform MedInria.

Partners: EPI Asclepios, RDP ENS-Lyon/INRA, PHIV CIRAD

6.2.2.3. Echap

Participants: Christophe Pradal, Christian Fournier, Corinne Robert [INRA, EGC].

Funding: ONEMA (Contractor for Virtual Plants: INRA, From 2012 to 2014)

The objective of the ECHAP project is to reduce the frequency of treatments and the doses of pesticides applied on crops by taking advantage of natural mechanisms of disease escape related to crop architecture and by optimizing interception of pesticides by plant canopies. It focuses on the development of an integrative, yet modular, modeling tool on the OpenAlea plateform that couples wheat architectural development, the interception and fate of fungicides and the dynamics of a pathogen. Various scenarios combining climate x architecture x fungicide treatment will be simulated to identify and propose efficient strategies of pesticide applications.

Partners: UMR EGC (Paris-Grignon), UMR LEPSE (Montpellier), ARVALIS (Institut du végétal, France), ALTERRA (Research Institute for the Green World, The Nederlands) , ADAS Intitute (UK), CNRS, and IRSTEA .

6.2.2.4. Morphogenetics

Participants: Christophe Godin, Frédéric Boudon, Christophe Pradal, Etienne Farcot, Yann Guédon.

Funding: Inria Project Lab (From 2011 to 2015)

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

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

6.2.2.5. Rose

Participants: Christophe Godin, Frédéric Boudon, Christophe Pradal.

Funding: INRA - Projet de Pari Scientifique (From 2012 to 2014)

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

Partners: UMR SAGAH, Angers

6.3. European Initiatives

6.3.1. Collaborations in European Programs, except FP7

- **iSAM** (Funding: European EraSybio+ Programme). This project aims at improving our knowledge of shoot apical meristem, and more specifically the combined action of auxin and cytokinin, using a systems biology approach. It is part of a wider program, the ERASysBio initiative, a consortium of European funding bodies, ministries and project management agencies. Four partners are involved in iSAM: the group of J. Murray will focus on mutants of cell cycle regulation, the group of Y. Helariutta is specialized in several aspects of cytokinin regulation, while the group of J. Traas in Lyon provides input regarding auxin regulation and transport, and Virtual Plants is in charge of the modeling aspects, in synergy with the three other groups.

6.4. International Initiatives

6.4.1. Inria International Partners

6.4.1.1. Informal International Partners

There is currently a very active connection with the group of Malcolm Bennett, at the Centre for Plant Integrative Biology (CPIB) in Nottingham, UK. The CPIB invests in the development of OpenAlea at the tissue level. This collaboration is expressed recently through several publication, e.g. [22].

An important collaboration with the Unit Hortsys of CIRAD et the Reunion island and in particular frédéric Normand has been established for a number of year. The topic of the collaboration is the study of the phenology of mango tree. Three members of the team have been visiting our collaborators during the years.

6.5. International Research Visitors

6.5.1. Visits of International Scientists

The team received several visitors from foreign research groups in 2013:

- Farah Ben Naoum, from Sidi Bel Abbes University, Algeria, visited the team last summer for 1 month.
- Katarina Smolenova, from University of Göttingen, Germany, visited the team last fall for 2 weeks.
- Jianming Guo, from Canberra, Australia, visited the team for 5 weeks.
- Xavier Sirault, from Canberra, Australia, visited the team last spring for 2 days.
- John Fozard, from University of Nothingham, visited the team for 2 days.

6.5.1.1. Internships

- Eugenio Espinosa, from Universidad de México (UNAM), visited the team last spring for 6 month.

6.5.2. Visits to International Teams

During the year, frédéric Boudon, Pierre Fernique and Jean Baptiste Durand visited Fred Normand of the UR Hortsys at the CIRAD La Réunion in April and November respectively.

CORTEX Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR project PHEROTAXIS

Participants: Dominique Martinez, Thomas Voegtlin.

How can animals so successfully locate odor sources? This apparently innocuous question reveals on analysis unexpectedly deep issues concerning our understanding of the physical and biological world and offers interesting prospects for future applications. Pherotaxis focuses on communication by sex pheromones in moths. The main aim of the project is to integrate the abundant experimental data on the pheromone plumes, neural networks and search behaviour available in the literature, as well as that collected or being collected by us at the molecular, cellular, systemic and behavioural levels into a comprehensive global model of the pheromonal olfactory processes. To reach this objective, the consortium combines several groups of specialists with different and complementary fields, in physics (Institut Pasteur IP), neurobiology (INRA) and bio-robotics (Inria).

7.1.2. ANR project KEOPS

Participant: Carlos Carvajal-Gallardo.

This «ANR Internal White Project» involving NEUROMATHCOMP and CORTEX (and now MNEMOSYNE since most Cortex members involved in ths project are now in this team) Inria EPI in France with the U. of Valparaiso, U. Tecnica Frederico Santa-Maria, and U. De Chili is a 3 years, 248 person-months, sensory biology, mathematical modeling, computational neuroscience and computer vision, project addressing the integration of non-standard behaviors from retinal neural sensors, dynamically rich, sparse and robust observed in natural conditions, into neural coding models and their translation into real, highly non-linear, bio-engineering artificial solutions. An interdisciplinary platform for translation from neuroscience into bioengineering will seek convergence from experimental and analytical models, with a fine articulation between biologically inspired computation and nervous systems neural signal processing (coding / decoding).

7.2. International Initiatives

7.2.1. Participation In other International Programs

Conacyt project with Mexico (2010-2013):

We work with the Cinvestav Tamaulipas research center (Mexico), on the analysis, methods and techniques for the embedded implementation of massively distributed bio-inspired connectionist processing for perception tasks on reconfigurable devices under a hardware/model codesign approach, through a project funded by the Mexican ministry Conacyt. Our works were mostly oriented towards the study of the properties of massively distributed elementary computations in bio-inspired models for vision in order to provide efficient implementation into reconfigurable logic devices. Other activities extended our works to sensori-motor systems, including embedded control of low-level locomotion by means of CPG models (central pattern generators).

7.3. International Research Visitors

7.3.1. Visits of International Scientists

7.3.1.1. Visiting professors/researchers

Chahinez Meriem BENTAOUZA (December 2013)

Funding: University of Mostaganem

Subject: Etude bibliographique de méthodes d'apprentissage statistique pour l'analyse de signaux médicaux

Institution: University of Mostaganem, Algeria

Fatiha HENDEL (April 2013)

Funding: University of Oran

Subject: Apprentissage et classification automatique

Institution: University of Oran, Algeria

Cesar TORRES-HUITZIL (July 2013)

Funding: Conacyt project

Subject: Hardware implementations of neural networks

Institution: Cinvestav Tamaulipas, Mexico

7.3.1.2. Internships

Hariharan NATANASIHAMANI (from May 2013 until Sep 2013)

Subject: Develomental reinforcement learning

Institution: McGill University, Canada

ARAMIS Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

8.1.1.1. ANR HM-TC

Participants: Olivier Colliot [Correspondant], Marie Chupin, Didier Dormont, Denis Schwartz, Dominique Hasboun, Linda Marrakchi-Kacem, Yohan Attal, Claire Cury.

Project acronym: HM-TC

Project title: Model of the hippocampo-cortical connectivity in "temporal consciousness" in normal and pathological memory derived from multimodal anatomical and functional brain imaging (aMRI, DT-MRI, MEG, fMRI)

Duration: Nov 2009- Nov 2014

Amount: 2M€

Coordinator: Olivier Colliot (ARAMIS) and Gianfranco Dalla Barba

Other partners: CENIR, ENS Cachan, Neurospin, Grenoble Institut des Neurosciences

Abstract: The aim of this project is to evaluate the role of the medial temporal lobe and its connections with various cortical regions in temporal consciousness related tasks and to derive a neuro-computational model of memory processing from multimodal imaging data. Temporal consciousness is defined as the ability to specify one's own time-location with respect to past, present and future, and is thus a more general framework than episodic memory. Based on an original cognitive model and relying on memory dysfunctions called confabulations, different groups of participants (controls, patients with Alzheimer's disease, patients with several memory disorders) will be evaluated through behavioural tests, MEG, anatomical, functional and diffusion-tensor MRI. New signal and image processing methods will be developed for all these modalities, in order to describe in a more robust and precise way both the anatomy and the function of the medial temporal lobe. First, using in vivo ultra high field MRI acquisitions (7 Tesla), we will build a precise anatomical atlas of the hippocampus and its inner structure. This model will allow designing efficient MEG source reconstruction in these regions, and new methods to analyse anatomical and functional connectivity. Using the most recent mathematical achievements in the theory of diffeomorphic deformations, we will propose new registration and morphometry methods in order to analyze very precisely the structural alterations of the medial temporal lobe. These new methods will be applied to the neuroimaging data acquired for the project in order to analyse extensively the relationships between memory disorders and structural and functional brain alterations revealed by neuroimaging.

8.1.2. IHU

Participants: Olivier Colliot, Mario Chavez, Stanley Durrleman, Marie Chupin, Didier Dormont, Dominique Hasboun, Damien Galanaud, Fabrizio de Vico Fallani.

Project acronym: IHU-A-ICM

Project title: Institute of Translational Neuroscience

Founded in 2011

General Director: Bertrand Fontaine

The IHU-A-ICM program was selected, in 2011, in a highly competitive national call for projects. A 10-year, 55M€ program, has been implemented by a recently created foundation for scientific cooperation. Based on the clinical and scientific strenghts of the ICM and the hospital Department of Nervous System Diseases, it mainly supports neuroscience research, but is also invested in improving care and teaching. ARAMIS is strongly involved in the IHU-A-ICM project, in particular in WP6 (neuroimaging and electrophysiology), WP7 (biostatistics), WP2 (Alzheimer) and WP5 (epilepsy). We have started collaborations with the new bioinformatics/biostatistics platform (IHU WP7, head: Ivan Moszer), in particular through a joint project on the integration of imaging and genomics data.

8.1.3. CATI (Alzheimer Plan)

Participants: Olivier Colliot [Correspondant], Marie Chupin [Correspondant], Stanley Durrleman, Didier Dormont, Chabha Azouani, Ali Bouyahia, Johanne Germain, Xavier Badé, Hugo Dary, Ludovic Fillon, Takoua Kaaouana, Alexandre Routier, Sophie Lecomte.

Project acronym: CATI

Project title: Centre d'Acquisition et de Traitement des Images

Founded in 2011

Amount: 9M€

Coordinator: Jean-François Mangin

Other partners: Neurospin, CENIR, Inserm U678, IM2A

Abstract: The CATI project (funded by the National Alzheimer Plan for 9M€, 2.1M€ for ARAMIS) aims at creating a national platform for multicenter neuroimaging studies. CATI aims to be a national resource for the scientific, medical and industrial research community and will provide a wide range of services: access to a national acquisition network, standardization of acquisitions, image quality control, image analysis, databasing/archiving, meta-analyses. Through CATI, our team coordinates a large network composed of over 30 image acquisition centers. CATI already supports over 15 multicenter projects including the national cohort MEMENTO (2300 subjects). CATI is integrated with France Life Imaging (PI: F. Lethimonnier) and the Neugrid for you (N4U, PI: G. Frisoni) network.

8.1.4. Institut Carnot

Participant: Mario Chavez [Correspondant].

ARAMIS is supported by the "Programme de Maturation Carnot" for the following projects:

Etude des interactions cortex-respiration. (Coordinators: P. Pouget and M. Chavez)

Evaluating anesthetic depth using electroencephalographical recording in human and non-human primates. (Coordinators: P. Pouget and M. Chavez)

8.1.5. Other National Programs

Participants: Olivier Colliot, Marie Chupin, Stanley Durrleman, Didier Dormont, Damien Galanaud.

ARAMIS is a partner of the following national projects :

- PHRC (Programme Hospitalier de Recherche Clinique) PredictPGRN, co-funding by Alzheimer Plan, *Caractérisation multimodale prospective de la démence frontotemporale dûe à des mutations du gène PGRN à un stade symptomatique et présymptomatique*. (Coordinator : A. Brice)
- PHRC (Programme Hospitalier de Recherche Clinique) ImaBio3, co-funding by Roche (pharmaceutical industry), *Rôle des réactions cellulaires sanguines, inflammatoires et immunitaires anti-amyloïde centrales et périphériques dans la maladie d'Alzheimer débutante*. (Coordinator : M. Sarazin)
- PHRC (Programme Hospitalier de Recherche Clinique) CAPP, *Caractérisation linguistique, anatomique/métabolique et biologique des différentes formes d'aphasie primaire progressive : vers le rationnel pour des essais pharmacologiques et des rééducations du langage ciblées*. (Coordinator: M. Teichmann)

8.2. European Initiatives

8.2.1. FP7 Projects

Participants: Stefan Thurner, Vito Latora, Albert Diaz-Guilera, Maxi San Miguel, Cecilia Mascolo, Mirco Murolesi, Mario Chavez [Correspondant].

Project acronym: LASAGNE

Project title: multi-LAyer SpAtiotemporal Generalized NEtworks

Founded in 2012

Amount: 1.6M€

Coordinator: Stefan Thurner

Other partners: Medical University of Vienna, Queen Mary University of London, Universitat de Barcelona, Universitat de les Illes Balears,University of Cambridge, University of Birmingham.

Abstract: The aim of the LASAGNE project is to provide a novel and coherent theoretical framework for analysing and modelling dynamic and multi-layer networks in terms of multi-graphs embedded in space and time. To do this, we will treat time, space and the nature of interactions not as additional dimensions of the problem, but as natural, inherent components of the very same generalised network description. The theory will be validated on real-world applications involving large and heterogeneous data sets of brain networks, on- and off-line social systems, healthcare systems, and transportation flows in cities. The LASAGNE project will provide new quantitative opportunities in different fields, ranging from the prediction of pathologies to the diffusion of ideas and trends in societies, and for the management of socio-technological systems.

8.3. International Initiatives

8.3.1. Informal International Partners

S. Durrleman has an enduring collaboration with the Scientific Computing and Imaging (SCI) Institute at the University of Utah (USA). He is consultant for NIH Grant "4D shape analysis for modeling spatiotemporal change trajectories in Huntington's Disease "predict-HD". He is part of the PhD committees of J. Fishbaugh and A. Sharma supervised by professor Guido Gerig.

M. Chupin and O. Colliot have an enduring collaboration with the Center for Magnetic Resonance Research, University of Minnesota, USA (P-F Van de Moortele, T. Henry, M. Marjanska, K. Ugurbil) a leading center in 7T MRI.

D. Galanaud has an enduring collaboration with the Massachusetts General Hospital, Harvard University, USA (R. Gupta).

M. Chavez has enduring collaborations with the Center for Applied Medical Research, Pampelune, Spain (M. Valencia), the Departement of Physics, Queen Mary University of London, UK (V. Latora) and the Anatomical Neuropharmacology Unit, University of Oxford, UK (J. Mena-Segovia).

8.4. International Research Visitors

8.4.1. Visits of International Scientists

In September 2013, the team welcome James Fishbaugh, as part of its training as PhD candidate at the University of Utah under the supervision of professor Guido Gerig.

ASCLEPIOS Project-Team

7. Partnerships and Cooperations

7.1. European Initiatives

7.1.1. FP7 Projects

7.1.1.1. VPH NOE

Participants: Maxime Sermesant [correspondant], Moulay Fadil, Florian Vichot, Nicholas Ayache.

medinria registration toolbox VPH NOE standards

Title: VPH NoE

Type: COOPERATION (ICT)

Defi: Virtual Physiological Man

Instrument: Network of Excellence (NoE)

Duration: June 2008 - November 2012

Coordinator: University College London, UK

Others partners: Core members include UCL (UK), Oxford (UK), CNRS (FR), ULB (BE), U. of Nottingham (UK), UPF (ES), U. Auckland (NZ), EMBL (DE), U. Sheffield (UK), Karolinka (SE), ERCIM (FR), IOR (IT).

See also: http://www.vph-noe.eu/

Abstract: The Virtual Physiological Human Network of Excellence (VPH NoE) is a EU seventh Framework funded project, working to connect and support researchers in the VPH field within Europe and beyond. Inria is one of the core members, and is mostly dedicated, through Asclepios, to the data fusion part of the VPH toolkit. More precisely, a registration toolbox has been delivered which aims at including registration algorithms from the team and elsewhere in the new version of medInria (2.x). During the extension of the project through 2013, we participated in a hackfest on software interoperability (May 20-24, 2013 in Kingston, Canada and Nov 4-8, 2013 in London, UK).

7.1.1.2. MedYMA

Title: Biophysical Modeling & Analysis of Dynamic Medical Images

Type:ERC

Instrument: ERC Advanced Grant (Advanced)

Duration: April 2012 - March 2017

Coordinator: Inria (France)

See also: http://www.inria.fr/en/centre/sophia/news/medical-imagery-and-i.t.-the-personalised-digital-patient

Abstract: During the past decades, exceptional progress was made with in vivo medical imaging technologies for capturing the anatomical, structural and physiological properties of tissues and organs in a patient, with an ever increasing spatial and temporal resolution. The physician is now faced with a formidable overflow of information, especially when a time dimension is added to the already hard to integrate 3-D spatial, multimodal and multiscale dimensions of modern medical images. This increasingly hampers the early detection and understanding of subtle image changes which can have a vital impact on the patient's health. To change this situation, this proposal introduces a new generation of computational models for the simulation and analysis of dynamic medical images. Thanks to their generative nature, they will allow the construction of databases

of synthetic, realistic medical image sequences simulating various evolving diseases, producing an invaluable new resource for training and benchmarking. Leveraging their principled biophysical and statistical foundations, these new models will bring remarkable added clinical value after they are personalized with innovative methods to fit the medical images of any specific patient. By explicitly revealing the underlying evolving biophysical processes observable in the images, this approach will yield new groundbreaking image processing tools to correctly interpret the patient's condition (computer aided diagnosis), to accurately predict future evolution (computer aided prognosis), and to precisely simulate and monitor an optimal and personalized therapeutic strategy (computer aided therapy). First applications will concern high impact diseases including brain tumors, Alzheimer's disease, heart failure and cardiac arrhythmia and will open new horizons in computational medical imaging.

7.1.1.3. MD PAEDIGREE

Type: COOPERATION

Defi: ICT for Health

Instrument: Integrated Project

Objectif: validating and advancing patient-specific, computer-based predictive models of six paediatric pathologies into clinical acceptance.

Duration: March 2013 - February 2017

Coordinator: Ospedale Pediatrico Bambino Gesu, Rome, Italy.

Partners: Siemens AG (DE), Siemens SCR (USA), Maat France (FR), MOTEK (NL), EMP (DE), VUmc (NL), Lynkeus (IT). Universities: KU Leuven (BE), Fraunhofer (DE), UMC Utrecht (NL), TU Delft(NL), Sheffield (UK), Athens (GR), Genoa (IT), Transilvania din Brasov (RO); Hospitals: OPBG (Roma, IT), Gaslini (Genoa, IT), GOSH/UCL (London, UK), JHU (Baltimore, USA).

See also: http://www.md-paedigree.eu/

Inria contact: Xavier Pennec

Abstract: MD-Paedigree is a clinically-driven and strongly VPH-rooted project, where 7 world-renowned clinical centres of excellence pursue improved interoperability of paediatric biomedical information, data and knowledge by developing together a set of reusable and adaptable multi-scale models for more predictive, individualised, effective and safer paediatric healthcare, being scientifically and technologically supported by one of the leading industrial actors in medical applications in Europe operating in conjunction with highly qualified SMEs and some of the most experienced research partners in the VPH community.

MD-Paedigree validates and brings to maturity patient-specific computer-based predictive models of various paediatric diseases, thus increasing their potential acceptance in the clinical and biomedical research environment by making them readily available not only in the form of sustainable models and simulations, but also as newly-defined workflows for personalised predictive medicine at the point of care. These tools can be accessed and used through an innovative model-driven infostructure powered by an established digital repository solution able to integrate multimodal health data, entirely focused on paediatrics and conceived of as a specific implementation of the VPH-Share project, planned to be fully interoperable with it and cooperating, through it, also with p-Medicine.

MD-Paedigree's goals are to integrate and share highly heterogeneous biomedical information, data and knowledge, using best practices from the biomedical semantic Web; develop holistic search strategies to seamlessly navigate through and manage the integrative model-driven infostructure and digital repository; jointly develop reusable, adaptable and composable multi-scale VPH workflow models, support evidence-based translational medicine at the point of care, and ultimately facilitate collaborations within the VPH community.

7.1.1.4. VP2HF

Type: COOPERATION

Defi: ICT for Health

Instrument: Specific Targeted Research Project

Objectif: New Patient Management for Heart Failure using Modelling

Duration: October 2013 - September 2016

Coordinator: King's College London (UK)

Partner: Philips Research Hamburg (DE), Universitat Pompeu Fabra (SP), Inria, French National Research Institute in Informatics and Mathematics (FR), Université Catholique de Louvain (BE), Caen University Hospital (FR), Philips Research Paris (FR), Simula Research Laboratory (NO), Centron Diagnostics (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 ageing population and improving survival following myocardial infarction. The poor short to medium term prognosis of these patients means that treatments such as cardiac re-synchronisation therapy and mitral valve repair can have substantial impact. However, these therapies are ineffective in up to 50% of 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. The tools will be tested and validated in 200 patients (including 50 historical datasets) across 3 clinical sites, including a prospective clinical study in 50 patients in the last year of the project. The key innovations in VP2HF that make it likely that the project results will be commercially exploited and have major clinical impact are: 1) all tools to process images and signals, and obtain the statistical and biophysical models will be integrated into one clinical software platform that can be easily and intuitively used by clinicians and tried out in the prospective clinical study; and 2) by utilising a decision tree stratification approach, only the appropriate parts of the tool chain, that will add maximum value to the predictions, will be used in individual patients, so that the more resource intensive parts will be used when they will add real value. We expect that the study results of substantial improved efficacy of decision making over current guidelines, and an integrated package that is used as part of clinical workflow will ensure the industrial project partners, in particular Philips, will develop project outputs into dedicated products that will have significant clinical impact.

7.1.2. Collaborations in European Programs, except FP7

7.1.2.1. Care4Me

Participants: Xavier Pennec [Correspondant], Nicholas Ayache, Hervé Delingette, Kristin Mcleod, Erin Stretton, Maxime Sermesant, Marco Lorenzi.

Program: ITEA2

Project acronym: Care4Me

Project title: Cooperative Advanced REsearch for Medical Efficiency

Duration: September 2009 - September 2013

Coordinator: Philips, NL.

Other partners: Alma (ES), Bull (FR), CEA (FR), CIMNE (ES), Compasiss (ES), CVSS (ES), Duodecim (FI), Erasmus MC (NL), ESI (NL), HSP (ES), Helsinki Hosp. (FI), ISI (GGR), LUMC (NL), MediConsult (FI), MEDIS (NL), Nokia (FI), Philips (NL), Pie Medical Imag. (NL), Pohjola (FI), Prowellness (FI), Robotiker (ES), UMC (NL), VTT (FI)

Abstract: This project aims at increasing quality and productivity in the healthcare care cycle by using more advanced medical imaging and decision support methods while combining them with different knowledge sources, from early diagnosis to treatment and monitoring. The final outcome of this project were clinical prototypes of novel medical image analysis and decision support systems for three specific disease areas (cancer, cardio-vascular and neurodegenerative diseases), that connect to hospital information systems using a new system architecture. In this project, the role of the Asclepios team is to develop an atlas of the ageing brain and the beating heart, and to model tumor growth.

7.2. International Initiatives

7.2.1. Inria Associate Teams

7.2.1.1. CAPNEONATES

Title: Analysis of structural MR and DTI in neonates

Inria principal investigator: Bertrand Thirion [Parietal]

Asclepios investigator: Xavier Pennec

International Partner (Institution - Laboratory - Researcher):

Institution: University of Southern California (United States)

Laboratory: Image Lab at Children Hospital at Los Angeles

Researcher: Natasha Leporé

Duration: 2011 - 2013

See also: http://www.capneonates.org/

While survival is possible at increasingly lower gestational ages at birth, premature babies are at higher risk of developing mental disorders or learning disabilities than babies born at term. A precise identification of the developmental differences between premature and control neonates is consequently of utmost importance. Nowadays, the continuously improving quality and availability of MR systems makes it possible to precisely determine, characterize and compare brain structures such as cortical regions, or white matter fiber bundles. The objective of this project is to understand the developmental differences between premature and normal neonates, using structural and diffusion MRI. This work consists in identifying, characterizing and meticulously studying the brain structures that are different between the two groups. To do so, we join forces with the Parietal team at Inria and the University of Southern California. Parietal has a recognized expertise in medical image registration and in statistical analyses of groups of individuals. USC has a broad knowledge in MR image processing. In particular, the Children's Hospital at Los Angeles (CHLA), which is part of USC, is in the process of collecting a unique database of several hundred MR scans of premature and normal neonates. This joint collaboration consequently offers a unique chance of addressing key questions pertaining to neonatal and premature development. It will make it possible to elaborate new tools for analyzing neonate MR images while tremendously increasing our knowledge of neuroanatomy at an early stage in life.

7.2.2. Inria International Partners

7.2.2.1. Declared Inria International Partners

7.2.2.1.1. Stanford, Statistics Department

France Stanford collaborative project grant (2013-2014):*Understanding Lower Back Pain through Geometric Statistical Analysis of computed tomography (CT) Images*. Stanford, Statistics Dept & Nice Univ. Hospital. Principal investigators X. Pennec (Inria) and S. Holmes (Stanford). Collaboration on statistics on group-valued trees and geometric subspace learning [55].

7.2.2.2. Collaboration with international hospitals

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

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

7.2.2.2.2. Massachusetts General Hospital, Boston

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

7.2.2.2.3. Other International Hospitals

Collaborations with several other European hospitals have been established through the European projects VP2HF, Care4Me and MD PAEDIGREE.

ATHENA Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

8.1.1.1. ANR ViMAGINE

Participants: Maureen Clerc, Rachid Deriche, Alexandre Gramfort [Parietal project-team, ENST since september 2012], Emmanuel Olivi [Former member of the Athena Project-Team], Théodore Papadopoulo, Anne-Charlotte Philippe.

Duration: *July 2008 to July 2013*

The partners of this project are ATHENA, the LENA (CHU Pitié-Salpétrière), and the Parietal project-team at Inria Futurs and Neurospin-Saclay.

This project takes a new challenge on the non invasive exploration of the Human visual system in vivo. Beyond the basic mechanisms of visual perception – which have already been investigated at multiple scales and through a large variety of modalities – we are primarily interested in proposing and exploring innovative solutions to the investigation of dynamic neural activations and interactions at the systems level. Bridging the elements involved in this endeavour requires that we are capable of observing, modelling and predicting the interplay between the anatomical/functional architecture of the brain systems and some identified timing properties of neural processes. The overall framework in which this project will be conducted is a federation of partners who will be bringing complementary expertise to this multidisciplinary research. The collaborators include experts in (1) electromagnetic and magnetic resonance brain imaging methods, (2) computational models of neural systems and (3) the neuroscience of vision. A central asset of our group is the easy access to state-of-the-art imaging platforms (e.g. high-density MEG and EEG arrays; 3T and 7T MR scanners) that will ensure the acquisition of quality experimental data.

8.1.1.2. ANR CO-ADAPT

Participants: Maureen Clerc, Dieter Devlaminck, Sebastian Hitziger, Loïc Mahé, Théodore Papadopoulo, Eoin Thomas, Romain Trachel.

Duration: *December 2009 to April 2014*

The partners of this projects are the INSERM U821 laboratory of Bron, the "laboratoire de Neurologie de la cognition" UMR6155 CNRS of Marseille, The Inria Lille Sequel project-team and the "Laboratoire d'Analyse Topologie et Probabilités" UMR6632/CNRS of Université de Provence, Marseille.

Brain Computer Interfaces (BCI) provide a direct communication channel from the brain to a computer, bypassing traditional interfaces such as keyboard or mouse, and also providing a feedback to the user, through a sensory modality (visual, auditory or haptic). A target application of BCI is to restore mobility or autonomy to severely disabled patients, but more generally BCI opens up many new opportunities for better understanding the brain at work, for enhancing Human Computer Interaction, and for developing new therapies for mental illnesses.

In BCI, new modes of perception and interaction come into play, and a new user must learn to operate a BCI, as an infant learns to explore his/her sensorimotor system. Central to BCI operation are the notions of feedback and of reward, which we believe should hold a more central position in BCI research.

The goal of this project is to study the co-adaptation between a user and a BCI system in the course of training and operation. The quality of the interface will be judged according to several criteria (reliability, learning curve, error correction, bit rate). BCI will be considered under a joint perspective: the user's and the system's. From the user's brain activity, features must be extracted, and translated into commands to drive the BCI system. Feature extraction from data, and classification issues, are very active research topics in BCI. However, additional markers may also be extracted to modulate the system's behavior. It is for instance possible to monitor the brain's reaction to the BCI outcome, compared to the user's expectations. This type of information we refer to as meta-data because it is not directly related to the command, and it may be qualitative rather than quantitative. To our knowledge, there is so far no BCI system that integrates such meta-data from the user's brain. From the point of view of the system, it is important to devise adaptive learning strategies, because the brain activity is not stable in time. How to adapt the features in the course of BCI operation is a difficult and important topic of research. A Machine Learning method known as Reinforcement Learning (RL) may prove very relevant to address the above questions. Indeed, it is an adaptive learning method that explicitly incorporates a reward signal, which may be qualitative (hence allowing meta-data integration). The aim of CO-ADAPT is to propose new directions for BCI design, by modeling explicitly the co-adaptation taking place between the user and the system (web site http://coadapt.inria.fr).

8.1.1.3. ANR NucleiPark

Participants: Rachid Deriche, Aurobrata Ghosh, Anne-Charlotte Philippe, Antoine Wolfermann.

Duration: *September 2009 to December 2013*

This project is about High field MR imaging (7T and 3T) of the brainstem, the deep nuclei and their connections in the parkinsonian syndromes with applications to prognosis, pathophysiology and improvement of therapeutic strategies. It involves three partners: The NeuroSpin team including C. Poupon and D. Le Bihan, the Inria with our project as well as the VISAGES project-team and the UPMC (University Pierre and Marie Curie, Paris) including INSERM U678 (H. Benali) and the CENIR (S. Lehericy).

The goal of the project is to find new neuroimaging markers of deep brain nuclei in neurodegenerative diseases that can be used for the diagnosis of Parkinsonian syndromes at the early stage. In addition, the goal is the characterization of lesions of deep brain structures and the detection of biomarkers of neuronal lesions in PD that can be related to clinical signs, such as gait disorders. Biomarkers of Parkinsonian syndromes could be used to create a diagnostic tool of the pathology and to correlate the identified markers with clinical signs. We will perform tractography of small fibre bundles using our HARDI techniques and Diffusion markers (anisotropy, apparent diffusion coefficient, fibre density, curvature, average diameter) will be collected along the reconstructed bundles.

Complementary parts of these objectives directly related to the acquisitions protocols have been accepted within the framework of another proposal submitted by the same partners and accepted for grant for two years (2009 & 2010) by the *France-Parkinson Association*

8.1.1.4. ANR Mosifah

Participants: Rachid Deriche, Maureen Clerc, Théodore Papadopoulo, Gonzalo Sanguinetti.

Duration: *October 2013 to September 2017*

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

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

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

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

8.1.1.5. ANR MULTIMODEL

Participants: Théodore Papadopoulo, Maureen Clerc, Sebastian Hitziger, Emmanuel Olivi.

Duration: *December 2010 to May 2014*

The MULTIMODEL project stems from a conjoint INSERM-Inria scientific initiative launched in December 2008 and ended in 2010. It involves 5 partners (Inserm U751 in Marseille, U678 in Paris, U836 in Grenoble, U642 in Rennes and Inria ATHENA project-team).

The general objectives of the MULTIMODEL project are :

- To develop computational models at the level of neuronal systems that will help interpreting neuroimaging data in terms of excitation-, inhibition- and synchronization-related processes.
- To acquire multimodal datasets, obtained in rats and humans under physiological and epileptogenic conditions, which will be used to develop the biophysical models and to test their face validity and predictability.

Specifically, the following questions are dealt with:

- How can models be integrated in order to link data from different modalities (electro/magneto-encephalography, optical imaging, functional MRI)?
- What is the influence of hidden parameters on the observed signals (e.g. ratio of excitation/inhibition and synchronization degree across regions)?
- To what extent can biophysical modelling bring valuable insights on physiological and pathological brain activity ?

We operate at the level of population of cells, i.e. at a scale compatible with the resolution of neuroimaging tools (at the level of the mm). A novel model structure is being investigated, which includes astrocytes at this “mesoscopic” level and operates in networks of connected regions. Moreover, models in physiological and pathological conditions will be compared, which is a step towards a better understanding of mechanisms underlying epileptic condition.

8.1.1.6. ANR VIBRATIONS

Participants: Théodore Papadopoulo, Maureen Clerc, Rachid Deriche.

Duration: *Early 2014 to early 2018*

This Translational ANR project has just been been accepted.

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

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

The project follows a three-fold strategy:

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

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

8.1.2. ADT

8.1.2.1. ADT MedInria-NT

Participants: Jaime Garcia Guevara, Loïc Cadour, Théodore Papadopoulo, Maureen Clerc, Rachid Deriche.

Duration: *December 2010 to December 2012, prolongated to December 2014*

The goal of this technical project, funded by Inria for 2 years, is to introduce some tools developed at ATHENA into the medInria platform. There are basically two such facilities:

- Integrate the tools developed for the statistical characterization of brain white matter fiber bundles.
- Develop an interface for M/EEG data within MedInria. This will focus on two main goals:
  - Create a facility to read and visualize M/EEG signals.
  - Integrate M/EEG forward problem tools.

8.1.2.2. ADT OpenViBe-NT

Participants: Théodore Papadopoulo, Maureen Clerc, Loïc Mahé.

Duration: *October 2012 to December 2014*

OpenViBE is an opensource software which development started in 2005 with the goal of offering an open research tool for BCI and for supporting disabled people. Since its release in 2009, this software has received a lot of success (+10.000 downloads). But since 2005, new use have appeared as well as some limitations. The current software thus lacks of some features that limit its use, deployment and perennity. The goal of this ADT is to solve these problems, to improve and to extend OpenViBe One main goal is to improve the usability and the attractivity of the software and to retain a large community of users so as to ensure its sustainability. This ADT will allow to support the research made in four Inria teams (ATHENA, HYBRID, NEUROSYS and POTIOC) on hot topics such as adaptive or hybrid BCIs.

8.2. International Initiatives

8.2.1. Inria Associate Teams

8.2.1.1. BRAINCONNECTIVITIES

Title: Fusing anatomical and functional connectivity information using diffusion MRI, MEG and EEG.

Inria principal investigator: Théodore PAPADOPOULO

International Partners (Institution - Laboratory - Researcher):

University of Québec, School of Higher Technology (Canada) - PhysNum Group, Centre de recherches mathématiques, Montréal - Théodore PAPADOPOULO

University of Sherbrooke (Canada) - Departement d'Informatique - Théodore PAPADOPOULO

Duration: 2012 - 2014

See also: http://brainconnectivities.inria.fr/wordpress/

Currently brain connectivity is studied through two different lenses: 1) Anatomical connectivity aims at recovering the "wires" that connect the various brain cortical "units", 2) Functional connectivity studies when and how cortical regions are connected. Providing tools to fuse these two complementary views is the central goal of this project. Our effort will focus on three imaging modalities: diffusion MRI (dMRI) , Electroencephalography (EEG) and Magnetoencephalography (MEG). dMRI (jointly with traditional MRI) provides a detailed anatomical view of the brain. It allows the recovery of the fiber structure of the white matter: these are the electrical connexions between distant cortical areas. But dMRI does not provide any clue on: 1) on the actual use of connexions during brain activity, 2) on the way information propagates along time for a given task. On the opposite, EEG and MEG (jointly named MEEG) provide (after source reconstruction) time courses of the activity of the cortical areas. It is possible to recover some connectivity information from these time courses, but these are purely signal based and do not take account of the anatomy so there are multiple solutions that are sometimes difficult to discriminate. Furthermore source reconstructions are regularized with purely mathematical a priori taking only partially account of the actual brain structures.The main goals of this project are to provide tools: 1) To acquire diffusion data more efficiently, 2) To use the information of dMRI to define better models and regularization schemes for spatio-temporal MEEG source reconstruction, 3) To use MEEG data to better understand the task-dependent spatio-temporal structure of connectivity patterns.

8.2.2. Inria International Partners

8.2.2.1. Informal International Partners

- CMRR, University of Minnesota, USA (Christophe Lenglet)
- Department of CISE, the University of Florida, Gainesville, USA (Baba C. Vemuri)
- Centre for Medical Image Computing (CMIC), Dept. Computer Science, UCL, UK (D. Alexander)
- SBIA, University of Pennsylvania Medical School, USA (R. Verma).
- University Houari Boumedienne (USTHB, Algiers) (L. Boumghar) and University of Boumerdes, (D. Cherifi), Algeria.
- BESA company of EEG/MEG source localisation.

8.3. International Research Visitors

8.3.1. Visits of International Scientists

- Maxime Descoteaux (USherbrooke) visited ATHENA (September 10-15 2013) and (December 13-20, 2013).

- Gabriel Girard (USherbrooke) has joined ATHENA for one year for a joint PhD (Samuel de Champlain grant) from October 10th, 2013 to September 30th, 2014. He is co-supervized by M. Descoteaux and R. Deriche.
- Jean-Marc Lina (CRM) visited ATHENA from December 17th to December 21th.

8.3.1.1. Internships

- Susana Merino-Caviedes (Valladolid University) visited ATHENA from Sep 2013 until Nov 2013.
- Mouloud Kachouane (USTHB, Algiers) visited ATHENA from October 20 until December 20, 2013).
- Thinhinane Megherbi (USTHB, Algiers) and Mouloud Kachouane (USTHB, Algiers) visited ATHENA (June 2013).

DEMAR Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Appel d'Offre Interne (AOI) CGS Merri (CHU Montpellier)

Development and evaluation of a freezing detection system for people subject to the Parkinson disease : CHU Montpellier - UM1 M2H (Montpellier) - DEMAR

8.1.2. Labex NUMEV

Optimization of the sitting to stand-up transfer under FES for paraplegic people : preliminary study.

8.1.3. Running CPP protocols (Comité de Protection des Personnes)

- Optimisation du transfert assis-debout sous électro myostimulation fonctionnelle du patient paraplégique : Etude préliminaire, PROPARA, Montpellier. CPP Sud Méditerranée III - ID RCB : 2010-A00808-31 + Amendement.
- Détection et quantification du freezing chez le sujet parkinsonien CHU Montpellier, A. Balmes. CPP Sud Méditerranée 4 - étude qualifiée "soins courants".
- Observation du cycle de marche chez des patients hémiplégiques dans le but d'améliorer le déclenchement de la stimulation électrique fonctionnelle CHU Nîmes, Grau du Roi. CPP Sud Méditerranée III
- Mise au point d'une stratégie pour le stimulation sélective chez le lapin. Laboratoire de recherches chirurgicales Institut de Biologie, Université Montpellier I. Comité d'Ethique pour l'Expérimentation Animale Languedoc-Roussillon

8.2. National Initiatives

8.2.1. DEMAR / MXM Innovation Lab "SoftStim" project

Participants: David Guiraud, David Andreu.

Inria Innovation-Lab "SoftStim" project (2011-2014). 1 engineer (3 y.), 20keuros.

The aim of this Inria's national initiative is to favor the scientific collaboration and technological transfer of the innovation between DEMAR and MXM.

The aim of this project is to prototype concepts conjointly patented like stimulation unit 's embedded sequencer and processor (new set of instructions), and implantable FES controller with its dedicated software environment.

8.2.2. Cosinus ANR - SoHuSim

Participants: Benjamin Gilles, Mitsuhiro Hayashibe, David Guiraud, Maxime Tournier.

Project SoHuSim on modeling muscle tissue during contraction in 3D movements using SOFA software and functional modeling of the organs. 150 kE. Partners: Inria Evasion, Tecnalia, HPC, CHU Montpellier (Oct. 2010 - Oct. 2014).

8.2.3. ADT SENSAS - SENSBIO

Participants: Christine Azevedo-Coste, David Andreu, Daniel Simon.

SENSAS is an Inria ADT (Actions de Développement Technologique), implying several Inria project teams on the “SENSor network ApplicationS” theme. SENSAS aims to propose applications based on wireless sensor and actuator network nodes provided from the work done around senslab and senstools preliminary projects. SENSAS is organized around the following work packages :

- SensRob : Robotics applications
- SensBio : Bio-Logging applications
- SensMGT : Wireless sensor/actuator network management/configuration applications
- SensBox : Wireless sensor/actuator network simulation applications and tools

Our team is mainly implied in the SensBio work package, in particular for the following applications: Spinal Cord Injured Patients FES-Assisted Sit to Stand, Post-Stroke Hemiplegic Patient FES-correction of drop foot, Gait analysis of parkinson freezing and Motion analysis of longterm race data.

8.2.4. Programme de recherche en qualité hospitaliere (PREQHOS)

Participants: Leader: Jean-Christophe Lucet [GH Bichat - Claude Bernard], Christine Azevedo-Coste, Eric Fleury [Inria DANTE], Bruno Grandsebastien [CHRU Lille].

Project: Surgery room behaviour and impact on infectious risks (ARIBO : Attitudes et Risque Infectieux au Bloc Operatoire)

8.2.5. INTENSE project

Participants: David Guiraud, Pawel Maciejasz, Olivier Rossel, Christine Azevedo-Coste, David Andreu, Fabien Soulier.

INTENSE (Initiative Nationale Technologique d’Envergure pour une NeuroStimulation Evoluée) is a PIA-PSPC Project (Programme Investissement d’Avenir, Projets RD Structurants des Pôles de Compétitivité) [2012-2018]. The aim of this project is to develop new implantable devices, based on neurostimulation, for heart failure.

Partners of this project are: DEMAR, SORIN CRM, MXM-Obélia, 3D plus, CEA-Leti, INRA Rennes, INSERM Rennes, HEGP, CHU Rennes.

8.3. European Initiatives

8.3.1. FP7 European project TIME

Participants: David Guiraud, David Andreu, Fabien Soulier, Pawel Maciejasz.

(2008-2013). 375keuros, "*Transverse, Intrafascicular Multichannel Electrode system for induction of sensation and treatment of phantom limb pain in amputees*".

Partners : AAU (Aalborg, Denmark), MXM (Vallauris, France), SSSA (Pisa, Italy), IMTEK (Freiburg, Germany), UAB (Barcelona, Spain), UCBM (Roma, Italy), IUPUI (Indianapolis, USA).

http://www.project-time.eu/

8.3.2. FP7 European project EPIONE

Participants: David Guiraud, David Andreu, Fabien Soulier, Pawel Maciejasz.

(2013-2017) "*Natural sensory feedback for phantom limb pain modulation and therapy*,

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

http://project-epione.eu/

8.4. International Initiatives

8.4.1. Participation In other International Programs

8.4.1.1. STIC AmSud

Title: CARAT (Computer Aided Rehabilitation Algorithms and Tools)

Inria principal investigator: Mitsuhiro Hayashibe

International Partner (Institution - Researcher):

Universidade de Brasília (UnB,Brazil) - Antônio P.L. Bó, Geovany Borges

Pontificia Universidad Católica del Perú (PUCP,Brazil) - Dante Elias

Duration: 2012 - 2013

Throughout the world there is an increasing need for better technologies for rehabilitation and assistance. These new solutions must present improved performance in terms of therapy effectiveness, while at the same time minimizing the corresponding costs. In this scenario, computer-aided methods represent a promising alternative for the challenges currently faced by the rehabilitation domain. Within this collaborative research project, we focus on the following research topics: - Algorithms for human motion analysis for both clinical and residential settings based on portable and external sensing technologies - Sensory feedback devices to improve effectiveness on rehabilitation procedures - Robotic platforms for rehabilitation - Software development for telerehabilitation

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Prof. Dante Elias (Professor, Pontificia Universidad Católica del Perú) visited and presented his work on "Characteristics of a walking simulator with parallel manipulators" (7th, Nov 2013).

8.5.1.1. Internships

David Andreu supervised Milan Demarcq on "Mesure et Optimisation de la consommation de systèmes numériques implantables", Engineer final internship, from March. 2013 to Sep. 2013.

David Guiraud supervised Charles Juillet on «Transmission d'énergie et de données à un implant via un câble bifilaire », Engineer final internship, from March. 2013 to Sep. 2013.

David Andreu supervised Arthur Hiairrassary on "Architecture logicielle temps-réel d'un contrôleur de SEF implantable", Projet Industriel de Fin d'Etudes (engineer final year project), from Sep. 2013 to Feb. 2014.

David Andreu supervised Joannick Azama on "Implémentation d'un protocole application multi-charge pour réseau de SEF sans-fil", Projet Industriel de Fin d'Etudes (engineer final year project), from Sep. 2013 to Feb. 2014.

David Andreu supervised Chams Jied on "Architecture logicielle d'un contrôleur temps-réel de stimulation électrique fonctionnelle", Projet Industriel de Fin d'Etudes (engineer final year project), from Sep. 2013 to Feb. 2014.

David Andreu supervises Guillaume Magro. "Spécification et prototypage d'un contrôleur de SEF implantable". Industrial Informatics Engineer, Inria Expert Engineer contract (3 years contract, Inria).

Daniel Simon supervised Jonathan Peguet on "Attitude Reconstruction of an Inertial Measurement Unit using IMUSim Software", IFMA (Clermont-Ferrand) engineer final year project, from Apr. to Sep. 2013.

Mitsuhiro Hayashibe supervised Sourav Chandra on "Dynamic modeling of fatigue induced hand tremor", PhD internship, Svaagata.eu: experience Europe as an Indian Erasmus Mundus, Indian Institute of Technology Madras, India, from Sep. 2013 to Feb. 2014.

8.5.2. Visits to International Teams

- Mitsuhiro Hayashibe visited Pontificia Universidad Católica del Perú for STIC Amsud - CARAT project and made a seminer on "Modeling and Control for Neuroprosthetic Systems and Rehabilitation" (15th May 2013 -25th May 2013).
- Mitsuhiro Hayashibe was Visiting Researcher at RIKEN BSI-TOYOYA research institute and worked on "Tacit Motor learning for rehabilitation" (Jul.-Aug. 2013).

GALEN Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Excellence Clusters

- Program: DIGITEO (OMTE)

  Project acronym: Curator

  Project title: Real-time 2D/3D Deformable Fusion Towards Computer Assisted Surgery

  Duration: 01/2013-01/2014

  Coordinator: ECP - FR

- Program: MEDICEN

  Project acronym: ADOC

  Project title: ADOC – Diagnostic peropératoire numérique en chirurgie du cancer

  Duration: 11/2011-10/2014

  Coordinator: LLTECH - FR

8.2. National Initiatives

8.2.1. 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: 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

8.3. European Initiatives

8.3.1. FP7 Projects

- Project acronym: MOBOT

Project title: Intelligent Active MObility Assistance RoBOT integrating Multimodal Sensory Processing, Proactive Autonomy and Adaptive Interaction

Duration: 01/2013-12/2015

Coordinator: TUM - DE

- Project acronym: RECONFIG

  Project title: Cognitive, Decentralized Coordination of Heterogeneous Multi-Robot Systems

  Duration: 01/2013-12/2015

  Coordinator: KTH - SE

8.3.2. Collaborations in European Programs, except FP7

- Program: European Research Council

  Project acronym: DIOCLES

  Project title: Discrete bIOimaging perCeption for Longitudinal Organ modEling and computEr-aided diagnosiS

  Duration: 9/2011-8/2016

  Coordinator: ECP - FR

8.4. International Initiatives

8.4.1. Inria Associate Teams

8.4.1.1. SPLENDID

Title: Self-Paced Learning for Exploiting Noisy, Diverse or Incomplete Data

Inria principal investigator: Nikos Paragios

International Partner (Institution - Laboratory - Researcher):

Stanford University (United States) - Artificial Intelligence Lab - Nikos Paragios

Duration: 2012 - 2014

The goal of the project is to develop methods for learning accurate probabilistic models using diverse (consisting of fully and weakly supervised samples), incomplete (consisting of partially labeled samples) and noisy (consisting of mislabeled samples) data. To this end, we will build on the intuitions gained from self-paced human learning, where a child is first taught simple concepts using simple examples, and gradually increasing the complexity of the concepts and the examples. In the context of machine learning, we aim to impart the learner with the ability to iteratively adapt the model complexity and process the training data in a meaningful order. The efficacy of the developed methods will be tested on several real world computer vision and medical imaging applications using large, inexpensively assembled datasets.

8.4.2. Inria International Partners

8.4.2.1. Informal International Partners

Europe

- Technical University of Munich (DE) – Collaborative research with the Chair for Computer Aided Medical Procedures & Augmented Reality at the department of Computer Science. Collaboration Topic: Graph-based methods for linear/deformable registration, segmentation, and tracking.
- University College London (UK) – Collaborative research with the Gatsby Computational Neuroscience Unit. Collaboration Topic: Kernel measures of dependence.

- University of Oxford (UK) – Collaborative research with the Visual Geometry Group of the Department of the Electrical Engineering. Collaboration Topic: Structured prediction, invariance, and parts-based models.
- University of Oulu (Finland) – Collaborative research with the Machine Vision Group at the department of Electrical Engineering. Collaboration Topic: Ranking based learning algorithms for cascaded object detection.

Americas

- University of California at Los Angeles (US) – Collaborative research with the UCLA Vision Lab and the UCLA Center for Cognition, Vision, and Learning Lab at the Departments of Computer Science and Statistics. Collaboration Topic: Action Recognition & Object Detection Parsing.
- University of Pensylvania (USA) – Collaborative research with the section of Biomedical Imaging of the Department of Radiology. Collaboration Topic: Graph-based methods for linear/deformable registration.
- StonyBrook University, Computer Science Department (USA) – Collaborative research with the image analysis lab in the context of the SubSample DIGITEO Chair. Collaboration Topic: Higher Order Graph-based methods in graph-matching, cocaine addiction analysis with sparse graph models, object detection and implicit 3D pose estimation
- Ecole Polytechnique de Montreal (CA) – Collaborative research with the Canada Research Chair in Medical Imaging and Assisted Interventions. Collaboration Topic: Higher Order Graph-based methods in Spine Imaging

Asia

- International Institute of Information Technology, Hyderabad (India) – Collaborative research with Center for Visual Information Technology. Collaboration Topic: Average precision with weak supervision & self-paced learning for deep convolutional neural networks.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Professor Spyretta Golemati lecturer at the school of medicine at the University of Athens has visited during her sabbatical the team from June 1st, 2013 to July 30th, 2013.

8.5.1.1. Internships

Siddhartha Chandra

Subject: machine learning for 3D reasoning.

Date: from May 2013 until December 2013.

Institution: IIIT Hyderabad (India)

Dimitrios Damopoulos

Subject: Automatic Detection and Characterization of Liver Tumors

Date: from Nov 2013 until Apr 2014

Institution: National Technical University of Athens (Greece)

José Ignacio Orlando

Subject: Machine Learning for Opthalmology

Date: from Apr 2013 until Sep 2013

Institution: National University of the Center of the Buenos Aires Province (Argentina)

Eduard Trulls

Subject: Segmentation-aware descriptors

Date: from March 2013 until July 2013

Institution: Polytechnical University of Catalunia (Spain)

8.5.2. Visits to International Teams

- M. Pawan Kumar (Inria): one week visit to Stanford University (May 2013).
- M. Pawan Kumar (Inria): one week visit to Stanford University (June 2013).
- Matthew Blaschko (Inria): one week visit to Stanford University (December 2013).

MNEMOSYNE Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

7.1.1.1. ANR project KEOPS

Participants: Frédéric Alexandre, Thierry Viéville.

We are responsible for this "ANR Internal White Project" involving Mnemosyne and Neuromathcomp Inria Project-Teams in France with the U. of Valparaiso, U. Tecnica Frederico Santa-Maria, and U. Chile. The project addresses the integration of non-standard behaviors of retinal neural sensors, observed in natural conditions, into neural coding models and their translation into real, highly non-linear, bio-engineering artificial solutions. This project is now a four year project untill the end of 2014, it has been evaluated by the reviewers at the end of 2013. Results concerning the thalamus and the retina evoked in § 6.3 and § 6.4 have been obtained in this project. Furthermore, new collaboration tracks have been conducted, taking benefit of interdisciplinarity of this international collaboration, e.g. at the methodological level [1].

7.2. International Initiatives

7.2.1. Inria Associate Teams

7.2.1.1. Cortina, associate team with Chile

Participants: Frédéric Alexandre, Thierry Viéville.

The goal of this associate team that finished this year is to combine our complementary expertise, from experimental biology and mathematical models (U de Valparaiso and U Federico Santa-Maria) to computational neuroscience (Mnemosyne and Neuromathcomp Project-teams), in order to develop common tools for the analysis and formalization of neural coding and related sensory-motor loops. Recording and modeling spike trains from the retina neural network, an accessible part of the brain, is a difficult task that our partnership can address, what constitute an excellent and unique opportunity to work together sharing our experience and to focus in developing computational tools for methodological innovations.

7.2.2. Inria International Partners

7.2.2.1. Informal International Partners

We have informal relations with the Computational Cognitive Neuroscience (CCN) Lab, University of Colorado, Boulder, USA (Prof. Randall O'Reilly) concerning the computationally-based understanding of the neural circuits involved in affectively-driven decision making, including the basal ganglia (BG) and ventral and medial prefrontal cortex areas.

7.3. International Research Visitors

7.3.1. Visits of International Scientists

7.3.1.1. Invited Professor

Prof. Adrian Palacios, responsible for the chilean part of our associate team Cortina (*cf.* § 7.2) has been visiting Bordeaux one month in September 2013. He was also partly supported by the Labex BRAIN.

7.3.1.2. Internships

Meropi Topalidou

Subject: Touch and the Body

Date: from Mar 2013 until Sep 2013

Institution: Université Nationale Capodistrienne d'Athènes (Greece)

Román Gorojovsky

Subject: Hierachical Associative Memories

Date: from Apr 2013 until Oct 2013

Institution: University of Buenos Aires (Argentina)

7.3.2. Visits to International Teams

From mid-july to end of August, Maxime Carrere, a newly-hired PhD student in the team, has visited the CCN lab in Boulder, USA (*cf.* § 7.2) for 6 weeks.

NEUROMATHCOMP Project-Team

6. Partnerships and Cooperations

6.1. National Initiatives

6.1.1. ANR

6.1.1.1. KEOPS

See section "International Initiatives" below.

6.2. European Initiatives

6.2.1. FP7 Projects

6.2.1.1. BRAINSCALES

Title: BrainScaleS: Brain-inspired multiscale computation in neuromorphic hybrid systems

Type: COOPERATION (ICT)

Defi: Brain-inspired multiscale computation in neuromorphic hybrid systems

Instrument: Integrated Project (IP)

Objectif: FET proactive 8: Brain Inspired ICT

Duration: January 2011 - December 2014

Coordinator: Universitaet Ruprecht- Karls Heidelberg (Germany)

Other Partners: Nederlandse Akademie van Wetenschappen, Amsterdam; Universitetet For Miljo Og Biovitenskap, Aas; Universitat Pompeu Fabra, Barcelona; University of Cambridge; Debreceni Egyetem, Debrecen; Technische Universität Dresden; CNRS-UNIC, Gif-sur- Yvette; CNRS-INCM, Marseille; CNRS-ISM, Marseille; TUG, Graz; Ruprecht-Karls-Universität Heidelberg; Forschungszentrum Jülich GmbH, Jülich; EPFL LCN, Lausanne; EPFL- BBP, Lausanne; The University Of Manchester, Manchester; KTH, Stockholm; Universität Zürich.

See also http://brainscales.kip.uni-heidelberg.de/

Inria contact: Olivier Faugeras

Abstract: The BrainScaleS project aims at understanding function and interaction of multiple spatial and temporal scales in brain information processing. The fundamentally new approach of BrainScaleS lies in the in-vivo biological experimentation and computational analysis. Spatial scales range from individual neurons over larger neuron populations to entire functional brain areas. Temporal scales range from milliseconds relevant for event based plasticity mechanisms to hours or days relevant for learning and development. In the project generic theoretical principles will be extracted to enable an artificial synthesis of cortical-like cognitive skills. Both, numerical simulations on petaflop supercomputers and a fundamentally different non-von Neumann hardware architecture will be employed for this purpose. Neurobiological data from the early perceptual visual and somatosensory systems will be combined with data from specifically targeted higher cortical areas. Functional databases as well as novel project-specific experimental tools and protocols will be developed and used. New theoretical concepts and methods will be developed for understanding the computational role of the complex multi-scale dynamics of neural systems in-vivo. Innovative in-vivo experiments will be carried out to guide this analytical understanding. Multiscale architectures will be synthesized into a non-von Neumann computing device realised in custom designed electronic hardware. The proposed Hybrid Multiscale Computing Facility (HMF) combines microscopic neuromorphic physical model circuits with numerically calculated mesoscopic and macroscopic functional units

and a virtual environment providing sensory, decision-making and motor interfaces. The project also plans to employ petaflop supercomputing to obtain new insights into the specific properties of the different hardware architectures. A set of demonstration experiments will link multiscale analysis of biological systems with functionally and architecturally equivalent synthetic systems and offer the possibility for quantitative statements on the validity of theories bridging multiple scales. The demonstration experiments will also explore non-von Neumann computing outside the realm of brain-science. BrainScaleS will establish close links with the EU Brain-i-Nets and the Blue Brain project at the EPFL Lausanne. The consortium consists of a core group of 10 partners with 13 individual groups. Together with other projects and groups the BrainScaleS consortium plans to make important contributions to the preparation of a FET flagship project. This project will address the understanding and exploitation of information processing in the human brain as one of the major intellectual challenges of humanity with vast potential applications.

This project started on January 1st, 2011 and is funded for four years.

6.2.1.2. MATHEMACS

Title: Mathematics of Multilevel Anticipatory Complex Systems

Type: Collaborative project (generic) (FP7-ICT)

Defi: develop a mathematical theory of complex multilevel systems and their dynamics.

Instrument: Integrated Project (IP)

Duration: October 2012 - September 2015

Coordinator: Fatihcan Atay, Max Planck Institute for Mathematics in the Sciences, Leipzig (Germany)

Other Partners: Max Planck Institute for Mathematics in the Sciences (Leipzig, Germany), Universität Bielefeld (Germany), Chalmers University of Technology (Gothenburg, Sweden), Ca'Foscari University of Venice (Italy), Università Politecnica delle Marche (Ancona, Italy).

See also: http://www.mathemacs.eu/description.html

Inria contact: Olivier Faugeras

Abstract: The MATHEMACS project aims to develop a mathematical theory of complex multi-level systems and their dynamics. This is done through a general formulation based on the mathematical tools of information and dynamical systems theories. To ensure that the theoretical framework is at the same time practically applicable, three key application areas are represented within the project, namely neurobiology, human communication, and economics. These areas not only provide some of the best-known epitomes of complex multi-level systems, but also constitute a challenging test bed for validating the generality of the theory since they span a vast range of spatial and temporal scales. Furthermore, they have an important common aspect; namely, their complexity and self-organizational character is partly due to the anticipatory and predictive actions of their constituent units. The MATHEMACS project contends that the concepts of anticipation and prediction are particularly relevant for multi-level systems since they often involve different levels. Thus, as a further unique feature, the project includes the mathematical representation and modeling of anticipation in its agenda for understanding complex multi-level systems.

This project started on October 1st, 2012 and is funded for four years.

6.2.1.3. RENVISION

Type: COOPERATION, FP7 FET (Future Emerging technology) proactive program: Neuro-Bio-Inspired Systems Call 9 Objective 9.11

Defi: Retina-inspired ENcoding for advanced VISION tasks (RENVISION)

Instrument: Specific Targeted Research Project

Duration: March 2013 - February 2016

Coordinator: Vittorio Murino, PAVIS, IIT (Italy)

Partner: PAVIS, IIT (Italy), NBT, IIT (Italy), NAPH, IIT (Italy), The Institute of Neuroscience, Newcastle University (UK), Institute for Adaptive and Neural Computation, The University of Edimburgh (UK), Neuromathcomp project-team, Inria (France)

Inria contact: Pierre Kornprobst

Abstract: The retina is a sophisticated distributed processing unit of the central nervous system encoding visual stimuli in a highly parallel, adaptive and computationally efficient way. Recent studies show that rather than being a simple spatiotemporal filter that encodes visual information, the retina performs sophisticated non-linear computations extracting specific spatio-temporal stimulus features in a highly selective manner (e.g. motion selectivity). Understanding the neurobiological principles beyond retinal functionality is essential to develop successful artificial computer vision architectures.

RENVISION's goal is, therefore, twofold:

- To achieve a comprehensive understanding of how the retina encodes visual information through the different cellular layers;
- To use such insights to develop a retina-inspired computational approach to high-level computer vision tasks.

To this aim, exploiting the recent advances in high-resolution light microscopy 3D imaging and high-density multielectrode array technologies, RENVISION will be in an unprecedented position to investigate pan-retinal signal processing at high spatio-temporal resolution, integrating these two technologies in a novel experimental setup. This will allow for simultaneous recording from the entire population of ganglion cells and functional imaging of inner retinal layers at near-cellular resolution, combined with 3D structural imaging of the whole inner retina. The combined analysis of these complex datasets will require the development of novel multimodal analysis methods.

Resting on these neuroscientific and computational grounds, RENVISION will generate new knowledge on retinal processing. It will provide advanced pattern recognition and machine learning technologies to ICTs by shedding a new light on how the output of retinal processing (natural or modelled) allows solving complex vision tasks such as automated scene categorization and human action recognition.

6.2.1.4. HBP

Type: COOPERATION, FET Flagship' project

Defi: Understanding the brain

Instrument: FET Flagship' project

Duration: October 2013 - March 2016

Coordinator: EPFL (Switzerland)

Partner: see http://www.humanbrainproject.eu.

Inria contact: Olivier Faugeras

Abstract: The Human Brain Project (HBP) is supported by the European Union as a 'FET Flagship' project and the 86 institutions involved will receive one billion euro in funding over ten years. HBP should lay the technical foundations for a new model of ICT-based brain research, driving integration between data and knowledge from different disciplines, and catalysing a community effort to achieve a new understanding of the brain, new treatments for brain disease and new brain-like computing technologies. http://www.humanbrainproject.eu

6.2.1.5. NERVI

Program: ERC IDEAS

Project acronym: NerVi

Project title: From single neurons to visual perception

Coordinator: Olivier Faugeras

Duration: January 2009 - December 2013

Abstract: The project is to develop a formal model of information representation and processing in the part of the neocortex that is mostly concerned with visual information. This model will open new horizons in a well-principled way in the fields of artificial and biological vision as well as in computational neuroscience. Specifically the goal is to develop a universally accepted formal framework for describing complex, distributed and hierarchical processes capable of processing seamlessly a continuous flow of images. This framework features notably computational units operating at several spatiotemporal scales on stochastic data arising from natural images. Mean-field theory and stochastic calculus are used to harness the fundamental stochastic nature of the data, functional analysis and bifurcation theory to map the complexity of the behaviours of these assemblies of units. In the absence of such foundations, the development of an understanding of visual information processing in man and machines could be greatly hindered. Although the proposal addresses fundamental problems, its goal is to serve as the basis for ground-breaking future computational development for managing visual data and as a theoretical framework for a scientific understanding of biological vision.

6.2.1.6. FACETS-ITN

Title: FACETS-ITN

Instrument: Initial Training Network (ITN)

Duration: September 2009 - August 2013

Coordinator: Universität Heidelberg- Ruprecht-Karls (Germany)

Inria contact: O. Faugeras

See also http://facets.kip.uni-heidelberg.de/ITN/index.html

This 'Marie-Curie Initial Training Network' (funded by the EU) involves 15 groups at European Research Universities, Research Centers and Industrial Partners in 6 countries. Website: http://facets.kip.uni-heidelberg.de/ ITN/index.html

6.3. International Initiatives

6.3.1. Inria Associate Teams

6.3.1.1. CORTINA

Title: Retina neural network coding

Inria principal investigator: Bruno CESSAC

International Partner (Institution - Laboratory - Researcher):

Technical University Federico Santa Maria, Valparaíso (Chile) - Electronics Engeneering Department - Bruno CESSAC

Duration: 2011 - 2013

See also: http://cortex.loria.fr/Projects/Cortina

Much progress has been made in the last decades in understanding the basic organization and function of the nervous system in general. Contributions to this end have come from various domains including computational neuroscience and numerical science of the information in general. The goal of this associate team is to combine our complementary expertise, from experimental biology and mathematical models (U de Valparaiso and U Federico Santa-Maria) to computational neuroscience (CORTEX and NEUROMATHCOMP), in order to develop numerical tools for the study and characterization of neural coding and related sensory-motor loops. Recording and modeling spike trains from the retina neural network, an accessible part of the brain, is a difficult task that our partnership

can address, what constitute an excellent and unique opportunity to work together sharing our experience and to focus in developing computational tools for methodological innovations. To understand how the neural spike coding from natural image sequences works we are addressing the following issues: How visual signals are coded at earlier steps in the case of natural vision? What are their functions? What are the computational coding principles explaining (in artificial or biological system) the statistical properties of natural images? We wish to advance our actual knowledge in natural and artificial visual signals processing and apply it to the field of education; to foster better capacities for learning and memory; sensory prosthesis design, to will help unpaired sensory persons to sense the world and physical rehabilitation, among others. In the context of the cooperation between the Inria and Chile, we propose to develop new neural decoding algorithms that are transverse to several field and applications.

6.3.2. Inria International Partners

6.3.2.1. Declared Inria International Partners

Paul Bressloff, Professor of applied mathematics at the University of Utah (USA) specialising in mathematical neuroscience, has been selected for an Inria International Chair. He will be visiting the Sophia-Antipolis Méditerranée research center two months every year for five years, starting in 2014.

6.3.3. Participation In other International Programs

6.3.3.1. ANR KEOPS

Type: Algorithms for modeling the visual system: From natural vision to numerical applications.

Principal Investigator: Thierry Viéville (Mnemosyne)

International partner:

- Institution: University of Valparaiso (Chile)
- Laboratory: Centro Interdiciplinario de Neurociencia de Valparaiso
- Researcher: Adrian PALACIOS

International partner:

- Institution: UTFSM Valparaiso (Chile)
- Laboratory: Direccion General de Investigacion y Postgrado de Valparaiso
- Researcher: Maria-Jose ESCOBAR

Duration: 2011 - 2013

See also: http://cortex.loria.fr/Research/Keops

Abstract: KEOpS attempts to study and model the non-standard behavior of retinal (ganglion cells) sensors observed in natural scenarios. KEOpS also attempts to incorporate the resulting models into real engineering applications as new dynamical early-visual modules. The retina, an accessible part of the brain, is a unique model for studying the neural coding principles for natural scenarios. A recent study proposes that some visual functions (e.g. movement, orientation, anticipatory temporal prediction, contrast), thought to be the exclusive duty of higher brain centers, are actually carried at the retina level. The anatomical and physiological segregation of visual scenes into spatial, temporal and chromatic channels begins at the retina through the action of local neural networks. However, how the precise articulation of this neural network contributes to local solutions and global perception necessary to resolve natural task remains in general a mystery. KEOpS thus attempts to study the complexity of retinal ganglion cells (the output to the brain) behaviors observed in natural scenarios and to apply this result to artificial visual systems. We revisit both the retinal neural coding information sent to the brain, and at the same time, the development of new engineering applications inspired by the understanding of such neural encoding mechanisms. We develop an innovative formalism that takes the real (natural) complexity of retinal responses into account. We also develop new dynamical early-visual modules necessary to solve visual problems task.

6.4. International Research Visitors

6.4.1. Visits of International Scientists

- Alexander Cerquera, Universidad Antonio Nariño, Facultad de Ingeniería Electrónica y Biomédica, Colombia, 25-29/03/2013.
- Antonio Galves, Statistics Department. Instituto de Matemática e Estatística · Universidade de São Paulo. 25-27/06/2013.
- Eva Loecherbach, Maths department, Cergy University. 25-27/06/2013.

6.4.1.1. Internships

- Gaia Lombardi, M2 Internship, March-August 2013.

NEUROSYS Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

In the *Contrat de Projet État Région (CPER) Action Modeling, Simulation and Interaction* (2009-2014), we are contributing to the axis *Situed Informatic* through the project CoBras for controlling a jaco robotic arm using EEG. Contact in Neurosys is Laurent Bougrain.

7.2. National Initiatives

7.2.1. ANR

We participate in the project *Keops:* Algorithms for modeling the visual system: From natural vision to numerical applications (2011-2014).
A recent description in the retina of non-standard ganglion cells types, beside a complex repertoire of standard ganglion cells, responses in front of natural stimulus and conveys important questions about the real, early processing capacity of the retina. This leads to revisit both the neural coding of the information the eye is sending to the brain, and also sheds light to engineering applications from the understanding of such encoding, as detailed in the sequel. At the modeling level, retinal cells are mainly formalized using a LN (Linear spatio-temporal filtering followed by a static Non-linear transduction), while an important fraction of non-standard cells response cannot be represented in such a model class. This is a challenge to develop an innovative formalism that takes such complex behaviors into account, with such immediate applications as new dynamical early-visual modules. Proposing new innovative bioinspired formalisms in order to perform dynamical visuo-perceptual tasks adapted to natural environment is a main goal of this project, with a special focus to scenes including complex visual motion interacting with light.
The project is a cooperation between the University of Nice (France), the University of Valparaiso (Chile), the Pontifical Catholic University of Chile in Santiago de Chile, the Inria teams NeuroMathComp, Mnemosyne, Cortex and Neurosys.

7.2.2. Others

- Inria Technological development action (ADT): OpenViBE-NT
  This is a two-year multi-site project (2012–2014) to develop OpenViBE further on several fronts such as usability, new algorithms and scope of applicability. Teams of the ADT are Hybrid(Rennes), Athena (Sophia), Potioc (Bordeaux) and Neurosys. Coordinator is Laurent Bougrain.
- Multidisciplinary Exploratory Project (PEPS 2013) Bio-Maths-Info (BMI): *Characterising the laminar profile of motor cortical oscillatory synchronization during visuomotor behavior with new analysis tools.*
  Oscillations are omnipresent in the brain, but their function is still disputed. In motor cortex, beta and gamma oscillations are often observed, but their proposed roles in sensorimotor behavior are largely overlapping. While much is known on the laminar distribution of oscillations in sensory areas, the very sparse data on the laminar profile of motor cortical oscillations largely limits their functional interpretations. The 2-years project studies the layer specificity of monkey motor cortical oscillations and oscillatory interactions between M1 and PMd during visuomotor behavior. Extending conventional tools, such as coherency analysis, Neurosys develops a new method to quantify short-lasting partial amplitude and phase synchronization in single-trial data, based on wavelets, exploiting the predefined vicinity of contacts on the laminar probes. The application of this new method to the data recorded in Marseille will reveal instantaneous amplitude and phase synchronization between cortical layers and between the brain areas *M*1 and *P*Md, providing novel insights into the functional roles of beta and gamma oscillations in visuomotor behavior. The experimental partner at the *Institut de Neurosciences de la Timone* in Marseille is Bjork Kilavik, the contact in Neurosys is Axel Hutt.

7.3. European Initiatives

7.3.1. FP7 Projects

The *ITN*-project *Neural Engineering Transformative Technologies (NETT)* (2012-2016) is a Europe-wide consortium of 18 universities, research institutes and private companies which together hosts 17 PhD students and 3 postdoctoral researchers over the next 4 years. Neural Engineering brings together engineering, physics, neuroscience and mathematics to design and develop brain-computer interface systems, cognitive computers and neural prosthetics. Neurosys will host a PhD-student for three months in winter 2014/2015. Contact is Axel Hutt.

7.3.2. Collaborations in European Programs, except FP7

Program: ERC Starting Grant
Project acronym: MATHANA
Project title: Mathematical Modeling of Anaesthesia
Duration: January 2011 – December 2015
Coordinator: Axel Hutt
Abstract: MATHANA aims to study mathematically spatially extended neural systems and reveal their spatio-temporal dynamics during general anaesthesia.

7.4. International Initiatives

7.4.1. Informal International Partners

- We collaborate with Jamie Sleigh (University of Auckland, New Zealand), who provides us with experimental EEG-data obtained in humans during anaesthesia (A. Hutt).
- In the collaboration with Flavio Frohlich (University of North Carolina - Chapel Hill), we receive experimental data measured intracranially in ferrets and analyse them on spectral properties (A. Hutt).
- The collaboration with Matthias Munk (Max Planck Institute for Biological Cybernetics in Tuebingen) lasts for over 10 years now and provides us with experimental Local Field Potentials measured during a visuomotor task of monkeys (A. Hutt).
- The collaboration with Linghai Zhang (Lehigh University, USA) on the mathematical analysis of neural field equations led to a publication in 2013 [6] (A.Hutt).
- In the collaboration with Jeremy Lefebvre (University in Geneva), we have been working out together a novel stochastic center manifold analysis method for delayed differential equations leading to new insights into the effects of additive noise close to bifurcation points (A. Hutt).
- The collaboration with Marina Palazova and Torsten Schubert (Humboldt University Berlin) on priming effects of subliminal visual stimuli has led to a publication in 2013 [8] (A. Hutt).
- The collaboration with Peter beim Graben (Humboldt University Berlin) on recurrence data analysis stimulated us to intensify our work on meta-stable states in neural systems (A. Hutt).
- An Inria Internship proposal has been submitted on topics that will involve Pr. Motoharu Yoshida at the Ruhr University Bochum, Germany, to study the role of persistent firing neurons in memory and more specifically in neural network synchronization. M. Yoshida provides us with biological data that we combine with simulations to test hypotheses on memory formation (L. Buhry).
- We also collaborate with Pr. John Rinzel (New York University, USA) and Pr. LieJune Shiau (University of Houston, Texas, USA) on more theoretical approaches concerning the role intrinsic neuronal dynamics in network synchronization and brain oscillations (L. Buhry).

7.5. International Research Visitors

7.5.1. Visits of International Scientists

We have hosted the visiting professors Peter beim Graben (Humboldt University Berlin, September–October) and Jamie Sleigh (September–October) to join forces in our common project on the analysis of multivariate EEG-data obtained during anaesthesia.

7.5.2. Visits to International Teams

Pedro Garcia Rodriguez works on stochastic transitions in neural systems and he has visited the group of Prof. Schimansky-Geier at Humboldt University Berlin in December for one week to start a future collaboration.

PARIETAL Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. Digiteo/DIM

7.1.1.1. HIDINIM Digiteo project

Participants: Bertrand Thirion [Correspondant], Virgile Fritsch.

High-dimensional Neuroimaging– Statistical Models of Brain Variability observed in Neuroimaging

This is a joint project with Select project team and with SUPELEC Sciences des Systèmes (E3S), Département Signaux & Systèmes Électroniques (A. Tennenhaus), 2010-2013.

Statistical inference in a group of subjects is fundamental to draw valid neuroscientific conclusions that generalize to the whole population, based on a finite number of experimental observations. Crucially, this generalization holds under the hypothesis that the population-level distribution of effects is estimated accurately. However, there is growing evidence that standard models, based on Gaussian distributions, do not fit well empirical data in neuroimaging studies.

In particular, Hidinim is motivated by the analysis of new databases hosted and analyzed at Neurospin that contain neuroimaging data from hundreds of subjects, in addition to genetic and behavioral data. We propose to investigate the statistical structure of large populations observed in neuroimaging. In particular, we investigate the use of region-level averages of brain activity, that we plan to co-analyse with genetic and behavioral information, in order to understand the sources of the observed variability. This entails a series of modeling problems that we address in this project: *i)* Distribution normality assessment and variables covariance estimation, *ii)* model selection for mixture models and *iii)* setting of classification models for heterogeneous data, in particular for mixed continuous/discrete distributions.

7.1.1.2. ICOGEN Digiteo project

Participants: Bertrand Thirion [Correspondant], Benoit Da Mota.

ICOGEN : Intensive COmputing for GEnetic-Neuroimaging studies

Project supported by a Digiteo grant in collaboration with Inria's KerData Team, MSR-Inria joint centre, Supélec Engineer School, Imagen project and CEA/Neurospin, 2012-2014.

In this project, we design and deploy some computational tools to perform neuroimaging-genetics association studies at a large scale.

Unveiling the relationships between genetic variability and brain structure and function is one of the main challenges in neuroscience, which can be partly addressed through the information conveyed by high-throughput genotyping on the one hand, and neuroimaging data on the other hand. Finding statistical associations between these different variables is important in order to find relevant biomarkers for various brain diseases and improve patient handling. Due to the huge size of the datasets involved and the requirement for tight bounds on statistical significance, such statistical analysis are particularly demanding and cannot be performed easily at a large scale with standard software and computational tools. In ICOGEN, we design and deploy some computational tools to perform neuroimaging-genetics association studies at a large scale. We implement and assess on real data the use of novel statistical methodologies and run the statistical analysis on various architectures (grids, clouds), in a unified environment.

7.1.1.3. SUBSAMPLE Digiteo chair

Participants: Bertrand Thirion [Correspondant], Gaël Varoquaux, Alexandre Abraham.

Parietal is associated with this Digiteo Chair by Dimitris Samaras, in which we will address the probabilistic structure learning of salient brain states (PhD thesis of Alexandre Abraham, 2012-2015).

Cognitive tasks systematically involve several brain regions, and exploratory approaches are generally necessary given the lack of knowledge of the complex mechanisms that are observed. The goal of the project is to understand the neurobiological mechanisms that are involved in complex neuro-psychological disorders. A crucial and poorly understood component in this regard refers to the interaction patterns between different regions in the brain. In this project we will develop machine learning methods to capture and study complex functional network characteristics. We hypothesize that these characteristics not only offer insights into brain function but also can be used as concise features that can be used instead of the full dataset for tasks like classification of healthy versus diseased populations or for clustering subjects that might exhibit similarities in brain function. In general, the amount of correlation between distant brain regions may be a more reliable feature than the region-based signals to discriminate between two populations e.g. in schizophrenia. For such exploratory methods to be successful, close interaction with neuroscientists is necessary, as the salience of the features depends on the population and the observed effects of psychopathology. For this aim we propose to develop a number of important methodological advances in the context of prediction of treatment outcomes for drug addicted populations, i.e. for relapse prediction.

7.1.1.4. MMoVNI Digiteo project

Participants: Bertrand Thirion [Correspondant], Pierre Fillard, Viviana Siless, Stéphanie Allassonnière, Hao Xu.

This is a joint project with CMAP http://www.cmapx.polytechnique.fr/~allassonniere/, 2010-2013.

Modeling and understanding brain structure is a great challenge, given the anatomical and functional complexity of the brain. In addition to this, there is a large variability of these characteristics among the population. To give a possible answer to these issues, medical imaging researchers proposed to construct a template image. Most of the time, these analysis only focus on one category of signals (called modality), in particular, the anatomical one was the main focus of research these past years. Moreover, these techniques are often dedicated to a particular problem and raise the question of their mathematical foundations. The MMoVNI project aims at building atlases based on multi-modal images (anatomy, diffusion and functional) data bases for given populations. An atlas is not only a template image but also a set of admissible deformations which characterize the observed population of images. The estimation of these atlases will be based on a new generation of deformation and template estimation procedures that build an explicit statistical generative model of the observed data. Moreover, they make it possible to infer all the relevant variables (parameters of the atlases) thanks to stochastic algorithms. Lastly, this modeling allows also to prove the convergence of both the estimator and the algorithms which provides a theoretical guarantee to the results. The models will first be proposed independently for each modality and then merged together to take into account, in a correlated way, the anatomy, the local connectivity through the cortical fibers and the functional response to a given cognitive task. This model will then be generalized to enable the non-supervised clustering of a population. This leads therefore to a finer representation of the population and a better comparison for classification purposes for example. The Neurospin center, partner of this project, will allow us to have access to databases of images of high-quality and high-resolution for the three modalities: anatomical, diffusion and functional imaging. This project is expected to contribute to making neuroimaging a more reliable tool for understanding inter-subject differences, which will eventually benefit to the understanding and diagnosis of various brain diseases like Alzheimer's disease, autism or schizophrenia.

7.2. National Initiatives

7.2.1. ANR

7.2.1.1. BrainPedia project

Participants: Bertrand Thirion [Correspondant], Gaël Varoquaux, Yannick Schwartz, Virgile Fritsch.

BrainPedia is an ANR JCJC (2011-2015) which addresses the following question: Neuroimaging produces huge amounts of complex data that are used to better understand the relations between brain structure and function. While the acquisition and analysis of this data is getting standardized in some aspects, the neuroimaging community is still largely missing appropriate tools to store and organize the knowledge related to the data. Taking advantage of common coordinate systems to represent the results of group studies, coordinate-based meta-analysis approaches associated with repositories of neuroimaging publications provide a crude solution to this problem, that does not yield reliable outputs and looses most of the data-related information. In this project, we propose to tackle the problem in a statistically rigorous framework, thus providing usable information to drive neuroscientific knowledge and questions.

7.2.1.2. IRMgroup project

Participants: Bertrand Thirion [Correspondant], Alexandre Gramfort, Michael Eickenberg.

This is a joint project with Polytechnique/CMAP http://www.cmap.polytechnique.fr/: Stéphanie Allassonnière and Stéphane Mallat (2010-2013).

Much of the visual cortex is organized into visual field maps, which means that nearby neurons have receptive fields at nearby locations in the image. The introduction of functional magnetic resonance imaging (fMRI) has made it possible to identify visual field maps in human cortex, the most important one being the medial occipital cortex (V1,V2,V3). It is also possible to relate directly the activity of simple cells to an fMRI activation pattern and Parietal developed some of the most effective methods. However, the simple cell model is not sufficient to account for high-level information on visual scenes, which requires the introduction of specific semantic features. While the brain regions related to semantic information processing are now well understood, little is known on the flow of visual information processing between the primary visual cortex and the specialized regions in the infero-temporal cortex. A central issue is to better understand the behavior of intermediate cortex layers.

Our proposition is to use our mathematical approach to formulate explicitly some generative model of information processing, such as those that characterize complex cells in the visual cortex, and then to identify the brain substrate of the corresponding processing units from fMRI data. While fMRI resolution is still too coarse for a very detailed mapping of detailed cortical functional organization, we conjecture that some of the functional mechanisms that characterize biological vision processes can be captured through fMRI; in parallel we will push the fMRI resolution to increase our chance to obtain a detailed mapping of visual cortical regions.

7.2.1.3. Niconnect project

Participants: Bertrand Thirion, Gaël Varoquaux [Correspondant], Alexandre Abraham.

- **Context:** The NiConnect project (2012-2016) 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 structured 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

7.3. European Initiatives

7.3.1. HBP

Type: COOPERATION

Instrument: Collaborative Project with Coordination and Support Action

Objectif: NC

Duration: October 2013 - March 2016

Coordinator: EPFL, Lausanne

Partner: 86 partners, https://www.humanbrainproject.eu/fr/discover/the-community/partners;jsessionid=10vokilfkjcyhhgmfxu609p40

Inria contact: Olivier Faugeras

Abstract:

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 disease and build revolutionary new computing technologies. Today, for the first time, modern ICT has brought these goals within sight.

Convergence of ICT and Biology The convergence between biology and ICT has reached a point at which it can turn the goal of understanding the human brain into a reality. This realisation motivates the Human Brain Project – an EU Flagship initiative in which over 80 partners will work together to realise a new "ICT-accelerated" vision for brain research and its applications.

One of the major obstacles to understanding the human brain is the fragmentation of brain research and the data it produces. Our most urgent need is thus a concerted international effort that uses emerging emerging ICT technologies to integrate this data in a unified picture of the brain as a single multi-level system.

Research Areas The HBP will make fundamental contributions to neuroscience, to medicine and to future computing technology.

In *neuroscience*, the project will use neuroinformatics and brain simulation to collect and integrate experimental data, identifying and filling gaps in our knowledge, and prioritising future experiments.

In *medicine*, the HBP will use medical informatics to identify biological signatures of brain disease, allowing diagnosis at an early stage, before the disease has done irreversible damage, and enabling personalized treatment, adapted to the needs of individual patients. Better diagnosis, combined with disease and drug simulation, will accelerate the discovery of new treatments, drastically lowering the cost of drug discovery.

In *computing*, new techniques of interactive supercomputing, driven by the needs of brain simulation, will impact a vast range of industries. Devices and systems, modelled after the brain, will overcome fundamental limits on the energy-efficiency, reliability and programmability of current technologies, clearing the road for systems with brain-like intelligence.

The Future of Brain Research

Applying ICT to brain research and its applications promises huge economic and social benefits. But to realise these benefits, the technology needs to be made accessible to scientists – in the form of research platforms they can use for basic and clinical research, drug discovery and technology development. As a foundation for this effort, the HBP will build an integrated system of ICT-based research platforms, building and operating the platforms will require a clear vision, strong, flexible leadership, long-term investment in research and engineering, and a strategy that leverages the diversity and strength of European research. It will also require continuous dialogue with civil society, creating consensus and ensuring the project has a strong grounding in ethical standards.

The Human Brain Project will last ten years and will consist of a ramp-up phase and a partially overlapping operational phase.

7.4. International Initiatives

7.4.1. Inria Associate Teams

Title: Analysis of structural MR and DTI in neonates

Inria principal investigator: Pierre Fillard

International Partner:

Institution: University of Southern California (United States)

Laboratory: Image Lab at Children Hospital at Los Angeles

Researcher: Natasha Lepore

International Partner:

Institution: University of Pennsylvania (United States)

Laboratory: Penn Image Computing and Science Laboratory

Researcher: Caroline Brun

Duration: 2011 - 2013

See also: http://www.capneonates.org/

While survival is possible at increasingly lower gestational ages at birth, premature babies are at higher risk of developing mental disorders or learning disabilities than babies born at term. A precise identification of the developmental differences between premature and control neonates is consequently of utmost importance. Nowadays, the continuously improving quality and availability of MR systems makes it possible to precisely determine, characterize and compare brain structures such as cortical regions, or white matter fiber bundles. The objective of this project is to understand the developmental differences of premature versus normal neonates, using structural and diffusion MRI. This work will consist in identifying, characterizing and meticulously studying the brain structures that are different between the two groups. To do so, we propose to join forces between the

Parietal team at Inria and the University of Southern California. Parietal has a recognized expertise in medical image registration and in statistical analyses of groups of individuals. USC has a broad knowledge in MR image processing. In particular, the Children's Hospital at Los Angeles (CHLA), which is part of USC, is in the process of collecting a unique database of several hundreds of premature and normal neonates MR scans. This joint collaboration is consequently a unique chance of addressing key questions pertaining to neonatal and premature development. It will make it possible to elaborate new tools to analyze neonate MR images while tremendously increasing our knowledge of neuroanatomy at such an early stage in life.

7.4.2. Inria International Labs

Parietal has taken part to the program Inria@SiliconValley, and had a 18-months post-doc funded to work on the comparison of anatomical and functional connectivity (18 months, 2011-2013):

In this project, we build probabilistic models that relates quantitatively the observations in anatomical and functional connectivity. For instance given a set of brain regions, the level of functional integration might be predicted by the anatomical connectivity measurement derived from the fibers in a given population of subjects. More generally, we seek to extract latent factors explaining both connectivity measures across the population. Such models require specifically that a generative model is proposed to explain the observations in either domain, so that a meaningful and testable link is built between the two modalities. The inference problem can then be formulated as learning the coupling parameters that are necessary to model the association between modalities, and tested e.g. by assessing the ability of the learned model to generalize to new subjects. The aim is then to provide the mathematical and algorithmic tools necessary to build a standardized model of brain connectivity informed by both modalities, associated with confidence intervals to take into account between subject variability. Such an atlas is a long-term project, that requires adequate validation on high-resolution data, but it is tightly linked to this project.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

7.5.1.1. Internships

Felipe Yanez made a three months internship (January-March 2013), funded by Inria Chile and Conycit. His research topic was *Improving the fit of functional MRI data through the use of sparse linear models*.

7.5.1.2. Other visitors

Danilo Bzdok (Forschungszentrum Jülich, institue of neuroscience and medicine) visited Parietal in September 2013, to develop collaborations on the use of machine learning techniques to model behavioral variables and find data-driven characterization of brain diseases.

7.5.2. Visits to International Teams

- Yannick Schwartz spent one month in University of Texas at Austin, in Poldrack's lab http://www.poldracklab.org/. This stay was an opportunity to improve our understanding of the main challenges in functional brain imaging modalities.
- Philippe Ciuciu spent two months in the Paul Sabatier University (Toulouse, france), as part of the CIMI labex, where he runs a collaboration on compressed sensing for MRI.

Popix Team

8. Partnerships and Cooperations

8.1. European Initiatives

8.1.1. FP7 Projects

The Drug Disease Model Resources (DDMoRe) consortium will build and maintain a universally applicable, open source, model-based framework, intended as the gold standard for future collaborative drug and disease modeling and simulation.

The DDMoRe project is supported by the Innovative Medicines Initiative (IMI), a large-scale public-private partnership between the European Union and the pharmaceutical industry association EFPIA.

Marc Lavielle is leader of WP6: "New tools for Model Based Drug Development".

DDMoRe website: http://www.ddmore.eu

Duration: 2010 - 2015

Project members: Uppsala Universitet, Sweden; University of Navarra, Spain; Universiteit Leiden, Netherlands; Université Paris Diderot, France; Universita degli Studi di Pavia, Italy; UCB Pharma , Belgium; Simcyp, UK; Pfizer, UK; Optimata , Israel; Novo Nordisk , Denmark; Novartis, Switzerland; Merck Serono, Switzerland; Mango Business Solutions , UK; Lixoft, France; Interface Europe, Belgium; Institut de Recherches Internationales Servier, France; Inria, France; GlaxoSmithKline Research and Development, UK; Freie Universitat Berlin, Germany; F. Hoffmann - La Roche , Switzerland; EMBL - European Bioinformatics Institute, UK; Eli Lilly , UK; Cyprotex Discovery, UK; Consiglio Nazionale delle Ricerche, Italy; AstraZeneca, Sweden.

SHACRA Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. Sofa, ADT

SOFA Large Scale Development Initiative (ADT) : the SOFA project (Simulation Open Framework Architecture) is an international, multi-institution, collaborative initiative, aimed at developing a flexible and open source framework for interactive simulations. This will eventually establish new grounds for a widely usable standard system for long-term research and product prototyping, ultimately shared by academic and industrial sites. The SOFA project involves 3 Inria teams, SHACRA, IMAGINE and ASCLEPIOS. The development program of the ADT started in 2007.

8.1.2. ANR Acoustic

The main objective of this project is to develop an innovative strategy based on models for helping decision-making process during surgical planning in Deep Brain Stimulation. Models will rely on different levels involved in the decision-making process; namely multimodal images, information, and knowledge. Two types of models will be made available to the surgeon: patient specific models and generic models. The project will develop methods for 1) building these models and 2) automatically computing optimal electrodes trajectories from these models taking into account possible simulated deformations occurring during surgery. The project belongs to the multidisciplinary domain of computer-assisted surgery (CAS). Computer assisted surgery aims at helping the surgeon with methods, tools, data, and information all along the surgical workflow. More specifically, the project addresses surgical planning and surgical simulation in Image Guided Surgery. It is related to the exponentially growing surgical treatment of Deep Brain Stimulation (DBS), originally developed in France by Pr. Benabid (Grenoble Hospital). The key challenges for this research project are 1) to identify, extract, gather, and make available the information and knowledge required by the surgeon for targeting deep brain structures for stimulation and 2) to realistically simulate the possible trajectories.

8.1.3. IHU, Strasbourg

Our team has been selected to be part of the IHU of Strasbourg. This new institute, for which funding (67M€) has just been announced, is a very strong innovative project of research dedicated to future surgery of the abdomen. It will be dedicated to minimally invasive therapies, guided by image and simulation. Based on interdisciplinary expertise of academic partners and strong industry partnerships, the IHU aims at involving several specialized groups for doing research and developments towards hybrid surgery (gesture of the surgeon and simulation-based guidance). Our group and SOFA have a important place in the project. Since September 2011 a part of our team is located within the IHU, to develop a number of activities in close collaboration with clinicians.

8.1.4. ANR IDeaS

IDeaS is a project targeted at per-operative guidance for interventional radiology procedures. Our main goal is to provide effective solutions for the two main drawbacks of interventional radiology procedures, namely: reduce radiation exposure and provide a fully 3D and interactive visual feedback during the procedure. To do so, our project relies on an original combination of computer vision algorithms and interactive physics-based medical simulation. Computer vision algorithms extract relevant information (like the actual projected shape of the guide-wire at any given time) from X-ray images, allowing adjusting the simulation to real data. Conversely, computer-based simulation is used as a sophisticated and trustful predictor for an improved initialization of computer vision tracking algorithms. Many outcomes may be expected both in scientific and clinical aspects. On the scientific side, we believe a better understanding of how real data and

simulation should be merged and confronted must lead, as a natural by-product, to image-based figures of merit to actually validate computer-based simulation outputs against real and dynamic data. A more accurate identification of the factors limiting the realism of simulation should follow with a rebound impact on the quality of the simulation itself. An actual integration of a mechanical model into the loop will improve the tracking. We firmly believe mechanical constraints can supplement the image data such that dynamic single view reconstruction of the interventional devices will be possible. On the clinical side, using the prediction capabilities of the simulation may decrease the need for X-ray images at high rates, thus leading to lower exposure to radiations for the patients and surgical staff. Finally, the output of the simulation is the 3D shape of the tool (e.g. guide-wire or catheter), but not only. Additional information may be visualized, for instance pressure of the catheter on the arterial wall, to prevent vessel wall perforations, or reduce stress on the arterial wall to prevent spasm. More generally, richer information on the live procedure may help surgeons to reduce malpractice or medical errors.

8.2. European Initiatives

8.2.1. FP7 Projects

8.2.1.1. RASimAs

Type: COOPERATION

Defi: NA

Instrument: Specific Targeted Research Project

Objectif: NC

Duration: nov 2012 - oct 2015

Coordinator: RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE (RWTH), Aachen, Germany

Partner: UNIVERSITAETS KLINIKUM AACHEN, Germany // RHEINISCH-WESTFAELISCHE TECHNISCHE HOCHSCHULE, Germany // BANGOR UNIVERSITY, United Kingdom // UNIVERSITY COLLEGE CORK, NATIONAL UNIVERSITY OF IRELAND, CORK, Ireland // UNIVERSIDAD REY JUAN CARLOS, Spain // FOUNDATION FOR RESEARCH AND TECHNOLOGY HELLAS, Greece // ZILINSKA UNIVERZITA V ZILINE, Slovakia // KATHOLIEKE UNIVERSITEIT LEUVEN, Belgium // SINTEF Norway, SENSEGRAPHICS, Sweden

Inria contact: Stéphane Cotin

Abstract: Regional anaesthesia has been used increasingly during the past four decades. This is addressed to the perceived advantages of reduced postoperative pain, earlier mobility, shorter hospital stay, and significantly lower costs. Current training methods for teaching regional anaesthesia include cadavers, video teaching, ultrasound guidance, and simple virtual patient modeling. These techniques have limited capabilities and do not consider individual anatomy. The goal of this project is to increase the application, the effectiveness and the success rates of RA and furthermore the diffusion of the method through the development VPH models for anaesthesia. The goal of the SHACRA team is to provide the computational infrastructure for the physics-based simulation and to propose new methods for patient-specific modeling and simulation of soft tissues and their interaction with the needle, including its effect on nerve physiology.

8.3. International Initiatives

8.3.1. Participation In other International Programs

Jeremie Dequidt has been a member of the Inria delegation at the India-France Technology Summit http://indiafrancesummit.org/. During a technology showcase, he presented SOFA and various medical simulators. He also was part of a roundtable about biotechnologies.

8.4. International Research Visitors

8.4.1. Visits to International Teams

Christian Duriez has been invited during one week (last week of October) by the JRL team in AIST Tsukuba Japan, to work with Pr. Eiichi Yoshida on using real-time simulation for the control of robotic tasks with deformable objects.

VISAGES Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Biogenouest

The VisAGeS team and the Neurinfo platform integrated the Biogenouest "Groupement d'Intérêt Scientifique (GIS)" in 2012.

Biogenouest is a Western France life science and environment core facility network. Research programmes are undertaken in the fields of Marine biology, Agriculture/Food-processing, Human health, and Bioinformatics. Set up in keeping with the inter-regional principle of complementarity, Biogenouest coordinates over twenty technological core facilities in both the Brittany and Pays de la Loire regions.

8.1.2. COREC projects

COREC is the "COmité de REcherche Clinique" of the University Hospital of Rennes. This comity proposes an annual project funding in the limit of 30k€ per project. In 2012, the Neurinfo platform as an incitative action for clinical research project emergence accompanied the COREC call by financially supporting the imaging part of the projects up to 50 MRI hours, ie 30k€. Two projects were selected by the COREC. The MALTA project led by radiologist Jean-Christophe Ferré will compare the ability of functional BOLD MRI and perfusion ASL MRI to detect language areas in patients with brain tumor.

8.1.3. Projet CRITT Santé Bretagne : AfaCorVis3D

Participants: Elise Bannier, Isabelle Corouge, Christian Barillot.

duration: 12 months from November 2011

A research projet in fMRI involving 3D visual stimulation was performed to try and differentiate areas activated by 2D versus 3D visualisation, whether static or dynamic. The task was evaluated on 10 volunteers in the context of the Master Research Projet of Guillaume Koch. Areas activated specifically by 3D visualisation were extracted.

8.1.4. Défis Scientifiques Emergents - Université de Rennes I

Participants: Aurore Esquevin, Isabelle Corouge, Elise Bannier, Jean-Christophe Ferré, Christian Barillot, Jean-Yves Gauvrit.

duration: 22 months from March 2012 (end: December 31, 2013)

The ASLDEM project was partially funded the University of Rennes 1 "Défis Scientifiques Emergents" grant (7000 euros).

8.1.5. Fondation de l'Avenir - Depression, suicide and fMRI

Participants: Elise Bannier, Isabelle Corouge, Jean-Christophe Ferré, Christian Barillot.

duration: 12 months from November 2012

In collaboration with EA 4712 "Comportement et Noyaux Gris Centraux" of the University of Rennes I, a complementary funding (20 000€) was obtained to support an ongoing fMRI research project on emotions, impulsivity and suicide. The study protocol and the fMRI task was finalized. Inclusions will start early 2013.

8.1.6. Fondation de l'Avenir - Stroke, rehabilitation and fMRI

Participants: Elise Bannier, Isabelle Bonan, Isabelle Corouge, Jean-Christophe Ferré, Christian Barillot, Jean-Yves Gauvrit.

duration: 12 months from November 2012

A complementary funding (20 000€) was obtained to support a new research project on rehabilation of stroke patients. The fMRI protocol was setup, the task developed and validation on volunteers is ongoing. Patient inclusions will start in spring 2013.

8.1.7. Fondation Planiol

Participants: Elise Bannier, Hélène Raoult, Jean-Yves Gauvrit.

duration: 12 months from November 2012

In the context of a neurovascular imaging research study, funding (13500€) was obtained to perform a phantom study on test objects representing carotid stenosis, with a circulating flow. This project will be performed as part of a collaboration with Dr Cavaro Ménard - Angers (LISA), Dr Langevin - Compiègne (UTC) and Pr Saint Jalmes - PRISM (UR1).

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. ANR "Neurological and Psychiatric diseases" NUCLEIPARK

Participants: Christian Barillot, Sylvain Prima, Juan Francisco Garamendi Bragado.

NucleiPark project: In the context of the ANR-09-MNPS-016 Nucleipark project we develop a pipeline for detecting shape changes in Parkinson and Paralysis Supranuclear Progressive (PSP) diseases.The pipeline is based on the previous work of Benoit Combès et al. [58]. The pipeline was first validated on controlled synthetic data. For Parkinson disease, a total of 16 patients and 11 healthy controls were evaluated. The structuctures analyzed were: PPN, GPe, GPi, Caudatge, Putamen, SN, STN, RN. Differences (uncorrected P <0.001) were found in the right putamen and caudate structures. And slight difference (uncorrected P<0.05) in the right GPe. No significant correlation was found in PPN, GPi, SN, STN, and RN structures. In the case of PSP disease, a total of 10 patients and 11 healthy controls were evaluated. the structures analyzed were: PPN, GPe, GPi, Caudate, Putamen, SN, STN, RN. Differences (uncorrected P <0.001) were found in the left caudate structure. No significant correlation was found in PPN,GPe, GPi, Putamen, SN, STN, and RN structures.

In the context of this project, we propose a statistical data analysis pipeline that uses the apparent diffusion coefficient (ADC) as biomarker. The ADC is computed considering the diffusion weighted signal as a scalar field on a 5-D manifold. This consideration allows to keep the information about direction of the ADC. We have tested the proposed pipeline on synthetic dataset with promising results. Other contributions were the implementation and minimization, in the 5-D non-euclidean space, of the total variation (in its dual formulation) inpainting problem as interpolation method used in the statistical pipeline.

8.2.1.2. ANR Cosinus VIP

Participants: Fang Cao, Olivier Commowick, Christian Barillot.

VIP is collaborative project supported by ANR "Conception and Simulation"; it was accepted in 2009 (around 1 million euros). VIP aims at building a computing environment enabling multi-modality, multi-organ and dynamic (4D) medical image simulation, using GRID infrastructure. The goal is to integrate proven simulation software of the four main imaging modalities (MRI, US, PET and X-Ray/CT), and to cope interoperability challenges among simulators. The partners are CREATIS in Lyon (main contractor, Principal Investigator: Tristan Glatard), UNS-I3S in Nice, CEA-LETI in Grenoble and MAAT-G Maat G, a spanish company. The role of VISAGES in this project concerns primarily Task 1.1 and Task 3.3, focusing respectively on ontologies development and application to multiple sclerosis images simulation. This grant serves as support for the positions of Olivier Luong (PhD student) and Germain Forestier (post-doc).

8.2.1.3. AINSI Inria joint project

Participants: Christian Barillot, Isabelle Corouge, Pierre Maurel, Jean-Christophe Ferré, Elise Bannier, Camille Maumet.

We have been involved in a 2-year Inria ARC project AINSI (http://thalie.ujf-grenoble.fr/ainsi). AINSI stands for “Modeles statistiques pour l’Assimilation d’Informations de Neuroimagerie fonctionnelle et de perfuSIon cerebrale”. The goal is to propose an innovative statistically well-based solution to the joint determination of neural activity and brain vascularization by combining BOLD constrast images obtained in functional MRI and quantitative parametric images (Arterial Spin Labelling: ASL). The partners involved are the Mistiss project from Inria in Grenoble (Lead F. Forbes) and Parietal in Saclay, the INSERM Unit U594 (Grenoble Institute of Neuroscience) and the LNAO laboratory from CEA NeuroSpin.

8.2.1.4. TRANSLATE-MS-REPAIR

Participants: Fang Cao, Laurence Catanese, Olivier Commowick, Isabelle Corouge, Jean-Christophe Ferré, Elise Bannier, Gilles Edan, Christian Barillot.

It is now commonly admitted that MS is not only an inflammatory disease but a neurodegenerative disease as well. This project is devoted to show that the olesoxime molecule is not only neuroprotective, but it has the ability to promote the maturation of oligodendrocyte progenitor cells (OPCs) into myelinating oligodendrocytes. However, before considering a large-scale clinical trial to assess efficacy. An important aspect is that to date, no treatment for neuroprotection / remyelination has reached the stage of clinical proof of concept that aims Trophos company who is leading this project. It appears that the best criteria for assessing neuroprotective/remyelinating effect of the drug candidate, are MRI criteria. However, these imaging criteria have not yet been validated for use in multicentre trials - so we will also check the feasibility of such measures under this condition. In addition to Trophos company, the partners of this project are AP-HM/CNRSCEMEREM-CRMBM, CHU Rennes, CHU Reims, and Inria-VISAGES.

8.2.2. Competitivity Clusters

8.2.2.1. The HEMISFER Project

Participants: Elise Bannier, Isabelle Bonan, Isabelle Corouge, Jean-Christophe Ferré, Jean-Yves Gauvrit, Pierre Maurel, Lorraine Perronnet, Christian Barillot.

The HEMISFER project ("Hybrid Eeg-MrI and Simultaneous neuro-FEedback for brain Rehabilitation") will be conducted at Inria Rennes with the support of the Cluster of Excellence "CominLabs" [1]. The goal of HEMISFER is to make full use of the neurofeedback paradigm in the context of rehabilitation and psychiatric disorders. The major breakthrough will come from the use of a coupling model associating functional and metabolic information from Magnetic Resonance Imaging (fMRI) to Electro-encephalography (EEG) to "enhance" the neurofeedback protocol. We propose to combine advanced instrumental devices (Hybrid EEG and MRI platforms), with new man-machine interface paradigms (Brain computer interface and serious gaming) and new computational models (source separation, sparse representations and machine learning) to provide novel therapeutic and neuro-rehabilitation paradigms in some of the major neurological and psychiatric disorders of the developmental and the aging brain (stroke, attention-deficit disorder, language disorders, treatment-resistant mood disorders, ...). This project will be conducted with the HYBRID and PANAMA Teams from Inria Rennes, the EA 4712 team from University of Rennes I and the ATHENA team from Inria Sophia-Antipolis. This work will benefit from the research 3T MRI and MRI-compatible EEG systems provided by the NeurInfo in-vivo neuroimaging platform on which these new research protocols will be set up. A budget of 500keuros will be provided by the CominLabs cluster in the next 3 years to support this project (through experimental designs, PhDs, Post-docs and Expert Engineers).

8.2.2.2. France Life Imaging (FLI)

Participants: Christian Barillot, Olivier Commowick, Michael Kain.

[1] https://iww.inria.fr/cominlabs-newsletter/april-2013-four-projects-selected/#hemisfer

France Life Imaging (FLI) is a proposed large-scale research infrastructure project aimed at establishing a coordinated and harmonized network of biomedical imaging in France. This project was recently selected by the call "Investissements d'Avenir - Infrastructure en Biologie et Santé". One node of this project is the node Information Analysis and Management (IAM), a transversal node build by a consortium of teams that will contribute to the construction of a network for data storage and information processing. Instead of building yet other dedicated facilities, the IAM node will use already existing data storage and information processing facilities (LaTIM Brest; CREATIS Lyon; CIC-IT Nancy; Visages U746 Inria Rennes; CATI CEA Saclay; LSIIT/ICube Strasbourg) that will increase their capacities for the FLI infrastructure. Inter-connections and access to services will be achieved through a dedicated software platform that will be developed based on the expertise gained through successful existing developments. The IAM node has several goals. It aims first at building a versatile facility for data management that will inter-connect the data production sites and data processing for which state-of-the-art solutions, hardware and software, will be available to infrastructure users. Modular solutions are preferred to accommodate the large variety of modalities acquisitions, scientific problems, data size, and adapted for future challenges. Second, it aims at offering the latest development that will be made available to image processing research teams. The team VISAGES fulfills multiple roles in this nation-wide project. Christian Barillot is the chair of the node IAM, Olivier Commowick is participating in the working group workflow and image processing and Michael Kain the technical manager. Apart from the team members, software solutions like medInria and Shanoir will be part of the final software platform.

8.2.2.3. OFSEP

Participants: Justine Guillaumont, Elise Bannier, Christian Barillot, Olivier Commowick, Gilles Edan, Isabelle Corouge, Jean-Christophe Ferré, Michael Kain.

The French Observatory of Multiple Sclerosis (OFSEP) is one of 10 projects selected in January 2011 in response to the call for proposal in the "Investissements d'Avenir - Cohorts 2010" program launched by the French Government. It allows support from the National Agency for Research (ANR) of approximately € 10 million for 10 years . It is coordinated by the Department of Neurology at the Neurological Hospital Pierre Wertheimer in Lyon (Professor Christian Confavreux), and it is supported by the EDMUS Foundation against multiple sclerosis, the University Claude Bernard Lyon 1 and the Hospices Civils de Lyon. OFSEP is based on a network of neurologists and radiologists distributed throughout the French territory and linked to 61 centers. OFSEP national cohort includes more than 35,000 people with Multiple Sclerosis, approximately half of the patients residing in France. The generalization of longitudinal monitoring and systematic association of clinical data and neuroimaging data is one of the objectives of OFSEP in order to improve the quality , efficiency and safety of care and promote clinical, basic and translational research in MS. For the concern of data management, the Shanoir platform of Inria has been retained to manage the imaging data of the National OFSEP cohort in multiple sclerosis.

8.3. European Initiatives

8.3.1. FP7 Projects

8.3.1.1. EuroBioimaging

Type: CAPACITIES

Defi: Provide access and training in imaging technologies, and share the best practice and image data in order to make Euro-BioImaging an engine that will drive European innovation in imaging research and technologies

Instrument: Combination of COLLABORATIVE PROJECTS and COORDINATION and SUPPORT ACTIONS

Objectif: Euro-BioImaging is a large-scale pan-European research infrastructure project on the European Strategy Forum on Research Infrastructures (ESFRI) Roadmap.

Duration: December 2010 - November 2013

Coordinators: Jan Ellenberg (EMBL) and Oliver Speck (University of Magdeburg)

Partner: EMBL (Germany); Erasmus Medical Center (Netherlands) for WG11

Inria contact: Ch. Barillot X. Pennec

Abstract: Euro-BioImaging is a pan-European infrastructure project whose mission is to build a distributed imaging infrastructure across Europe that will provide open access to innovative biological and medical imaging technologies for European researchers. The project is funded by the EU and currently the consortium is finalizing the basic principles for the operation of future Euro-BioImaging organisation.

Euro-BioImaging will be governed by representatives of the European countries that will join Euro-BioImaging (Euro-BioImaging member states).

The infrastructure established by Euro-BioImaging will consist of a set of geographically distributed but strongly interlinked imaging facilities (Euro-BioImaging Nodes), which will be selected among the leading European imaging facilities based on an independent evaluation process.

Inria and the Visages team is involved through the FLI national infrastructure and contributes to the WG11 Working Group on Data Storage and Analysis. This WG performs a series of tasks to define a European Biomedical Imaging Data Storage and Analysis infrastructure plan for the construction phase.

8.3.2. Collaborations in European Programs, except FP7

Program: COST

Project acronym: AID (oc-2010-2-8615)

Project title: Arterial spin labelling Initiative in Dementia

Acceptation date: 18/05/2011

Coordinator: X. Golay, UCL, London, UK

Other partners: Ghent University (BE), Liege University (BE), Hospital Cantonal de Geneve (CH), Fraunhofer MEVIS (D), Freiburg University (D), Max Planck Institute for Human Cognitive & Brain Sciences (D), Glostrup Hospital (DK), Hospital Santa Creu I Sant Pau (ES), Universidad Rey Juan Carlos (ES), University of Narvarra (ES), INSERM U836 Grenoble (FR), University of Rennes I (FR), Centro San Giovanni di Dio - Fatebenefratelli (IT), Fondazione Instituto Neurologico Besta (IT), Leiden University Medical Center (NL), UMC Utrecht (NL), VU University Medical Centre (NL), Instituto Superior Técnico (PT), University of Porto (PT), Lund University Hospital (SE), Uppsala University Hospital (SE), Skane University Hospital (SE), Bogazici University (TR), King's College London (UK), University College London (UK), University of Nottingham (UK), University of Oxford (UK)

Abstract: Dementia is a major clinical challenge with care costs approaching 1% of global GDP. Recent estimates suggest that delaying disease onset by 5 years would halve its prevalence. As new disease-modifying treatments will be specific to causative diseases, expensive and bear significant side effects, early diagnosis of dementia will be essential. Current diagnostic criteria include the use of image-based biomarkers using radiotracers. The AID Action aims at coordinating the development of an alternative and cost-effective tool based on an MRI technique, Arterial Spin Labelling (ASL), to obtain reproducible brain perfusion measurements in dementia patients by bringing together scientists and clinicians from across Europe through the flexibility of the COST mechanism. The scientific program is centered around four work packages and three workgroups aiming at developing standards, improving the reliability of the technique and as establishing it as a possible clinical trial outcome measure. Development of MRI methods, post-processing tools, protocols of cross-validation, statistical analyses and launch of clinical and comparative studies will be undertaken. The main benefit of this Action will be to provide a cost-effective alternative to radiotracer-based biomarkers, and help care providers throughout Europe balancing the need for early diagnosis of dementia with the necessary healthcare cost containment.

8.4. International Initiatives

8.4.1. Inria Associate Teams

8.4.1.1. BARBANT

Title: Boston and Rennes, Brain image Analysis Team

Inria principal investigator: Christian Barillot

International Partner:

Children's Hospital Boston - Harvard Medical School (United States) - Computational Radiology Laboratory - Christian Barillot

Duration: 2012 - 2014

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

This associated team is shared between Inria Visages team and the Computational Radiology Laboratory of the Children?s hospital Boston at Harvard Medical School. We will address the topic of better understanding the behavior and evolution of neurological pathologies (such as neurodevelopmental delay or multiple sclerosis) at the organ and local level, and the modeling of normal and pathological groups of individuals (cohorts) from image descriptors. At term, this project will allow to introduce objective figures to correlate qualitative and quantitative phenotypic markers coming from the clinic and image analysis, mostly at the early stage of the pathologies. This will allow for the selection or adaptation of the treatment for patients at an early stage of the disease.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Within the BARBANT associate team, P. Simon K. Warfield, Dr. Benoit Scherrer and Dr. Maxime Taquet (Computational Radiology Laboratory, Harvard Medical School) visited us for a workshop on multiple sclerosis and diffusion image processing.

8.5.2. Visits to International Teams

- Several members of the Visages team (Christian Barillot, Olivier Commowick, Renaud Hédouin, Yogesh Karpate) visited the Computational Radiology Laboratory (Harvard Medical School) for an associate team (BARBANT) meeting to discuss new research topics.
- Christian Barillot visited the Information and Communications department at the Graduate School of Information Science of the Nagoya University, Japan in May 2013

ANGE Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Instabilities in Hydrodynamics (2011–2015)

Participant: Nicolas Seguin.

The Emergence project (Ville de Paris and FSMP) "Instabilities in Hydrodynamics" is related to theoretical, applied, and numerical mathematics for the study of hydrodynamical turbulence phenomena. The postdoc of Aude Bernard-Champmartin is held within this project.

8.1.2. Plasticity of geophysical flows and seismic emissions (2013–2016)

Participant: Anne Mangeney.

This project is funded by Sorbonne Paris Cité (80.000 euros) and is a collaboration between IPGP and Univ. Paris 13.

8.2. National Initiatives

8.2.1. GdR EGRIN (2013–2017)

Participant: Jacques Sainte-Marie.

EGRIN stands for Gravity-driven flows and natural hazards. J. Sainte-Marie is the head of the scientific committee of this CNRS research group. As such, J. Sainte-Marie participated to the consortium of the prospective think tank "Mathematics and the complexity of the system Earth" launched by the French agency for research in the framework of the UNESCO year "Mathematics of Planet Earth".

8.2.2. Inria Project Lab "Algae in Silico"

Participants: Anne-Céline Boulanger, Marie-Odile Bristeau, Raouf Hamouda, Jacques Sainte-Marie.

The team is involved in the GreenStars project ("Investissement d'avenir") which is a collaboration between academic institutions (INRA, Inria, Univ. Pierre et Marie Curie Paris 6, ...) and the industrial world. [2] The main purpose of GreenStars is to lay the foundations for the entire sector, from energy generation to waste recycling and production of compounds of interest. GreenStars also plans to play a long-term role in this field by training technicians, engineers and researchers. In order to structure and support the contributions of Inria in this domain, an Inria Project Lab called "Algae in Silico" has been funded.

The PhD thesis of A.-C. Boulanger was a part of this project. Likewise, the ADT In@lgae was launched in this framework in collaboration with the BIOCORE Inria project-team and enabled the recruitment of R. Hamouda as a young engineer.

8.2.3. ANR LANDQUAKE (2012–2016)

Participant: Anne Mangeney.

Within the ANR domain "Mathematics and Interfaces", this ANR project (between Univ. Paris-Est – LAMA, Univ. Denis Diderot Paris 7 – IPGP, Univ. Nantes – LPGN, Univ. Strasbourg EOST, 180.000 euros) deals with the mathematical and numerical modelling of landslides and generated seismic waves.

[2] among which are: Air Liquide, ACRI, Alfa Laval, Algaestream, Algenics, Algu'Innov, Bioalgostral, EADS, Eco-Solution, Envolure, Fermentalg, Greensea, IDEE Aquaculture, La Compagnie du Vent-GDF Suez, Microphyt, Naskeo Environnement, Ondalys, Peugeot Citroën Automobiles, Rhodia, Roquette, Sofiprotéol, Soliance, Solvay, Suez Environnement, TIA, TOTAL, Véolia Environnement.

8.2.4. LRC Manon (2010–2014)

Participants: Edwige Godlewski, Yohan Penel, Nicolas Seguin.

CEA and Laboratory Jacques-Louis Lions launched a collaboration 4 years ago. Studies are carried out about compressible two-phase flows and model coupling, for instance in the case of an asymptotic hierarchy of models.

8.2.5. Structure Health Monitoring

Participant: Nicolas Seguin.

This collaboration with the Ifsttar also comprises Inria researchers from the I4S team. The goal is to provide efficient numerical tools to take into account the impact of the flows around the structures. The most challenging part of this project concerns the off-shore wind turbines and the understanding of the ice formation on the structure.

8.2.6. ANR project HJnet (2013–2015)

Participant: Edwige Godlewski.

This research project consists in studying Hamilton-Jacobi equations on networks, and more generally on heterogeneous structures. This theoretical problem has several potential applications, in particular to traffic flow theory.

8.2.7. Hydraulics for environment and sustainable development (HED^2)

The scienfitic group (GIS in French), to which Inria is a partner, brings together scientists and engineers involved in hydraulics, risk management and sustainable development. ANGE belongs to this group. On the one hand, the team can be provided with experimental measurements (erosion, long waves, fluid structure interactions,...) thanks to this collaboration; on the other hand, the GIS can favor the transfer of numerical tools and scientific results.

8.3. European Initiatives

8.3.1. ERC Consolidator Grant (2013–2018)

Participant: Anne Mangeney.

The project SLIDEQUAKES about detection and understanding of landslides by observing and modelling gravitational flows and generated earthquakes has been funded by the European Research Council (2.000.000 euros).

8.4. International Initiatives

8.4.1. Informal International Partners

The team has developed strong relations with researchers from spanish universities, in particular with Carlos Pares (Malaga), Enrique Fernandez-Nieto and Tomas Chacon Rebollo (Sevilla). They have an expertise in complex flows, including variable density flows, erosion, non-hydrostatic effects, ...

8.5. International Research Visitors

Enrique Fernandez-Nieto and Gladys Narbona-Reina (Univ. Sevilla) were hosted for 1 month by A. Mangeney's team at IPGP.

BANG Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. CIRB-Collège de France

Jonathan Touboul is leading the team "Mathematical Neuroscience Laboratory" in the Centre for Interdisciplinary Research in Biology of the Collège de France. Several collaborations have been initiated, two postdocs have been recruited (Jérôme Ribot and Alberto Romagnoni), student scholarships have been provided and 3 PhD students have started their research in the laboratory (C. Quiñinao and L. C. García del Molino in 2012, Tanguy Cabana in 2013).

7.1.2. DIGITEO and Cancéropôle IdF

The DIGITEO IdF LSC *ALMA* and *ALMA2* programs, coordinated by C. Bonnet (DISCO team, Inria Saclay IdF) studies a model of leukaemia based on previous works by M. Adimy and F. Crauste (Lyon), with theoretical model design adjustments and analysis in J. L. Avila Alonso's Ph D thesis (supervised by C. Bonnet, S. Niculescu and J. Clairambault) and experimental parameter identification initiated by F. Merhi, Bang postdoc (Dec. 2010-Nov. 2011), then continued by A. Ballesta (Sep. 2011-Feb. 2013), Bang postdoc detached at INSERM, working at St. Antoine Hospital (Paris), under the supervision of J. Clairambault and C. Bonnet to link experimental and theoretical aspects and of J.-P. Marie and R.P. Tang (INSERM-UPMC) to supervise biological experiments on leukaemic cells. ALMA has been granted for 3 years, beginning in December 2010.

A. Ballesta's postdoc at St. Antoine Hospital, granted by Cancéropôle IdF *ALMA2* has led to increased collaboration of the same with the Commands Inria team (F. Bonnans, X. Dupuis, Saclay) with the aim to design optimisation procedures for anti-leukaemic therapies by cytosine arabinoside and by an anti-Flt3 targeted agent (see above "Optimisation of cancer chemotherapy").

7.2. National Initiatives

7.2.1. ANR and other national projects

7.2.1.1. ANR program Bimod

This ANR program, coordinated by V. Volpert (Lyon), involves 3 partners: CNRS (Institut Camille Jordan) in Lyon (V. Volpert), University Bordeaux II (P. Magal) and Inria (Bang project-team and DISCO team, Saclay IdF). It associates PDE models, both spatial and physiologically structured, with individual-based models in *hybrid models* to represent cancer growth (leukaemia and colorectal cancer) and therapy. It has been granted for 4 years, beginning in December 2010.

7.2.1.2. ANR Sine2Arti

Participation in the ANR project Sine2Arti. The project considers tissue homeostasis and cell reprogramming. The project is coordinated by Gregory Batt (coordinator, Contraintes research team, Inria), PIs are Oded Maler (Univ. of Grenoble) and Dirk Drasdo, an external collaborator is Ron Weiss (MIT)

7.2.1.3. GDR DarEvCan

The GDR DarEvCan, for Darwinian Evolution and Cancer, is a interdisciplinary consortium which associates 10 teams in France around the theme of evolution and cancer, in particular evolution of cancer cell populations towards drug resistance [18]. It has held its first national meeting in December 2011 in Paris, another one in April 2012 in Montpellier, and has organised an international conference in Roscoff in November 2013 http://www.cnrs.fr/insb/cjm/archives/2013/Hochberg_e.html, to which J. Clairambault presented an invited talk on behalf of the Bang team. The Bang team takes an active part in its development, which relies mainly on applying methods from evolutionary theory to cancer biology [22] (http:///www.darevcan.univ-montp2.fr/).

7.2.1.4. PEPS PTI 'Ondes de concentration en bactéries'

People of the BANG team are involved in this project funded by the CNRS. This is a collaboration with biophysicists of the Institut Curie dedicated to the description of the collective motion of bacteria by chemotaxis.

7.2.1.5. PEPS PTI 'Neuro-Info' (Jonathan Touboul)

Jonathan Touboul obtained a support of the CNRS for a collaboration with Princeton University on the information in biological systems, including neuronal networks and quorum sensing.

7.2.1.6. PEPS PTI 'NeuroGauge' (Jonathan Touboul and Alberto Romagnoni)

Alberto Romagnoni (Postdoc in the Mathematical Neuroscience Team) and Jonathan Touboul obtained a support from the CNRS program PEPS PTI in order to use tools from the non-abelian gauge theory for the modeling of the visual cortex. This is a collaboration with theoretical physicists from U. Autonoma of Madrid (Carlos Pena).

7.2.1.7. ITMO-Cancer grant PhysCancer

Participation in the ITMO-Cancer (Aviesan) project Physics of Cancer. The project studies the impact of a constraining extracellular material on the growth and division of cells and cellular aggregates. The project is coordinated by Pierre Nassoy (Institut Curie), collaborators are Dirk Drasdo and Christophe Lamaze (INSERM).

7.2.1.8. INVADE

Participation in the project INVADE (INSERM). The project studies invasion patterns of breast cancer cells. The project is coordinated by Emmanuel Barillot (Inst. Curie), collaborators include Dirk Drasdo and other groups from Institut Curie.

7.3. European Initiatives

7.3.1. FP7 Projects

7.3.1.1. ERASysbio+ C5Sys European network.

This European program (http://www.erasysbio.net/index.php?index=272) has begun in April 2010 to end up in June 2013, with the title "Circadian and cell cycle clock systems in cancer". Coordinated by F. Lévi (Villejuif) and D. Rand (Warwick), it studied both from a theoretical and from an experimental viewpoint the relationships between molecular circadian clocks and the cell division cycle, in cancer and in healthy tissues. A postdoctoral fellow (F. Billy) has been hired at Inria-Bang until November 2012 on this funding, giving rise to various publications in 2013 [7], [8], [9], [27].

7.3.1.2. NOTOX

Type: COOPERATION

Instrument: Integrated Project

Objective: NC

Duration: January 2011 - December 2015

Coordinator: Elmar Heinzle, Universität des Saarlandes, Saarbrücken

Partner: Centre National de la Recherche Scientifique, Strasbourg

Partner: Stichting Het Nederlands Kanker Instituut - Antoni Van Leeuwenhoek Ziekenhuis, Amsterdam

Partner: Karolinska Institutet, Stockholm

Partner: Insilico Biotechnology AG, Stuttgart

Partner: Institut National de Recherche en Informatique et en Automatique, Rocquencourt

Partner: Deutsches Forschungszentrum für Künstliche Intelligenz GmbH, Saarbrücken

Partner: Forschungsgesellschaft für Arbeitsphysiologie und Arbeitsschutz e.V, Dortmund

Partner: Biopredic International, F35760 St. Grégoire

Partner: Weizmann Institute of Science, Rehovot, Israel

Partner: Cambridge Cell Networks Ltd, Cambridge, UK

Partner: European Research and Project Office GmbH, Saarbrücken

Inria contact: Dirk Drasdo

Abstract: NOTOX will develop and establish a spectrum of systems biological tools including experimental and computational methods for (i) organotypic human cell cultures suitable for long term toxicity testing and (ii) the identification and analysis of pathways of toxicological relevance. NOTOX will initially use available human HepaRG and primary liver cells as well as mouse small intestine cultures in 3D systems to generate own experimental data to develop and validate predictive mathematical and bioinformatic models characterizing long term toxicity responses. Cellular activities will be monitored continuously by comprehensive analysis of released metabolites, peptides and proteins and by estimation of metabolic fluxes using 13C labelling techniques (fluxomics). At selected time points a part of the cells will be removed for in-depth structural (3D-optical and electron microscopy tomography), transcriptomic, epigenomic, metabolomic, proteomic and fluxomic characterisations. When applicable, cells derived from human stem cells (hESC or iPS) and available human organ simulating systems or even a multi-organ platform developed in SCREEN-TOX and HEMIBIO will be investigated using developed methods. Together with curated literature and genomic data these toxicological data will be organised in a toxicological database (cooperation with DETECTIVE, COSMOS and TOXBANK). Physiological data including metabolism of test compounds will be incorporated into large-scale computer models that are based on material balancing and kinetics. Various omics, data and 3D structural information from organotypic cultures will be integrated using correlative bioinformatic tools. These data also serve as a basis for large scale mathematical models. The overall objectives are to identify cellular and molecular signatures allowing prediction of long term toxicity, to design experimental systems for the identification of predictive endpoints and to integrate these into causal computer models.
Webpage: http://notox-sb.eu/fp7-cosmetics-europe/

7.3.1.3. ERC Starting Grant SKIPPER^{AD}

Type: IDEAS

Instrument: ERC Starting Grant

Duration: December 2012 - November 2017

Coordinator: Marie Doumic

Partner: INRA Jouy-en-Josas, France

Inria contact: Marie Doumic

Abstract: Amyloid diseases are of increasing concern in our aging society. These diseases all involve the aggregation of misfolded proteins, called amyloid, which are specific for each disease (PrP for Prion, Abeta for Alzheimer's). When misfolded these proteins propagate the abnormal configuration and aggregate to others, forming very long polymers also called fibrils. Elucidating the intrinsic mechanisms of these chain reactions is a major challenge of molecular biology: do polymers break or coalesce? Do specific sizes polymerize faster? What is the size of the so-called nucleus, i.e., the minimum stable size for polymers? On which part of the reactions should a treatment focus to arrest the disease ? Up to now, only very partial and partially justified answers have been provided. This is mainly due to the extremely high complexity of the considered processes, which may possibly involve an infinite number of species and reactions (and thus, an infinite system of equations).

The great challenge of this project is to design new mathematical methods in order to model fibril reactions, analyse experimental data, help the biologists to discover the key mechanisms of polymerization in these diseases, predict the effects of new therapies. Our approach is based on

a new mathematical model which consists in the nonlinear coupling of a size-structured Partial Differential Equation (PDE) of fragmentation-coalescence type, with a small number of Ordinary Differential Equations. On the one hand, we shall solve new and broad mathematical issues, in the fields of PDE analysis, numerical analysis and statistics. These problems are mathematically challenging and have a wide field of applications. On the other hand we want to test their efficacy on real data, thanks to an already well-established collaboration with a team of biophysicists. With such a continuing comparison with experiments, we aim at constantly aligning our mathematical problems to biological concerns.

7.4. International Initiatives

7.4.1. ECOS-CONICYT

B. Perthame and K. Vilches take part in the Franco-Chilean project 'Functional analysis, asymptotics and dynamics of fronts' headed by J. Dolbeault (University Paris-Dauphine) funded by ECOS-CONICYT.

7.4.2. EuroMed 3+3

M3CD, *Mathematical Models and Methods in Cell Dynamics*, a transmediterranean EuroMed3+3 program, has begun in January 2012 for 4 years, under the coordination of J. Clairambault. It associates 2 Inria teams: Bang and Dracula (Mostafa Adimy, Lyon) with the IAC-CNR in Rome (Roberto Natalini), the LMDP team in Marrakech (Hassan Hbid) and the MoMinBi team at Institut Pasteur, Tunis (Slimane BenMiled, Amira Kebir) to work on the general theme "Mathematical Models and Methods in Cell Dynamics". It has fostered in 2013 visits of students to Paris and Lyon, for Y. Bourfia, PhD student at Marrakech and UPMC, who works under the supervision of H. Hbid, M. Adimy and J. Clairambault and for Rym Jaroudi, M2 student at the University of Tunis, who works under the supervision of Slimane BenMiled and Amira Kebir.

A 2-day M3CD workshop, organised by Hassan Hbid, following a first one organised in November 2012 in Tunis, will take place in January 2014 (27-28) in Marrakech. Newcomers, researchers from the Northern side, who will be present in this workshop, will join the network in 2014: Marcello Delitala (Polito, Turin) and Oscar Angulo (University of Valladolid).

7.4.3. Xuguang Qi-Hubert Curien program

C. Emako-Kazianou and N. Vauchelet take part in a Xuguang Qi-Hubert Curien program funded by Campus-France in collaboration with Shanghai Jiao Tong university. This program no 30043VM entitled "PDE models for cell self-organization" is headed by N. Vauchelet and allows visits for both parts of the project. The chinese researchers involved in this program are Min Tang and Jie Lao.

7.4.4. Inria International Partners

1. **German Research Ministry (BMBF) funded project on the systems biology of lung cancer.** The major aim is to better understand the early metastasis formation and invasion of lung cancer, including therapeutical options. Data on all levels ranging from intracellular up to organ level will be used to establish successively an integrated multiscale model of cellular and migration decisions in lung cancer. A particular focus will be on dissecting how cellular organisation and communication in spheroid cultures and co-cultures of lung cancer cell lines with selected endothelial cells affects information processing and the proliferation and migration decisions downstream. To reveal the inhomogeneous spatio-temporal organisation in these tumour growth models, specific probes for medical imaging, quantify extracellular cytokine concentrations will be used, and the effects of pharmacological inhibitors be monitored. By data and model integration, parameters should be identified that critically determine early spread and facilitate to predict possibilities for improved therapeutic options.
   The project coordinator is Ursula Klingmueller, German Cancer Research Centre (DKFZ), Heidelberg (http://www.lungsys.de/)

2. **German Research Ministry (BMBF) funded project on the systems biology of liver (Virtual Liver Network).** The aim of the VLN project is to set up multiscale models of liver. The Virtual Liver will be a dynamic model that represents, rather than fully replicates, human liver physiology morphology and function, integrating quantitive data from all levels of organisation. Our part ranges from the intracellular up to the level of groups of liver lobules. A liver lobule is the basic repetitive functional unit of liver. Applications are explained in the text. The networks has 69 Principle Investigators organised in about 10 work packages, each of which have a number of sub-projects (http://www.virtual-liver.de/about/).

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- H.T. Banks (North Carolina State University), 2 weeks at UPMC (SKIPPER^{AD} project)
- Bard Ermentrout (University of Pittsburgh), 1 week at the Mathematical Neuroscience Team
- Miguel Escobedo (University of Bilbao, BECAM), 2 weeks at UPMC (SKIPPER^{AD} project)
- Thibaud Taillefumier (University of Princeton), 2 weeks at the Mathematical Neuroscience Team
- Jonathan Rubin (University of Pittsburgh), 3 days at the Mathematical Neuroscience Team
- Justyna Signerska (Polish Academy of Mathematics), 10 days at the Mathematical Neuroscience Team
- Suzanne Sindi (University of California MERCED), 1 week at UPMC (SKIPPER^{AD} project)
- Wei-Feng Xue (University of Canterbury), 2 days at UPMC (SKIPPER^{AD} project)
- Min Tang (Shanghai Jiaotong Univ.) , 1 month at BANG (Xu GuangQi Hubert Curien program no30043V M PDE models for cell self-organization, N. Vauchelet)

7.5.1.1. Internships

- Rym Jaroudi (University of Tunis) on the subject “Applying evolutionary game theory and adaptive dynamics to modelling cancer treatments”, supervised by S. Ben Miled, A. Kebir (Tunis) and J. Clairambault: October

7.5.2. Visits to International Teams

- 10 days at the University of Pittsburgh (J. Touboul)
- 1 week at the North Carolina State University (M. Doumic and C. Kruse)
- 3 weeks at the Biophysics Lab in Princeton (J. Touboul)
- 2 days at the Courant Institute (New-York) (J. Touboul)
- 3 days at BECAM Center (Bilbao) (M. Doumic)
- 4 weeks at the CEDOC center at Gulbenkian Science Institute (L. Almeida)
- 10 days at the CMM, University of Chile (B. Perthame)
- 10 days at MIT, USA (F. Bertaux)

CASTOR Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- ANR ECINADS

  Castor is associated to the ANR ECINADS project started in end of 2009, devoted to the design of new solution algorithms for unsteady compressible flows, adapted to scalable parallelism and to reverse (adjoint) Automatic Differentiation. See in the activity report of Ecuador.

- ANR ESPOIR

  The ANR ESPOIR (Edge Simulation of the Physics Of Iter Relevant turbulent transport) associates the CASTOR team with the M2P2, LPIIM and LATP laboratories in Marseille and IRFM in Cadarache to investigate edge plasma turbulence. The numerical simulation of the plasma wall interactions requires efficient codes and thus the development of advanced numerical methods and solvers. The aim of this project is to study different numerical strategies for edge plasma models in the real geometrical and magnetical configurations corresponding to the future Iter machine.

- ANEMOS : ANR-11-MONU-002

  ANEMOS : Advanced Numeric for Elms : Models and Optimized Strategies associates JAD Laboratory/Inria (Nice, Manager), IRFM-CEA (Cadarache), Maison de la Simulation (Saclay) and Inria EPI Bacchus (Bordeaux) Elms are disruptive instabilities occurring in the edge region (SOL) of a tokamak plasma. The development of Elms poses a major challenge in magnetic fusion research with tokamaks, as these instabilities can damage plasma-facing components, particularly divertor plates. The mitigation or suppression of large Elms is a critical issue for successful operation of ITER. Goal for ANEMOS is to develop and improve numerical tools in order to simulate physical mechanisms of Elms and qualifies some strategies for their control. We then need to design efficient numerical strategies on the most advanced computers available to contribute to the science base underlying of proposed burning plasma tokamak experiments such as ITER.

- ANR IODISEE : IOnospheric DIsturbanceS and SatEllite-to-Earth communications. http://iodissee.math.cnrs.fr/project/index.html. In this ANR project, CASTOR will address the use of data-models coupling method to identify the input model parameters (especially, the initial data for the electronic density).

8.1.2. Federation on Magnetic Confinement Fusion Projects

- FR FCM (Federation on Magnetic Confinement Fusion) project within Euratom-CEA association, "Reconstruction, simulation and control of plasma equilibrium"
- FR FCM (Federation on Magnetic Confinement Fusion) project within Euratom-CEA association, “Two-fluid numerical modelling of edge plasma in tokamak; Application to ITER”.

8.2. European Initiatives

8.2.1. Collaborations with Major European Organizations

EFDA (European Fusion Development Agreement)

EFDA ITM Task Force (Integrated Tokamak Modelling) CEDRES++ and Equinox are developped within the framework of the Task Force on Integrated Tokamak Modelling of the European Fusion Development Agreement.

EFDA (European Fusion Development Agreement)

JOREK, BOUT++ non-linear MHD modelling of MHD instabilities and their control in existing tokamaks and ITER

8.3. International Initiatives

8.3.1. Participation In other International Programs

8.3.1.1. Euromediterranée 3+3 Medlagoon program

Participants: Hervé Guillard, Marco Bilanceri.

The goal of the Medlagoon project (https://project.inria.fr/medlagoon/en) is to contribute to the design of simulations tools aimed to the integrated mathematical modeling of Mediterranean lagoons ranging from hydrodynamics and sediment transport modeling to biological models for phyto and zoo-plankton. This program associates CASTOR with the Mohamedia Engineering school and the university of Oujda in Morocco, the University of Pisa (Italy), the Polytechnic school of Tunis in Tunisia, the University of Paris 13, The Ain Sham University in Egypt and the Department of Applied Mathematics, University of Crete in Greece.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

- Pavla Frankova, University of Pilzen : Algebraic Multigrid Solvers. In the framework of a collaboration on algebraic multigrid solvers with Petr Vanek and Roman Kuzel of the University of Pilzen, Cezch Republic, Pavla Frankova PhD student in Pilzen has visited CASTOR in November.
- Abdou Hafar, Ecole Mohamedia Ingénieur, Rabat : In the framework of the Medlagoon program, Abou Hafar PhD student has visited CASTOR in November to work on meshless methods.

CLIME Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- The ANR project Estimair aims at quantifying the uncertainties of air quality simulations at urban scale. The propagation of uncertainties requires the use of model reduction and emulation. A key uncertainty source lies in the traffic emissions, which will be generated using a dynamic trafic assignment model. Ensembles of traffic assignments will be calibrated and used in the uncertainty quantification. Estimair is led by Clime.
- Clime is one partner of the ANR project GeoFluids. It focuses on the specification of tools to analyse geophysical fluid flows from image sequences. Clime objectives concern the definition of reduced models from image data.
- Clime takes part to the ANR project IDEA that addresses the propagation of wildland fires. Clime is in charge of the estimation of the uncertainties, based on sensitivity studies and ensemble simulations.

8.1.2. PRIMEQUAL (ADEME)

- Clime takes part to the PRIMEQUAL project PREQUALIF, "Programme Pluridisciplinaire de REcherche sur la QUALité de l'air en Île-de-France" (i.e., "Multidisciplinary Program on Air quality research in Île-de-France"). The objective is to investigate the impact of low emission zones. The project aims at designing a new generation of diagnostic tools for assessment of health and analysis of economic benefits attributed to traffic restrictions. Clime brings data assimilation expertise which allows to compute the most accurate air pollution maps.

8.2. European Initiatives

8.2.1. Collaborations in European Programs, except FP7

Program: COST Action ES104.

Project acronym: EuMetChem.

Project title: European framework for online integrated air quality and meteorology modeling.

Duration: January 2011 - December 2014.

Coordinator: Alexander Baklanov, Danish Meteorological Institute (DMI) Danemark.

Other partners: around 14 european laboratories, experts from United States, ECMWF.

Abstract: European framework for online integrated air quality and meteorology modeling (EuMetChem) focuses on a new generation of online integrated Atmospheric Chemical Transport (ACT) and Meteorology (Numerical Weather Prediction and Climate) modeling with two-way interactions between different atmospheric processes including chemistry (both gases and aerosols), clouds, radiation, boundary layer, emissions, meteorology and climate. Two application areas of the integrated modeling are considered: (i) improved numerical weather prediction (NWP) and chemical weather forecasting (CWF) with short-term feedbacks of aerosols and chemistry on meteorological variables, and (ii) two-way interactions between atmospheric pollution/ composition and climate variability/change. The framework consists of four working groups namely: 1) Strategy and framework for online integrated modeling; 2) Interactions, parameterizations and feedback mechanisms; 3) Chemical data assimilation in integrated models; and finally 4) Evaluation, validation, and applications. Establishment of such a European framework (involving also key American experts) enables the EU to develop world class capabilities in integrated ACT/NWP-Climate modeling systems, including research, forecasting and education.

8.2.2. Collaborations with Major European Organizations

Partner: ERCIM working group “Environmental Modeling”.

The working group gathers laboratories working on developing models, processing environmental data or data assimilation.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

Partner: Chilean meteorological office (Dirección Meteorológica de Chile)

The partner produces its operational air quality forecasts with Polyphemus. The 3-day forecasts essentially cover Santiago. The forecasts are accessible online in the form of maps, time series and video (http://www.meteochile.gob.cl/modeloPOLYPHEMUS.php).

Partner: Marine Hydrophysical Institute http://mhi.nas.gov.ua/eng/, Ukraine.

The collaboration concerns the study of the Black Sea surface circulation and the issue of image assimilation in forecasting models.

Partner: IBM Research, Dublin, Ireland

The collaboration addresses the assimilation of classical observations as well as images, with application to geophysics. New assimilation methods are developed, mainly based on minimax filtering.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Sergiy Zhuk, IBM, Dublin Research Lab, Ireland, September 2013.

COFFEE Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

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

7.1.2. National and European networks

- GdR MoMas.

  The research group MoMaS (Mathematical Modeling and Numerical Simulation for Nuclear Waste Management Problems) has activities centered around scientific computing, design of new numerical schemes and mathematical modelling (upscaling, homogenization, sensitivity studies, inverse problems,...). Its goal is to coordinate research in this area, as well as to promote the emergence of focused groups around specific projects
- S. Junca is involved in the GdR-e "Wave Propagation in Complex Media for Quantitative and non Destructive Evaluation".
- GdR EGRIN is a newly created CNRS-network, devoted to gravitational flows and naturals risks; Coffee is among the members of this network.

7.2. International Initiatives

7.2.1. Inria Associate Teams

As of March 2014, the project CoKLyCo will start: this is a joint research program with the group of F. Filbet from the Math. Dept. of the University of Lyon and the team of K. Aoki from the Dept. of Mechanical Engineering at Kyoto University. The project is concerned with fluid and kinetic model for some rarefied gases.

7.2.1.1. Informal International Partners

Quite recently, S. Junca has started a collaboration with Mathias Legrand, from the Mechanical Engineering department at Mc Gill, Montréal with the supervision of the internship of a master student (S. Heng, 6 months, June-Nov. 2013). Furthermore, S. Junca is an active member of the European network "Wave propagation in complex media for quantitative and non destructive evaluation" [1]

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

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

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

7.3. International Research Visitors

7.3.1. Visits of International Scientists

A. Vasseur, from UT Austin, J. A. Carrillo from ICL, Corrado Mascia from Sapienza, Università di Roma and Gabriella Puppo from Politecnico di Torino visited the team

[1] `http://www.gdre-us.cnrs-mrs.fr/spip.php?rubrique8`

FLUMINANCE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Britanny concil ARED IMAGEO:

Participants: Cédric Herzet, Etienne Mémin, Véronique Souchaud.

duration 36 months. This project of the Britanny concil, which finances the PhD thesis of Véronique Souchaud, aims at studying methods for the estimation of reduced order modeling of fluid flows evolution laws from image sequences. The goal consists here at defining the estimation of a reduced basis describing the flow evolution as a motion estimation problem.

8.2. National Initiatives

8.2.1. ANR-COSINUS PREVASSEMBLE: Ensemble methods for assimilation of observaions and for prevision in Meteorology and Oceanography

Participants: Sébastien Beyou, Anne Cuzol, Etienne Mémin.

duration 36 months.

The purpose of this project is to further study ensemble methods -, and to develop their use for both assimilation of observations and forecast. Among the specific questions to be studied are the theory of Particle Filters and Ensemble Kalman Filters, the possibility of taking temporal correlation into account in ensemble assimilation, the precise assessment of what can and cannot be achieved in ensemble prediction, and the objective validation of ensemble methods.

The partners of this project are Laboratoire de Météorologie Dynamique/ENS (leader), Météo-France and three Inria groups (ALEA, ASPI, FLUMINANCE).

8.2.2. ANR SYSCOMM MSDAG: MultiScale Data Assimilation in Geophysics

Participants: Patrick Héas, Dominique Heitz, Cédric Herzet, Etienne Mémin.

duration 36 months.

Changing scale is a well-known topic in physics (geophysics, fluid mechanics and turbulence, theoretical and statistical physics, mechanics, porous media, etc.). It has led to the creation of powerful sophisticated mathematical tools: renormalization, homogenization, etc. These ideas are also used in numerical analysis (the so-called multigrid approach) for solving efficiently partial differential equations. Data assimilation in Geophysics is a set of methods that allows to combine optimally numerical models in large spaces with large dataset of observations. At the confluence of these two topics, the goal of this project is to study how to embed the change of scales (a multiscale point of view) issue into the framework of geophysical data assimilation, which is a largely unexplored subject.

The partners of this 3 years project are the CEREA/ CLIME Inria group (leader), the LSCE/CEA, the Inria groups MOISE and FLUMINANCE.

8.2.3. ANR SYSCOMM GeoFluids: Analyse et simulation d'écoulements fluides à partir de séquences d'images : application à l'étude d'écoulements géophysiques

Participants: Dominique Heitz, Etienne Mémin.

duration 48 months.

The project Geo-FLUIDS focuses on the specification of tools to analyze geophysical fluid flows from image sequences. Geo-FLUIDS aims at providing image-based methods using physically consistent models to extract meaningful features describing the observed flow and to unveil the dynamical properties of this flow. The main targeted application domains concern Oceanography and Meteorology . The project consortium gathers the Inria research groups: FLUMINANCE (leader), CLIME and MOISE. The group of the "Laboratoire de Météorologie Dynamique" located at the ENS Paris, the IFREMER-CERSAT group located at Brest and the METEOFRANCE GMAP group in Toulouse.

8.2.4. ANR JCJC GERONIMO : Advanced GEophysical Reduced-Order Model construction from IMage Observations

Participant: Cédric Herzet.

duration 48 months. The GERONIMO project which starts in January 20014 aims at devising new efficient and effective techniques for the design of geophysical reduced-order models from image data. The project both arises from the crucial need of accurate low-order descriptions of highly-complex geophysical phenomena and the recent numerical revolution which has supplied the geophysical scientists with an unprecedented volume of image data. The project is placed in the intersection of several fields of expertise (Bayesian inference, matrix factorization, sparse representations, etc) which will be combined to handle the uncertainties associated to image measurements and to characterize the accurate reduced dynamical systems.

8.2.5. INSU-LEFE: Vers de nouvelles méthodes d'estimation de la sous-mésoéchelle océanique

Participants: Patrick Héas, Cédric Herzet.

duration 36 months. This project tackles the problem of deriving a precise submesoscale characterization of ocean currents from satellite data. The targeted methodologies should in particular enable the exploitation of data of different nature (for example sea surface temperature or height) and/or resolutions. This 36-month project benefits from a strong collaboration with Guillaume Lapeyre (Laboratoire de Météorologie Dynamique, Ecole Normale Supérieure, Paris).

MAGIQUE-3D Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

The PhD fellowship of Elodie Estecahandy is partially (50%) funded by the Conseil Régional d'Aquitaine.

The PhD fellowship of Vanessa Mattesi is partially (50%) funded by the Conseil Régional d'Aquitaine.

The Post-Doctoral fellowship of Juliette Chabassier is partially (50%) funded by the Conseil Général des Pyrénées Atlantiques.

The Post-Doctoral fellowship of Ángel Rodríguez Rozas is partially (50%) funded by the Conseil Régional d'Aquitaine.

8.2. National Initiatives

8.2.1. Depth Imaging Partnership

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

Since its beginning (2009), eight PhD students have been funded and Magique 3D has hired six of them, one being shared with the project team Nachos (http://www-sop.inria.fr/nachos/). Moreover, several internships have been realized. 2013 was a particular year for the project because Total decided to extent DIP for five years. It has been necessary to update the legal framework of the project which explains that the second phase of DIP will officially begin in 2014. Nevertheless, in order to preserve the dynamic of the project, Magique-3D has hired an internship, Wilfredo Salazar, coming from the Engineering school INSA at Rouen.

8.2.2. Micro-local analysis of wave equations

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

8.2.3. Partnership with the department DMAE of ONERA

title: Modeling of multiperforated plates

Coordinator: Sébastien Tordeux

Other partners: Department DMAE of ONERA

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

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

numerical library based on the discontinuous Galerkin approximation which aims in interpreting experimental data.

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

8.3. European Initiatives

8.3.1. FP7 Projects

8.3.1.1. HPC-GA

Title: High Performance Computing for Geophysics Applications

Type: PEOPLE

Instrument: International Research Staff Exchange Scheme (IRSES)

Duration: January 2012 - December 2014

Coordinator: Inria (France)

Others partners: BCAM (Basque Center of Applied Mathematics), Spain; BRGM (Bureau de Recherches Géologiques et Minières), France; ISTerre (Institut des Sciences de la Terre, France; UFRGS (Federal University of Rio Grande do Sul), Institute of Informatics, Brazil; UNAM (National Autonomous University of Mexico) , Institute of Geophysics, Mexico;

See also: https://project.inria.fr/HPC-GA/en

Abstract: Simulating large-scale geophysics phenomenon represents, more than ever, a major concern for our society. Recent seismic activity worldwide has shown how crucial it is to enhance our understanding of the impact of earthquakes. Numerical modeling of seismic 3D waves obviously requires highly specific research efforts in geophysics and applied mathematics, leveraging a mix of various schemes such as spectral elements, high-order finite differences or finite elements.

But designing and porting geophysics applications on top of nowadays supercomputers also requires a strong expertise in parallel programming and the use of appropriate runtime systems able to efficiently deal with heterogeneous architectures featuring many-core nodes typically equipped with GPU accelerators. The HPC-GA project aims at evaluating the functionalities provided by current runtime systems in order to point out their limitations. It also aims at designing new methods and mechanisms for an efficient scheduling of processes/threads and a clever data distribution on such platforms.

The HPC-GA project is unique in gathering an international, multidisciplinary consortium of leading European and South American researchers featuring complementary expertise to face the challenge of designing high performance geophysics simulations for parallel architectures: UFRGS, Inria, BCAM and UNAM. Results of this project will be validated using data collected from real sensor networks. Results will be widely disseminated through high-quality publications, workshops and summer-schools.

Three members of MAGIQUE-3D (Julien Diaz, Victor Péron and Angel Rodríguez Rozas) participated to the second Workshop of HPC-GA in Bilbao on March 11th-15th, 2013, http://www.bcamath.org/en/workshops/second-workshop-of-the-hpc-ga-project.

Manuela Longoni de Castro, Assistant Professor at UFRGS, spent one month in MAGIQUE-3D in January 2013.

8.3.2. Collaborations in European Programs, except FP7

8.3.2.1. AKELARRE

Joint project with BCAM (Basque Center of Applied Mathematics) funded by the Conseil Régional d'Aquitaine and the Basque Government in the framework of the Aquitaine-Euskadi Call. Total Amount: 14 000 euros.

Program: Fonds commun de coopération Aquitaine/Euskadi

Project acronym: AKELARRE

Project title: Méthodes numériques innovantes et logiciels performants pour la simulation de la propagation des ondes électromagnétiques en milieux complexes

Duration: février 2011 - février 2013

Coordinator: Hélène Barucq

Other partners: BCAM (Basque Center of Applied Mathematics), Spain

Abstract: This project brings together complementary skills of two research teams which are respectively located in Pau and Bilbao. The main objective of this collaboration is to develop innovative numerical methods in the field of wave propagation and to implement powerful software for the simulation of electromagnetic waves in complex media. These waves play an important role in many industrial applications and the development of such software is of great interest for many industrial enterprises located in the region. Theoretical and practical issues are considered. In particular, we focus on the mathematical analysis of boundary conditions that play a crucial role for accurate numerical simulations of waves.

8.3.2.2. Procope Inria - TU Berlin

Joint project with the Matheon Research Center in Berlin funded by the European Union in the framework of the Procope 2012 Call. Total Amount: 2800 euros.

Program: PHC Procope 2012

Project acronym: Procope Inria - TU Berlin

Project title: Procope Inria - TU Berlin

Duration: January 2012 - December 2013

Coordinator: Sébastien Tordeux

Other partners: Matheon Research Center, TU Berlin, Germany

Abstract: This project aims in funding trips between Pau and Berlin. The young research group of Kersten Schmidt and Magique 3D are both specialist of the modeling and the simulation of the wave propagation phenomena. During this program we focus on the modeling of multiperforate plates which are present in the combustion chambers; on the derivation of absorbing boundary conditions for stratified media and on the development of precise numerical methods in the context of the Hardy problem.

In this framework several members of Magique 3D visited the Matheon Research Center in Berlin :

- Julien Diaz, May 7th to May 10th
- Victor Péron spent one week in Berlin in November
- Juliette Chabassier spent one month in Berlin

and several members of Matheon Research Center visited Magique 3D :

- Kersten Schmidt spent one week in Pau in November
- Robert Gruhlke spent one week in Pau in November
- Philipp Kliewe spent one week in Pau in November
- Dirk Klindworth spent one week in Pau in December
- Maxim Zeinaliyev spent two weeks in Pau in December

8.4. International Initiatives

8.4.1. Inria International Partners

8.4.1.1. MAGIC

Program: Inria International Partner

Title: Advance Modelling in Geophysics

Inria principal investigator: Hélène Barucq

International Partner (Institution - Laboratory - Researcher):

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

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

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

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

Élodie Estécahandy defended her PhD thesis, *Contribution à l'analyse mathématique et à la résolution numérique d'un problème inverse de scattering élasto-acoustique*, on September 19th 2013. She has been coadvised by Hélène Barucq and Rabia Djellouli in the framework of MAGIC.

Rabia Djellouli visited MAGIQUE-3D in September 2013.

8.4.2. Participation In other International Programs

8.4.2.1. HOSCAR

Program: Inria-CNPq

Title: High performance cOmputing and SCientific dAta management dRiven by highly demanding applications

Inria principal investigator: Stéphane Lanteri (Nachos, Inria Sophia Antipolis-Méditerranée

International Partners:

LNCC (Laboratório Nacional de Computaçäo Científica), Brazil;

COPPE/UFRJ (Instituto Alberto Luiz Coimbra de Pós-Graduaçäo e Pesquisa de Engenharia/Alberto Luiz Coimbra Institute for Grad<uate Studies and Research in Engineering, Universidade Federal do Rio de Janeiro), Brazil;

INF/UFRGS (Instituto de Informática, Universidade Federal do Rio Grande do Sul);

LIA/UFC (Laboratórios de Pesquisa em Ciência da Computaçäo Departamento de Computaçäo, Universidade Federal do Ceará).

Inria Teams :

NACHOS, Inria Sophia Antipolis - Méditerranée;

ZENITH, Inria Sophia Antipolis - Méditerranée;

MOAIS, Inria Grenoble - Rhone-Alpes;

HIEPACS, Inria Bordeaux - Sud-Ouest;

MOAIS, Inria Bordeaux - Sud-Ouest;

MAGIQUE 3D, Inria Bordeaux - Sud-Ouest;

Duration: 2012-2015

See also: http://www-sop.inria.fr/hoscar/

HOSCAR is a CNPq - Inria collaborative project between Brazilian and French researchers, in the field of computational sciences, also sponsored by the French Embassy in Brazil. It is coordinated by the team-project Nachos

The general objective of the project is to setup a multidisciplinary Brazil-France collaborative effort for taking full benefits of future high-performance massively parallel architectures. The targets are the very large-scale datasets and numerical simulations relevant to a selected set of applications in natural sciences: (i) resource prospection, (ii) reservoir simulation, (iii) ecological modeling, (iv) astronomy data management, and (v) simulation data management. The project involves computer scientists and numerical mathematicians divided in 3 fundamental research groups: (i) numerical schemes for PDE models, (ii) scientific data management, and (iii) high-performance software systems. Several Brazilian institutions are participating to the project among which: LNCC (Laboratório Nacional de Computaçäo Científica), COPPE/UFRJ (Instituto Alberto Luiz Coimbra de Pós-Graduaçäo e Pesquisa de Engenharia/Alberto Luiz Coimbra Institute for Grad<uate Studies and Research in Engineering, Universidade Federal do Rio de Janeiro), INF/UFRGS (Instituto de Informática, Universidade Federal do Rio Grande do Sul) and LIA/UFC (Laboratórios de Pesquisa em Ciência da Computaçäo Departamento de Computaçäo, Universidade Federal do Ceará). The French partners are research teams from several Inria research centers. MAGIQUE-3D is involved by the way of its research activities on finite element approximations which can be used for resource prospection and reservoir simulation. Several members of MAGIQUE-3D participated to the third workshop of the project in Bordeaux, Sep 2nd to 6th 2013 [69], [46], [60], [78]. In the framework of HOSCAR, Théophile Chaumont-Frelet who is a PhD student in Magique-3D, spent two weeks in August 2013 at the LNCC to initiate a collaboration with Prof. F. Valentin on the development of new finite element methods for the Helmholtz equation.

8.4.2.2. GEO3D

Program: Inria-Russia

Title: Models and numerical simulations in Geosciences: wave propagation in complex media

Inria principal investigator: Sébastien Tordeux

International Partner (Institution - Laboratory - Researcher):

Novosibirsk State University (Russia (Russian Federation)) - Institute of Numerical Mathematics and Mathematical Geophysics - Sébastien Tordeux

Duration: January 2012 - December 2014

See also: http://uppa-inria.univ-pau.fr/m3d/ConfFR/participants.html

GEO3D is a collaborative project between Magique 3D team-project (Inria Bordeaux Sud-Ouest) and the Institute of Numerical Mathematics and Mathematical Geophysics (Novosibirsk State University) and the Institute of Petroleum Geology and Geophysics, of in the context of geosciences.

We are mainly interested in the derivation of numerical methods (discontinuous Galerkin approximation, space-time refinement), the design of direct and inverse high performance solver, and the modeling of complex media.

More precisely, we are actually interested

1. in the computation of truncated Singular Value decomposition of very large matrix to analyze the inverse problem;
2. in the coupling of a discontinuous Galerkin method with a finite differences method for the direct problem;
3. in a spectral time stepping method for the direct problem;
4. in an algorithm to determine an impedance coefficient using indirect measurement.

Several researchers from the Institutes of Novosibirsk visited MAGIQUE-3D in 2013

- Serguey Kabanikhin spent one week in June 2013
- Maxim Shishlenin spent one month in June 2013 as invited Professor
- Vadim Lisitsa spent one month in September 2013
- Vladimir Tcheverda spent one month in September 2013

Several researchers from MAGIQUE-3D visited the Institute of Numerical Mathematics and Mathematical Geophysics in 2013

- Julien Diaz spent two weeks in February 2013
- Vanessa Mattesi spent three weeks in February 2013
- Sébastien Tordeux spent three weeks in February 2013
- Sébastien Tordeux spent two weeks in February 2013
- Vincent Popie spent two weeks in October 2013

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Patrick Dular (Université de Liège) spent two months MAGIQUE-3D between January 2013 and April 2013 as invited Professor.
- Manuela Longoni de Castro, Assistant Professor at UFRGS, spent one month in MAGIQUE-3D in January 2013.
- Serguey Kabanikhin spent one week in June 2013
- Maxim Shishlenin spent one month in June 2013 as invited Professor
- Vadim Lisitsa, Assistant Professor at Novossibirsk State University, spent one month in MAGIQUE-3D in September 2013.
- Vladimir Tcheverda, Professor at Novossibirsk State University, spent one month in MAGIQUE-3D in September 2013.

MOISE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- M. Nodet is responsible for the workpackage "numerical modelling" within the regional project (Région Rhône-Alpes) "**Envirhonalp**" http://www.envirhonalp.fr.
- M. Nodet is involved in E. Maitre MSTIC project MENTOL about Optimal Transport.
- A. Rousseau leads the working group *Couplage Fluide/Vivant* in Montpellier for the study of coupled systems (fluid dynamics and life sciences) in nearshore regions. This research is funded by the Labex NUMEV in Montpellier.
- Clémentine Prieur is a member of the project "Soutien à l'Excellence et à l'Innovation Grenoble INP" MEPIERA (MEthodologies innovantes Pour l'Ingénierie de l'Eau et des Risques Associés) leaded by A.- C. Favre (LTHE).

8.1.1. Collaborations with Various Regional Research Teams

- LGGE, MEOM team : 6.3.2 ,6.2.1 ,6.3.2 ,6.3.6 , 6.3.5 , 6.1.2 .
- LGGE Grenoble, Edge team (C. Ritz, O. Gagliardini, F. Gillet-Chaulet, G. Durand), see paragraphs 6.2.2 and 6.2.3 .
- LTHE, A.C. Favre: hydrological risk assessment.
- LTHE, Thierry Lebel, Théo Vischel: tracking of mesoscale convective systems,
- LTHE, MISTIS, LJK: PEPS (CNRS, PRES Grenoble) project AGREE on multivariate risk assessment. The project was funded in 2013 and leaded by M. Clausel (LJK).
- LTHE, MISTIS, LJK: AGIR project. Clémentine Prieur obtained the funding for a thesis on risk assessment.
- Building energy (G2ELab, Mathilde Grandjacques, Benoît Delinchant). : 6.4.1 ,6.5
- Univ. Lyon 1 collaboration with V. Maume-Deschamps and S. Loisel.

8.2. National Initiatives

8.2.1. Interactions with other Inria Project-Teams or Actions

Participants	Inria Project-Team	Research topic	Link
F. Lemarié	POMDAPI	Coupling methods	6.1.1
A. Rousseau	TOSCA	Stochastic Downscaling Method	5.4
A. Rousseau	MODEMIC	Bioremediation of natural resources	6.10
C.Prieur, P. Tencaliec	MISTIS	hydrological risk assessment	6.6
C. Helbert, C.Prieur, A. Vidard, N. Papadakis	STEEP	Calibration and sensitivity analysis for LUTI models	6.9
A. Vidard M. Nodet F.X. Le Dimet	CLIME, FLUMINANCE	Image assimilation	6.3.2
A. Vidard, M. Nodet, E.Kazantsev	TROPICS	Ocean Adjoint Modelling	6.2.1 ,6.3.6
L.Debreu,	CLIME, FLUMINANCE	Multiscale data assimilation	6.2.1
C.Prieur, L. Viry	GRAAL	Grid deployment for the study of West African Monsoon	6.4

8.2.2. Collaborations with other Research Teams in France

Participants	Research Team	Research topic	Link
L. Debreu, F. Lemarié	IFREMER (Brest), LOCEAN (Paris)	Ocean modelling, Ocean-atmosphere coupling	6.1.2 , 6.1.1
F. Lemarié	CNRM (Toulouse)	Ocean-atmosphere coupling	6.1.1
A. Rousseau	Institut de Mathématiques et de Modélisation de Montpellier (I3M)	Modelling and simulation of coastal flows	6.1
A. Rousseau	Laboratoire de Météorologie Dynamique (Ecole Polytechnique)	Stochastic Downscaling Method	5.4
E.Blayo, A.Rousseau, F. Lemarié	LAMFA (Amiens), LAGA (Paris 13)	Coupling methods	6.1.1 , 6.1.1
A. Rousseau	IFREMER (Sète), UMR Ecosym (Montpellier)	Coupling fluids and life sciences	6.10
C. Prieur	IMT Toulouse, IFP Rueil, EDF, CEA Cadarache	Sensitivity analysis	6.4.1
C. Prieur	ISFA Lyon 1, Université de Bourgogne, CNAM	Multivariate risk indicators	6.6
C. Prieur	IMT Toulouse, Caracas	non parametric estimation for hypoelliptic diffusions	6.7
A. Vidard	Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique (Toulouse), Mercator-Océan (Toulouse), Laboratoire de Physique des Océans (Brest),	Ocean Data Assimilation	6.2.1
A. Vidard	LOCEAN (Paris)	Ocean Adjoint Modelling	6.2.1
A. Vidard	LPO (Brest), CERFACS	Ocean data assimilation	6.2.1
B.Lemieux	LSCE (Laboratoire des Sciences de l'Environnement et du Climat)	DatIce tool	5.3

8.2.3. Other National Initiatives:

- A. Vidard leads a group of projects gathering multiple partners in France and UK on the topic "Variational Data Assimilation for the NEMO/OPA9 Ocean Model", see 6.2.1 .
- C. Prieur chairs GdR MASCOT NUM, in which are also involved M. Nodet, E. Blayo, A. Rousseau, C. Helbert, L. Viry, A. Janon, S. Nanty, L. Gilquin and G. Chastaing. http://www.gdr-mascotnum.fr/doku.php
- M. Nodet is PI of the project "Méthodes inverses en glaciologie" supported by INSU-LEFE.
- A. Rousseau is PI of the project COCOA "Couplages Côtes, Océan, Atmosphère" supported by INSU-LEFE.
- F. Lemarié leads a group of projects gathering multiple partners in France on the topics « ocean-atmosphere coupling » and « numerical analysis of time schemes in ocean models » (funded by CNRS-INSU LEFE).

- E.Kazantsev, E.Blayo, F. Lemarié participate in the project "PACO - Vers une meilleure paramétrisation de la côte et des conditions limites dans les modèles d'océan" supported by LEFE-GMMC and LEFE-MANU .
- M. Nodet is involved in GDR Calcul and GDR Ondes.
- E. Blayo is the chair of the CNRS-INSU research program on mathematical and numerical methods for ocean and atmosphere LEFE-MANU. http://www.insu.cnrs.fr/co/lefe
- L. Debreu is the coordinator of the national group COMODO (Numerical Models in Oceanography)

8.2.4. ANR

- A 4-year ANR contract: ANR COSTA-BRAVA (Complex Spatio-Temporal Dynamics Analysis by Reduced Models and Sensitivity Analysis)http://www.math.univ-toulouse.fr/COSTA_BRAVA/index.html
- A 4-year ANR contract: ANR ADAGe (Adjoint ice flow models for Data Assimilation in Glaciology.
- A 4-year ANR contract: ANR Geo-FLUIDS (Fluid flows analysis and simulation from image sequences: application to the study of geophysical flows, see paragraph 6.3.2) .
- A 4-year ANR contract: ANR TOMMI (Transport Optimal et Modèles Multiphysiques de l'Image), see paragraphs 6.3.3 ,6.3.2 .
- A 4 year ANR contract (2011-2015): ANR COMODO (Communauté de Modélisation Océanographique) on the thematic "Numerical Methods in Ocean Modelling". (coordinator L. Debreu) 6.1.2
- A 3.5 year ANR contract: ANR CITiES (numerical models project selected in 2012). http://steep.inrialpes.fr/?page_id=46

8.3. European Initiatives

8.3.1. FP7 Projects

8.3.1.1. ERA-CLIM2

Type: COOPERATION

Instrument: Specific Targeted Research Project

Program: Collaborative project FP7-SPACE-2013-1

Project acronym: ERA-CLIM2

Project title: European Reanalysis of the Global Climate System

Duration: 01/2014 - 12/2016

Coordinator: Dick Dee (ECMWF, Europe)

Other partners: Met Office (UK), EUMETSAT (Europe), Univ Bern (CH), Univ. Vienne (AT), FFCUL (PT), RIHMI-WDC (RU), Mercator-Océan (FR), Météo-France (FR), DWD (DE), CERFACS (FR), CMCC (IT), FMI (FI), Univ. Pacifico (CL), Univ. Reading (UK), Univ. Versailles St Quentin en Yvelines (FR)

Inria contact: Arthur Vidard

8.3.2. Collaborations with Major European Organizations

Partner: European Centre for Medium Range Weather Forecast. Reading (UK)

World leading Numerical Weather Centre, that include an ocean analysis section in order to provide ocean initial condition fo the coupled ocean atmosphere forecast. They play a significant role in the NEMOVAR project in which we are also partner.

Partner: Met Office (U.K) National British Numerical Weather and Oceanographic service. Exceter (UK).

We do have a strong collaboration with their ocean initialization team through both our NEMO, NEMO-ASSIM and NEMOVAR activities. They also are our partner in the NEMOVAR consortium.

Partner: Marine Hydrographic Institute, Natinal Ac.Sci. Ukraine, Sevastopol.

We have a long term collaboration about data assimilation with the Black Sea. This collaboration is getting to a new level with their plan to adopt NEMO and NEMOVAR for their operational forecasting system. On our side, we will benefit from their expertise on the Black Sea dynamics, that is an excellent test case for our developments and methods.

Partner: GDR-E CONEDP

Subject: Control of Partial Differential Equations.

Partner: University of Reading, Department of Meteorology, Department of Mathematics

Subject: Data assimilation for geophysical systems.

8.4. International Initiatives

8.4.1. Inria International Labs

- A. Rousseau spent 2 weeks in Santiago in April 2013 and started a collaboration with Inria Chile.

8.4.2. Participation In other International Programs

- C. Prieur collaborates with Antonio Galves (University Sao Paulo) and Jose R. Leon (UCV, Central University of Caracas). She is a member of a USP-COFECUB project on the study of stochastic models with variable length memory (2010-2013) with University of Sao Paulo.
- C. Prieur is leader of a project ECOS Nord with Venezuela (2012-2015).
- F.-X. Le Dimet collaborates with the Institute of Mechanics of the Vietnamese Academy of Sciences Ha Noi, and with the Institute of Numerical Mathematics of the Russian Academy of Sciences.
- F. Lemarié collaborates with A.F. Shchepetkin and J.C. McWilliams from the University of California at Los Angeles (UCLA).

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Angie Pineda (invited 6 weeks in 2013 by C. Prieur through the ECOS Nord project),
- Jose R. León (invited 2 weeks in 2013 by C. Prieur through the ECOS Nord project).
- Victor Shutyaev, Institute of Numerical Mathematics, Russian Academy of Sciences, Moscow (invited for 4 weeks by F.-X. Le Dimet, see 6.4.2 , 6.4.3)
- Igor Gejadze, University of Strathclyde, Glasgow, UK (invited for 4 week by F.-X. Le Dimet, see 6.4.2)
- Nancy Nichols, University of Reading, invited for 1 week by A. Vidard and M. Nodet

8.5.2. Visits to International Teams

- F.-X. Le Dimet was invited to the Florida State University for 6 weeks in May 2013 and to the Institute of Numerical Mathematics Moscow for 2 weeks in June 2013

POMDAPI Project-Team

6. Partnerships and Cooperations

6.1. National Initiatives

ANR GEOPOR: "Geometrical approach for porous media flows: theory and numerics", with LJLL (Université de Paris 6).

ANR MANIF: "Mathematical and numerical issues in first-principle molecular simulation", with Cermics (École Nationale des Ponts et Chaussées), and LJLL (Université de Paris 6).

ARC Geofrac: (*Action de Recherche Coopérative*, Inria) "Large-scale computation of flow in complex 3D geological fractured porous media" with Inria project-teams Sage and Gamma3. From 2011.

C2S@Exa (Computer and Computational Sciences at Exascale) is an Inria Porject Lab (IPL). This national initiative aims at the development of numerical modeling methodologies that fully exploit the processing capabilities of modern massively parallel architectures in the context of a number of selected applications related to important scientific and technological challenges for the quality and the security of life in our society. This project supports in particular the PhD of N. Birgle (supervised by. J. Jaffré) which is part of an Inria-Andra collaboration.

Projet P: Project P is a four-year research project funded by the French FUI (*Fonds Unique Interministériel*) that started in 2011. Project P aims at supporting the model-driven engineering of high-integrity embedded real-time systems by providing an open code generation framework. The contribution of project-team Pomdapi is in the domain of language translation and block-schema modelisation semantics. This project supports the work of C. Franchini (under the supervision of P. Weis).

6.2. European Initiatives

6.2.1. FP7 Projects

Program: ERC Czech Republic

Project acronym: MORE

Project title: Implicitly constituted material models: from theory through model reduction to efficient numerical methods

Duration: September, 2012–August, 2017

Coordinator: Josef Málek, Charles University in Prague

Other partners: Charles University in Prague, Czech Republic; Institute of Mathematics, Academy of Sciences of the Czech Republic, Czech Republic; Oxford Centre for Nonlinear Partial Differential Equations, United Kingdom

www: http://more.karlin.mff.cuni.cz/

6.3. International Initiatives

Pomdapi is associated with LIRNE-Équipe d'Ingéniérie Mathématiques, Université Ibn Tofaïl (Kenitra, Morocco) (PHC Volubilis) in the project "Techniques multi-échelles adaptatives pour la résolution des problèmes d'écoulement et de transport en milieux poreux hétérogènes". From 2010.

Pomdapi is part of the EuroMediterranean 3+3 program with the project HYDRINV (Direct and inverse problems in subsurface flow and transport). Besides Inria institutions participating in this project are: Universitat Politècnica de Catalunya (Barcelona, Spain), Universidad de Sevilla (Spain), École Mohamedia d'Ingénieurs (Rabat, Morocco), Université Ibn Tofaïl (Kenitra, Morocco), University Centre of Khemis Miliana (Algeria), École Nationale d'Ingénieurs de Tunis (Tunisia). From 2012.

6.4. International Research Visitors

6.4.1. Visits of International Scientists

Laïla Amir, professor at FSTG in Marrakech, Morocco, was invited for one week.

H. Ben Ameur, professor at IPEST and member of the ENIT-Lamsin laboratory, Tunis, Tunisia, was invited for three months.

Lamia Guellouz, associate professor at Ecole Nationale d'Ingénieurs de Tunis, Tunisia, was invited for two weeks.

Z. Mghazli, professor at university Ibn Tofaïl, Kenitra, Morocco, was invited for one week.

6.4.2. Internships

E. Ahmed, from École Nationale d'Ingénieurs de Tunis (Tunisia), has visited Pomdapi for nine months on the subject *Modélisation d'écoulements diphasiques dans un milieu poreux fracturé*.

F. Cheikh, from École Nationale d'Ingénieurs de Tunis (Tunisia), has visited pomdapi for six months on the subject *Identification de failles dans un milieu poreux par une méthode d'indicateurs*.

M. H. Riahi, from École Nationale d'Ingénieurs de Tunis (Tunisia), has visited Pomdapi for six months on the subject *Identification de paramètres hydrogéologiques dans un milieu poreux*.

6.4.3. Visits to International Teams

M. Vohralík has visited from March 29th till May 15th Charles University in Prague, Czech Republic, Departement of Numerical Analysis (collaboration on the project MORE, teaching a Master 2nd year course).

SAGE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Brittany council: FRACINI project

Participants: Jean-Raynald de Dreuzy, Jocelyne Erhel, Géraldine Pichot.

Contract with Brittany council
Duration: one year from December 2013.
Title: European initiative towards models and numerical methods for simulations in fractured-porous geological media.
Coordination: Géraldine Pichot.
Partners: Geosciences Rennes.
Web page: http://www.irisa.fr/sage/
Abstract: FRACINI is an initiative funded by the Région Bretagne. It aims at gathering researchers from the European community working on models and numerical methods for simulations in fractured-porous media. Two international workshops will be organized in 2014. The overall objective of these workshops is to end up with a submission of a proposal in response to the Future and Emerging Technology (FET) call of H2020 Funding.

8.2. National Initiatives

8.2.1. ANR-MN: H2MNO4 project

Participants: Édouard Canot, Jocelyne Erhel, Grégoire Lecourt, Aurélien Le Gentil, Lionel Lenôtre, Géraldine Pichot, Souhila Sabit.

Contract with ANR, program Modèles Numériques
Duration: four years from November 2012.
Title: Original Optimized Object Oriented Numerical Model for Heterogeneous Hydrogeology.
Coordination: Jocelyne Erhel and Géraldine Pichot, with Fabienne Cuyollaa.
Partners: Geosciences Rennes, University of Poitiers, University of Lyon 1, Andra, Itasca.
International collaborations: University of San Diego (USA), UPC, Barcelona (Spain)
Web page: http://h2mno4.inria.fr/
Abstract: The project H2MNO4 develops numerical models for reactive transport in heterogeneous media. It defines six mathematical and computational challenges and three applications for environmental problems with societal impact (see 6.3 , 5.1.1).

8.2.2. Inria Project Lab: HEMERA project

Participants: Jocelyne Erhel, Géraldine Pichot.

Title: Hemera - developing large scale parallel and distributed experiments
Duration: September 2010 - July 2014
Coordination: C. Perez, Avalon team.
Partners: 22 Inria teams.
Webpage: http://www.grid5000.fr/mediawiki/index.php/Hemera
Abstract: Hemera is an Inria Project Lab, started in 2010, that aims at demonstrating ambitious up-scaling techniques for large scale distributed computing by carrying out several dimensioning experiments on the Grid'5000 infrastructure, at animating the scientific community around Grid'5000 and at enlarging the Grid'5000 community by helping newcomers to make use of Grid'5000.

The team Sage is the leader of the Scientific Challenge Hydro: Multi-parametric intensive stochastic simulations for hydrogeology. The objective is to run multiparametric large scale simulations (see 6.3).

8.2.3. Inria Project Lab: C2S@EXA project

Participants: Édouard Canot, Thomas Dufaud, Jocelyne Erhel, Géraldine Pichot, Souhila Sabit.

Title: C2S@EXA - Computer and Computational Scienecs at Exascale
Duration: from January 2012.
Coordination: S. Lanteri, Nachos team.
Partners: Inria teams working on HPC; external partners: ANDRA and CEA.
Webpage: http://www-sop.inria.fr/c2s_at_exa/
Abstract: The C2S@Exa Inria Project Lab is concerned with the development of numerical modeling methodologies that fully exploit the processing capabilities of modern massively parallel architectures in the context of a number of selected applications related to important scientific and technological challenges for the quality and the security of life in our society (see 6.1 , 6.3 , 6.4). The team participated in several workshops.

8.2.4. Inria Technological development actions: H2OGuilde project

Participants: Jocelyne Erhel, Aurélien Le Gentil, Grégoire Lecourt, Géraldine Pichot.

Title: H2OGuilde - Graphical User Interface and Library Development for H2OLab platform
Duration: October 2011 - October 2013.
Coordination: J. Erhel and G. Pichot.
Partner: Charles Deltel, SED Inria Rennes
Webpage: http://www.irisa.fr/sage/
Abstract: The project H2OGuilde aims at developing an interface for the platform H2OLab and at designing software libraries with a large academic diffusion (see 5.1.1 ,5.1.5 , 5.1.4).

8.2.5. Inria Collaborative Research Action: GEOFRAC project

Participants: Thomas Dufaud, Jocelyne Erhel, Géraldine Pichot.

Title: GEOFRAC
Duration: June 2011-June 2013.
Coordinator: J. Erhel and G. Pichot.
Partners: Pomdapi and Gamma3 Inria teams, Géosciences Rennes.
Webpage: http://www.irisa.fr/sage/geofrac/
Abstract: In the last twenty years, the interest of geological fractured rocks has been renewed by a variety of energy-related applications, such as carbonate oil reservoirs, geothermic energy production, geological storage of high level nuclear waste, geological sequestration of CO2. Fractures are highly permeable pathways within a less pervious but more porous medium generally called matrix. The discrete modeling of fractures faces at least two challenging numerical issues. First, the fracture and matrix phases have very different hydraulic properties. Permeability is at least two orders of magnitude larger in the fractures than in the matrix. Second, the fracture structure complexity yield intricate geometrical configurations difficult to mesh. We propose to address these limitations by developing new numerical methods (see 6.4 , 5.1.1).

8.2.6. GENCI: project on advanced linear solvers

Participants: Édouard Canot, Jocelyne Erhel, Grégoire Lecourt, Lionel Lenôtre, Géraldine Pichot.

Title: Scalabilité de méthodes numériques pour l'hydrogéologie
Duration: 2012
Coordination: J. Erhel and G. Pichot.
Webpage: http://www.genci.fr/
Abstract: To run large scale simulations, we defined a project, based on the software H2OLab, SBM, PALMTREE and GRT3D. We obtained and used computing time on machines located at GENCI supercomputing centers. (see 6.1 , 6.3).

8.2.7. GNR MOMAS: project on reactive transport

Participants: Jocelyne Erhel, Souhila Sabit.

Webpage: https://www.ljll.math.upmc.fr/cances/gdrmomas/

The working group MOMAS includes many partners from CNRS, Inria, universities, CEA, ANDRA, EDF and BRGM. It covers many subjects related to mathematical modeling and numerical simulations for nuclear waste disposal problems (see 6.3 , 6.4). The team participated in workshops.

8.3. European Initiatives

8.3.1. FP7: EXA2CT project

Title: EXascale Algorithms and Advanced Computational Techniques

Instrument: Specific Targeted Research Project

Duration: September 2013 - August 2016

Coordinator: S. Ashby, IMEC, Belgium

Partners: 10 partners

Inria contact: Luc Giraud

Web page: https://projects.imec.be/exa2ct/

Abstract: The goal of this project is to develop novel algorithms and programming models to tackle what will otherwise be a series of major obstacles to using a crucial component of many scientific codes at exascale, namely solvers and their constituents. The results of this work will be combined in running programs that demonstrate the application-targeted use of these algorithms and programming models in the form of proto-applications.

8.3.2. Collaborations with Major European Organizations

UPC: Universitat Politècnica de Catalunya-UPC, Institute of Environmental Assessment and Water Research (Spain)

numerical simulations in hydrogeology, reactive transport in heterogeneous media, upscaling, scientific software platform (see 5.1.1 , 6.3.1 , 6.4).

UFZ: Helmholtz Centre for Environmental Research-UFZ, Hydrogeology group (Germany)

numerical simulations in hydrogeology, flow in porous fractured media, scientific software platform

HPCLab: University of Patras, High Performance Information Systems Laboratory (Greece)

cooperation with B. Philippe in writing a book, and in common research on low rank approximations of matrix functions.

ERCIM: working group on numerical algorithms, high performance computing.

8.4. International Initiatives

8.4.1. Informal International Partners

University of Kent (USA)

Krylov methods

University of Purdue (USA)

High Performance Scientific Computing

University of San Diego (USA)

Hydrogeology

8.4.2. LIRIMA laboratory: momappli team (Cameroon)

Participant: Bernard Philippe.

Program: Laboratoire International de Recherche en Informatique et Mathématiques Appliquées

Title: Modélisation Mathématique et Applications

Inria principal investigator: Bernard Philippe

International Partner (Institution - Laboratory - Researcher): University of Yaounde, Cameroon - Norbert Noutchegueme

Duration: 2010-2013

See also: http://www.lirima.uninet.cm/index.php/recherche/equipes-de-recherche/momappli

Abstract: The team deals with high performance scientific computing, with a focus on reliable tools for localizing eigenvalues of large sparse matrices (see 6.1.4).

8.4.3. LIRIMA laboratory: EPIC team (Tunisia)

Participants: Amine Abdelmoula, Jocelyne Erhel, Sinda Khalfallah, Bernard Philippe.

Program: Laboratoire International de Recherche en Informatique et Mathématiques Appliquées

Title: Problèmes Inverses et Contrôle

Inria principal investigator: Houssem Haddar, Defi team

International Partner (Institution - Laboratory - Researcher): ENIT, University of Tunis, Tunisia - LAMSIN - Amel ben Abda

Duration: 2011-2013

See also: http://www.lirima.uninet.cm/index.php/recherche/equipes-de-recherche/epic

Abstract: The team deals with nonlinear and inverse problems.

8.4.4. Joint Laboratory for Petascale Computing (USA)

Participant: Jocelyne Erhel.

Program: Joint Laboratory for Petascale Computing

Inria principal investigator: Franck Cappello and Laura Grigori, Grand Large team

International Partner (Institution - Laboratory - Researcher): University of Illinois at Urbana-Champaign, USA - Marc Snir and Bill Gropp

Duration: 2011-2013

See also: http://jointlab.ncsa.illinois.edu/

Abstract: The team works on deflation methods and their integration into the software PETSc (see 6.1.1); the team works also on domain decomposition methods (see 6.4.2).

8.4.5. CEDRE program: MODNUM project (Lebanon)

Participants: Édouard Canot, Jocelyne Erhel, Bernard Philippe.

Program: CEDRE Lebanon

Title: Modélisation numérique pour des applications libanaises

Inria principal investigator: Jocelyne Erhel and Bernard Philippe

International Partner (Institution - Laboratory - Researcher): American University of Beirut (Lebanon)

Duration: Jan 2012 - Dec 2013

Abstract: the project deals with numerical parallel algorithms and with applications to archaeology.

8.4.6. ECOS Sud (Argentina): ARPHYMAT project

Participant: Édouard Canot.

Program: COFECUB

Title: Processus de formation et transformation de structures de combustion archéologique

Inria principal investigator: Édouard CANOT

International Partner (Institution - Laboratory - Researcher): University of Buenos Aires (Argentina)

Duration: Jan 2012 - Dec 2014

Abstract: the project concerns numerical simulations of prehistoric fires and comparison with archaeological data in South America.

8.4.7. Inria Euromediterranean: HYDRINV project

Participants: Édouard Canot, Jocelyne Erhel, Sinda Khalfallah, Bernard Philippe.

Program: Euromediterranean 3+3

Title: Direct and inverse problems in subsurface flow and transport

Coordination: H. ben Ameur, ENIT, Tunisia and J. Jaffré, Inria, Paris

Inria-Rennes principal investigator: Jocelyne Erhel

International Partners (Institution - Laboratory - Researcher):

Université Ibn Tofail - Faculté des Sciences de Kénitra (Morocco) - Laboratoire Interdisciplinaire en Ressources Naturelles et en Environnement - Zoubida Mghazli

Ecole Nationale d'Ingénieurs de Tunis (Tunisia) - Laboratoire de Modélisation en Hydraulique et Environnement - Rachida Bouhlila

Universidad de Sevilla (Spain) - Department Ecuaciones Diferenciales y Anâlisis Numérico - Tomas Chacon Rebollo

Universitat Politècnica de Catalunya (Spain) - Department of Geotechnical Engineering and Geo-Sciences - Xavier Sànchez Vila

University Centre of KHEMIS MILIANA (Algeria) - Laboratoire de l'Energie et des Systèmes Intelligents - Mohammed Hachama

Ecole Mohammadia d'Ingénieurs (Morocco) - LERMA - Rajae Aboulaich

Ecole Nationale d'Ingénieurs de Tunis (Tunisia) - Laboratoire de Modélisation Mathématique et Numérique dans les Sciences de l'Ingénieur - Hend Ben Ameur

Duration: Jan 2012 - Dec 2015

The management of water resources is a problem of great importance in all countries, and is particularly acute around the Mediterranean sea. The goal is to find a reasonable balance between these resources and demand while preserving the quality of water. Towards this goal it is essential to understand and simulate flow and transport in the subsurface. The science corresponding to this topic is hydrogeology. Since models become more and more complicated and quantitative answers must be given, numerical modeling become more and more sophisticated and mathematicians must also be involved. This project brings together hydrogeologists and mathematicians from France, Spain, Algeria, Morocco and Tunisia in order to develop, analyze, and validate numerical methods for several problems arising from modeling flow and transport in the subsurface. The emphasis is put on direct nonlinear problems (air-water flow, density driven flow related to salinization, transport with chemistry) and on inverse problems.

8.4.8. Joint supervision of M. Oumouni's PhD (Morroco)

Participants: Jocelyne Erhel, Mestapha Oumouni.

Program: International joint supervision of PhD agreement

Title: Méthodes numériques et leur analyse pour la résolution des équations de l'écoulement et de transport en milieux poreux hétérogènes et aléatoires

Inria principal investigator: Jocelyne Erhel

International Partner (Institution - Laboratory - Researcher): University Ibn Tofail - Faculté des Sciences de Kénitra (Morocco) - Zoubida Mghazli

Duration: Jan 2009 - June 2013

Abstract: see 6.3.3 .

8.4.9. Joint supervision of A. Abdelmoula's PhD (Tunisia)

Participants: Amine Abdelmoula, Bernard Philippe.

Program: International joint supervision of PhD agreement

Title: Résolution de problèmes inverses en géodésie physique

Inria principal investigator: Bernard Philippe

International Partner (Institution - Laboratory - Researcher): Ecole Nationale d'Ingénieurs de Tunis - LAMSIN (Tunisia) - Maher Moakher

Duration: 2005 - 2013

Abstract: The objective is to compute a set of point-mass which generate an a priori given gravitational field (see 8.4.7 , 8.4.3).

8.4.10. Joint supervision of S. Khalfallah's PhD (Tunisia)

Participants: Jocelyne Erhel, Sinda Khalfallah.

Program: International joint supervision of PhD agreement

Title: Contribution à l'analyse mathématique et numérique de quelques problèmes issus de l'hydrogéologie

Inria principal investigator: Jocelyne Erhel

International Partner (Institution - Laboratory - Researcher): Ecole Nationale d'Ingénieurs de Tunis - LAMSIN (Tunisia) - Amel ben Abda

Duration: 2010 - 2014

Abstract: The objective is to solve data completion problems applied to hydrogeology (see 8.4.7 , 8.4.3).

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Emmanuel Kamgnia, University of Yaoundé, 2 months, March-April 2013
- Nabil Nassif, American University of Beirut, 3 weeks, July 2013, November 2013, December 2013
- Stratis Gallopoulos, Uiversity of Patras, 1 week, August 2013
- Ahmed Sameh, University of Purdue, 1 week, August 2013
- Mohamad Muhieddine, Libanese University, 2 weeks, June 2013
- Lamia Guellouz, University of Tunis, 1 week, December 2013

8.5.2. Internships (Joint supervision of Ph-D students

- Louis-Bernard Nguenang, University of Yaoundé, 4.5 months, March-July 2013

- Mestapha Oumouni, University of Kenitra, 3 months, March-June 2013
- Marwen ben Refifa, University of Tunis, 3 months, April-July 2013
- Salwa Mansour, Lebanese University, 7 months, Feb-Aug 2013

8.5.3. Visits to International Teams

- Édouard Canot, ENIT Tunis, Tunisia, 1 week, February 2013 (project HYDRINV)
- Jocelyne Erhel and Géraldine Pichot, UPC Barcelona, Spain, 1 week, April 2013 (project H2MNO4)
- Édouard Canot and Salwa Mansour and Bernard Philippe, Beirut, Lebanon, 1 week, May 2013 (project MODNUM)
- Édouard Canot, ANCBA Buenos Aires, Argentina, 2 weeks, November 2013 (project ARPHY-MAT)
- Bernard Philippe, Yaoundé, Cameroon, 1 week, December 2013 (project MOMAPPLI)

STEEP Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

In 2012, we started an informal collaboration with Serge Fenet from the University of Lyon (LIRIS lab), which among others accompanied Brindusa Smaranda's MSc thesis. In 2013, a project we submitted to the IXXI Complex Systems Institute of the Rhône-Alps region, together with the CERAG lab, was accepted. The project is about modeling and data mining applied to territorial ecology.

8.2. National Initiatives

8.2.1. ANR

CITiES (*Calibrage et valIdation de modèles Transport - usagE des Sols*)
Program: "*Modèles Numériques*" 2012, ANR
Duration: 2013 – 2016
Coordinator: Emmanuel Prados (STEEP)
Other partners: LET, IDDRI, IRTES-SET ("Systemes and Transports" lab of Univ. of Tech. of Belfort-Montbéliard), IFSTTAR-DEST Paris (formerly INRETS), LVMT ("*Laboratoire Ville Mobilité Transport*", Marne la Vallée), VINCI (Pirandello Ingenierie, Paris), IAU Île-De-France (Urban Agency of Paris), AURG (Urban Agency of Grenoble), MOISE (Inria project-team)
Abstract: Calibration and validation of transport and land use models.

8.2.2. FRB (Fondation pour la Recherche sur la Biodiversité)

ESNET (Futures of ecosystem services networks for the Grenoble region)
Program: "Modeling and Scenarios of Biodiversity" flagship program, Fondation pour la Recherche sur la Biodiversité (FRB). This project is funded by ONEMA (*Office National de l'Eau et des Milieux Aquatiques*).
Duration: 2013 – 2016
Coordinator: Sandra Lavorel (LECA)
Other partners: EDDEN (UPMF/CNRS), IRSTEA Grenoble (formerly CEMAGREF), PACTE (UJF/CNRS), ERIC (Lyon 2/CNRS)
Abstract: This project explores alternative futures of ecosystem services under combined scenarios of land-use and climate change for the Grenoble urban area in the French Alps. In this project, STEEP works in particular on the modeling of the land use and land cover changes, and to a smaller extent on the interaction of these changes with some specific services.

8.3. International Initiatives

8.3.1. Participation In other International Programs

TRACER (*TRANUS, analyse de la calibration et des erreurs, retours sur Grenoble et Caracas*)
Program: Ecos-NORD
Duration: 2012 – 2014
Coordinator: Mathieu Saujot (IDDRI)
Other partners: University of Caracas (Venezuela)

8.4. International Research Visitors

8.4.1. Visits of International Scientists

In July 2013, we received a one week visit by Professor Tomás de la Barra (University of Caracas and Modelistica) and by Dr. Brian Morton (University of North Carolina), the two leading experts of the TRANUS model (de la Barra developed the model). We organized a 3-day training course on the TRANUS model around these visits, with attendees from various labs in France and Belgium as well as an extended visit to the urban planning agency of the Grenoble region.

8.4.2. Internships

Participant: Thomas Capelle.

Subject: Calibration of the TRANUS land use module

Date: from Apr 2013 until Aug 2013

Institution: Universidad de Chile, Santiago

Participant: Lara Antonela Colombo.

Subject: Optimization based formulation of local material flow assessment

Date: from Mar 2013 until Aug 2013

Institution: Universidad National de Rosario (Argentina)

Participant: Martin Crespo.

Subject: Parameter optimization algorithm for a Transport/land use model via adjoint method.

Date: from Jul 2012 until Jan 2013

Institution: Universidad National de Rosario (Argentina)

Participant: Laurent Gilquin.

Subject: Sensitivity analysis of TRANUS

Date: from Mar 2013 until Aug 2013

Institution: ENS Lyon

Participant: Jakub Krzywda.

Subject: Data mining for ecological accounting and material flow analysis

Date: from Mar 2013 until Aug 2013

Institution: Poznan University of Technology (Poland)

Participant: Brindusa Smaranda.

Subject: Data mining for ecological accounting and material flow analysis

Date: from Mar 2013 until Aug 2013

Institution: Erasmus Mundus on Data Mining Knowledge Management (Lyon and Barcelona)

Participant: Pablo Virgolini.

Subject: Optimization based formulation of local material flow assessment

Date: from Mar 2013 until Aug 2013

Institution: Universidad National de Rosario (Argentina)

BIOCORE Project-Team

8. Partnerships and Cooperations

8.1. National initiatives

8.1.1. National programmes

- **ANR-GeMCo:** The objective of this project is to do model reduction, experimental validation, and control for the gene expression machinery in E. coli. The project is funded by ANR (2010-BLAN-0201-01) and coordinated by M. Chaves.
- **ANR-Facteur 4:** The objective of this project to propose non OGM strain of microalgae with enhanced performance. BIOCORE is involved in the directed selection of microalgae with interesting properties from an industrial point of view. The theory of competition is used to give a competitive advantage to some species. This competitive advantage can be provided by an online closed loop controller.
- **ANR-Purple Sun:** The objective of this project (ANR-13-BIME-004) is to propose study and optimize a new concept consisting in coupling the production of microalgae with photovoltaic panels. The main idea is to derive the excess of light energy to PV electricity production, in order to reduce both the phenomena of photoinhibition and process overwarming.
- **ANR-FunFit:** The objective of this project is to develop a trait-based approach linking individual fitness of fungal plant pathogens to ecological strategies. The idea is to derive eco-epidemiological strategies from fitness optimization in colonized environments and during colonization, as well as understanding the coexistence of sibling species. This project is co-coordinated by F. Grognard.
- **SIGNALIFE:** Biocore is part of this Labex (scientific cluster of excellence) whose objective is to build a network for innovation on Signal Transduction Pathways in Life Sciences, and is hosted by the University Nice Sophia Antipolis.
- **RESET:** The objective of this project is to control the growth of *E. coli* cells in a precise way, by arresting and restarting the gene expression machinery of the bacteria in an efficient manner directed at improving product yield and productivity. RESET is an “Investissements d’Avenir” project in Bioinformatics (managed by ANR) and it is coordinated by H. de Jong (Ibis, Inria)
- **FUI-Salinalgue:** The objective of this project is to take benefit of endemic microalgae species in areas of high salinity (previously used to produce salt) to produce both biofuel (either lipid based or methane) and co products. BIOCORE is in charge of lab scale experiments and of the modelling of the process.

8.1.2. Inria funding

- **ColAge:** The goal of this joint Inria-INSERM consortium is to study bacterial growth and aging by using mathematical modelling and computational predictions to design and implement a *de novo* biological system. This Large-Scale Initiative Action is partly funded by Inria and supervised by H. Berry (Beagle, Inria).

8.1.3. INRA funding

- **Propagules:** INRA-SPE is funding the project “Effet de différentes composantes de la pression de propagules sur le succès d’établissement d’un auxiliaire de lutte biologique" in which BIOCORE is a partner with INRA Sophia Antipolis (2011-2013).
- **Dynamique spatiale:** INRA-SPE is funding the project “Intégration des approches comportementales et démographiques de la dynamique spatiale des populations d’insectes” in which Biocore is a partner with INRA Sophia Antipolis and Agrocampus Ouest (2012-2014).

- **Take Control:** This project, "Deployment strategies of plant quantitative resistance to take control of plant pathogen evolution," is funded by the PRESUME call of the SMAcH INRA metaprogram. BIOCORE is a partner together with INRA PACA (Sophia Antipolis and Avignon) and INRA Toulouse (2013-2016). This project will provide the major part of the funding for the experiments held for Elsa Rousseau's thesis.

8.1.4. Networks

- **RTP-M3D:** BIOCORE is a participant in the RTP-M3D workgroup (Mathématiques et décision pour le développement durable) that is supported by the "Environment and sustainable growth" department of CNRS. L. Mailleret is one of the co-leaders of M3D.
- **GDR PROBBE:** The objective of this GDR is the development of new biotechnological processes based on microorganisms producing metabolites which can be used as fuel for transportation (lipids, sugars, methane, hydrogen, ...). BIOCORE is taking part mainly in the modelling and control aspects of the processes involving anaerobic bacteria or microalgae.
- **COREV:** BIOCORE is an active participant in the research group COREV (Modèles et théories pour le contrôle de ressources vivantes et la gestion de systèmes écologiques).
- **Seminar:** BIOCORE organizes a regular seminar "Modeling and control of ecosystems" at the station zoologique of Villefranche-sur-Mer, at INRA-ISA or at Inria.

8.2. European Initiatives

8.2.1. FP7 Projects

8.2.1.1. PURE

Title: Pesticide Use-and-Risk reduction in European farming systems with Integrated Pest Management

Type: COOPERATION (ICT)

Instrument: Collaborative Project (CP)

Duration: 2011 - 2014

Coordinator: Françoise Lescourret (INRA Avignon, FR)

Other partners: **Research:** Institut National de la Recherche Agronomique - INRA (FR) Rothamsted Research - RReS (UK) Aarhus University - AU (DK) Julius Kühn Institut - JKI (DE) Stichting DLO - DLO (NL) Wageningen University - WU (NL) Consiglio Nazionale delle Ricerche - CNR (IT) Agricultural Institute of Slovenia - KIS (SLO) James Hutton Institute - JHI (UK) Fondazione Edmund Mach - FEM (IT) Instituto Valenciano de Investigacio- nes Agrarias - IVIA (ES) Institute of Plant Protection - IOR (PL) University of Debrecen - Centre of Agricultural Sciences - UDCAS (HU) Joint Research Centre - Institute for Prospective Technological Studies - JRC-IPTS (EU **Extension:** Knowledge Centre for Agriculture - VFL (DK) Association de Coordination Technique Agricole - ACTA (FR) **Industry:** Bayer Crop Science (DE) BIOTOP (FR) Natural Plant Protection (FR) Burkard Manufacturing Co Ltd (UK) Blgg Bv (NL) **Management:** INRA Transfert (FR)

See also: http://www.pure-ipm.eu/project

Abstract: The overall objective of PURE is to provide practical integrated pest management (IPM) solutions to reduce dependence on pesticides in selected major farming systems in Europe, thereby contributing to a reduction of the risks to human health and the environment and facilitating the implementation of the pesticides package legislation while ensuring continued food production of sufficient quality.
PURE will provide IPM solutions and a practical toolbox for their implementation in key European farming systems (annual arable and vegetable, perennial, and protected crops) in which reduction of pesticide use and better control of pests will have major effects. In that project, L. Mailleret develops modeling approaches dedicated to the optimization of plant protection methods relying on biological control and integrated pest management.

8.2.2. Collaborations with Major European Organizations

Imperial college, Department of Chemical engineering (UK)

Modelling and optimization of microalgal based processes.

Imperial College, Centre for Synthetic Biology and Innovation, Dept. of Bioengineering (UK)

Study of metabolic/genetic models

University of Stuttgart, Institute for Systems Theory and Automatic Control (D)

Identification of gene networks

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Inria informal international partners

Universidad Técnica Federico Santa María, Departamento de Matemática, Valparaíso, Chile
Universidad de Chile, Departamento de Matemáticas, Ñuñoa Santiago, Chile
Ben-Gurion University of the Negev, Microalgal Biotechnology Laboratory, Beer Sheva, Israel
Center for Environmental Technology and Engineering, Massey University , Palmerston North, New Zealand.

8.3.2. Participation In International Programs

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

8.4. International Research Visitors

8.4.1. Visits of International Scientists

We only list the visitors that stayed more than 2 days in our project-team or presented a seminar

- Claude Aflalo (Ben Gurion University of the Neguev, Israel), 1 week;
- Andrei Akhmetzhanov (Université de Montpellier II, F), 1 week;
- Gonzalo Ruiz (Catholic University of Valparaiso, Chile), 2 days;
- David Jeison (University of La Frontera, Chile), 2 days;
- Benoit Guieysse (Massey University, New Zealand), 1 day;
- Quentin Béchet(Massey University, New Zealand). 6 days;
- Yves Dumont (CIRAD, F), 1 week;
- Andreas Kremling (TU Munchen, Germany), 1 day;
- Leon Glass (McGill University, Canada), 3 days;

8.5. Project-team seminar

BIOCORE organized a 3-day seminar in October in Tourrettes-sur-Loup. On this occasion, every member of the project-team presented his/her recent results and brainstorming sessions were organised.

An additionnal 2-day seminar was dedicated to modelling and control of microalgae.

CARMEN Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- Project Modélisation pour les données multimodales (2012-2015) funded by the Conseil Regional Aquitaine. Coordinator J.-F. Aujol (Pr University Bordeaux 1). The PhD of G. ravon is funded within this project: 3D reconstruction by inverse problem in cardiac optical mapping.

8.2. National Initiatives

8.2.1. IHU LIRYC

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

- For 2013: the salary of M. Potse, member of Carmen, is payed by the LIRYC.
- The LIRYC gives us a partial financial support. In 2013: support to go to the conference IEEE EMBC in Osaka, Japan (http://embc2013.embs.org), and partial support for a PhD jury.
- For 2012-2015: 1/2 PhD thesis associated to the project *Modélisation pour les données multimodales* (see section Regional Initiaves).

8.2.2. ANR HR-CEM

In 2013, we obtained a financial support for the project "High Resolution Cardiac Electrophysiology Models: HR-CEM" within the call for project « Modèles Numériques » of the ANR.

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

It is an international project that involves three partners, Inria (coordinator), IHU LIRYC, and UMI-CRM at Montréal (Canada). The project has some external collaborators in Univ. Nantes, Univ. Pau and BCAM (Basque Center for Applied Math) at Bilbao (Spain).

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

8.2.3. AMIES – Medic Activ

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

8.2.4. ANR Labcom CardioXcomp

We are participant in the ANR Labcom project between Inria and the society Notocord (www.notocord.com). At Inria, the proejct is leaded by JF. Gerbeau from the Reo team and we participate to the study and developpment of cardiac electrophysiology models suited to the context of the proejct.

The project is in its starting phase in 2013: the objective of the first 6 months is to define precisely the nature and objectives of the common laboratory between Inria and Notocord. A contract is planned to be signed after these 6 months, and the ANR financial support to be granted at that time.

8.3. European Initiatives

8.3.1. Collaborations with Major European Organizations

Partner 1: Computational Biology Group, Department of Computer Science, Oxford University (United Kingdom).

Our work with the computational biology group concerns the development of multi-scale models of the drugs and their effect on the electrical activity of the heart. The main goal is to assess the drug-induced effects on the electrocardiogram, using a computational model describing the physiology from ion channel to body surface potentials.

Partner 2: BCAM (Basque Center for Applied Mathematics), Bilbao (Spain).

We collaborate with L. Gerardo Giorda, research fellow at the BCAM on: the development of our new sopftware CEPS, the design and study of new domain decomposition methods suited to our cardiac electrophysiology models, the evaluation of some sensitivity analysis issues in cardiac electrophysiology.

Partner 3: Department of Experimental Cardiology, Academic Medical Center, University of Amsterdam (Netherland).

With the groups of Pr J. de Bakker and of Dr R. Coronel, we work on the arythmias related to degradations of the tissues (due to aging or cardiomyopathies), combined with diseases of the ionic channels, qsuch as the Brugada syndrome.

8.4. International Initiatives

8.4.1. Inria International Partners

8.4.1.1. Informal International Partners

- Collaboration with the Pr. Y. Bourgault (http://aix1.uottawa.ca/ ybourg/personal.html) from the department of Mathematics and statistics of the University of Ottawa (Canada).

  Subject: models and numerical methods for cardiac electrophysiology.

  Support: This collaboration has been supported by the ANR project Momme (ANR-JCJC-07-0141), the Region des Pays de la Loire and the Natural Sciences and Engineering of Research council of Canada (NSERC). From 2013, it is supported by the ANR project HR-CEM. Y. Bourgault had an "invited researcher" position at Inria for two months for October and November, 2013.

8.4.2. Inria International Labs

- LIRIMA: Equipe Problèmes Inverses et Contrôle (EPIC), University Tunis Al Manar et Laboratoire de Modélisation Mathématique et Numérique dans les Sciences de l'Ingénieur (LAMSIN), Tunisia.

  The EPIC team has an important experience in dealing with ill-posed inverse problems for static and evolution problems. The goal of this collaboration is to apply the methods developed in this team to inverse problems in electrocardiography.

  This collaboration is mainly supported by the international laboratory LIRIMA.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Y. Bourgault, Pr. University of Ottawa, Department of mathematics and statistics. Invited researcher for 2 months, 1/10/2013 to 30/11/2013.

  Comparison between the monodomain and bidomain models for cardiac electrophysiology, and design of an optimalmonodomain aprroximation of the nidomain equations.
- In July, 2013, B. Smaill, Professor at the Auckland Bioengineering Institute (ABI) and leader of the Cardiac Electrophysiology group, and M. Nash, Professor and Associate Director of the ABI, visited the LIRYC Institute, including a visit to our team Carmen and rich exchanges about our approaches of modelling and the role of experimental data.
- Mohamed Jebalia, Assistant professor, ENIT (Tunisia), researcher from the LAMSIN, May toJuly 2013.

8.5.1.1. Internships – Visiting PhD Students

- Mohammed Addouche, March 2013.

  Institution: University of Tlemcen (Algeria)

  Subject: On using factorisation methods for the quasistatic inverse problems of electrocardiology.
- Najib Fiakl, PhD student, December 2013.

  Institution: University of Rabat (Morroco)

  Subject: Study of the uncertainties on the thoracic electrical conductivities on the resolution of the direct problem of electrocardiology.
- Wajih Mbarki, November to December 2013.

  Institution: Université El Manar of Tunis, Tunisia

  Subject: Theoretical and numerical study of the Purkinje-muscle coupling in cardiac electrophysiology.
- Jamila Lassoued, September 2013.

  Institution: ENIT of Tunis, Tunisia

  Subject: application of model reduction techniques to the inverse problems in cardiac electrophysiology.
- Laura Bear, October to December 2013, was co-localized between the LIRYC and Inria.

  Institution: University of Auckland (New Zealand), Auckland Bioengineering Institute

  Subject: Laura started to work on our inverse solutions for the cardiac electrical imaging problem using the datasets obtained during the first two years of her PhD at the Auckland Bioengineering Institute. The objective is to investigate the possibility and limitations of cardiac non-invasive electrical imaging.

8.5.1.2. Internships

- Hamed Bourenane, July to August 2013

  Institution: Student in medicine at the University Bordeaux Segalen

  Subject: Segmentations of CT-scan images from the CardioInsight system including fat, bones, lungs, etc.
- Valentin heisel, June to September 2013

  Institution: ENSEIRB-MATMECA

  Subject: Developped a fortran module to account for 2nd order solvers in cardiac electrophysiology and compared various solvers for cellular electrophysiology.
- Nina Le Devehat, June to July 2013

  Institution: First year of University Bordeaux I, supported by the programme “stages d’excellence” from the University

Subject: She studied the modelling of cellulat electrophysiology by the Vanderpol equations.

- Abdessamad Sobhi, July to September 2013

  Institution: ENSEIRB-MATMECA

  Subject: Inverse problem of cardiac electrophysiology.

- Thibaut Vandromme, June to September 2013

  Institution: ENSEIRB-MATMECA

  Subject: Fast solvers for cardiac electrophysiology, continued the work in SOFA of a previous trainee (N. Claude in 2012).

- Bastien Verot, June to September 2013

  Institution: ENSEIRB-MATMECA

  Subject: Numerical approximation of the microscopic bidomain equations of cardiac electrophysiology in a simplified linear context.

- Mathias Cassonnet, January 2013

  Institution: secondary school pupil

  Subject: Trainee for observation only

- Alexandre Lourenco Peirera, January 2013

  Institution: secondary school pupil

  Subject: Trainee for observation only

8.5.2. Visits to International Teams

- Y. Coudière visited the GIREF (« Groupe Interdisciplinaire de Recherche en Éléments Finis »), June, 2013.

DRACULA Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

Projects coordination by a member of Dracula

- ANR (jeunes chercheurs) ProCell "Mathematical Methods for Erythropoiesis Modelling: from Proteins to Cell Populations", 2009-2013.
  Participants: Samuel Bernard, Fabien Crauste [Coordinator], Olivier Gandrillon, Laurent Pujo-Menjouet, Vitaly Volpert.
- ANR (jeunes chercheurs) MADCOW "Modelling amyloid dynamics and computation output work: applications to Prion and Alzheimer's disease", 2008-2013.
  Participants: Samuel Bernard, Fabien Crauste, Laurent Pujo-Menjouet [Coordinator], Vitaly Volpert.
- ANR BIMOD "Hybrid models of cell populations. Application to cancer modelling and treatment", 2010-2014.
  Participants: Mostafa Adimy, Fabien Crauste, Vitaly Volpert [Coordinator].
- ANR STOCHAGENE "Role of the chromatin dynamics on the stochasticity in gene expression in higher eukaryotic cells", 2011-2015.
  Participant: Olivier Gandrillon [Coordinator].

Collaboration in other projects

- ANR RPIB PrediVac "Innovative modeling tools for the prediction of CD8 T cell based vaccine efficacy", 2013-2015. Partners: U1111 Inserm (J. Marvel, coordinator), Dracula, Altrabio (small company), CoSMo (small company). For Dracula, the budget in 2013 is 88 keuros, including two one-year post-doc positions, recruited in February (Floriane Lignet) and in April (Sotiris Prokopiou).
- Thomas Lepoutre participates in the ANR (jeunes chercheurs) MODPOL (head Vincent Calvez (ENS Lyon)) "Cell polarization modeling", 2011-2015.
- Thomas Lepoutre is a member of the ANR KIBORD (head L. Desvillettes) dedicated to "kinetic and related models in biology". 2012-2016.
- Olivier Gandrillon participates in the ANR (Investissement d'Avenir) Iceberg (head Gregory Batt (Inria)) "From population models to model populations: single cell observation, modeling, and control of gene expression".

8.2. European Initiatives

8.2.1. Collaborations with Major European Organizations

- University of Valladolid (Spain). Collaboration with Oscar Angulo, Juan Carlos Lopez-Marcos and Miguel Ange Lopez-Marcos, on the analysis of an age-structured model describing erythropoiesis, and its numerical resolution.
- Karolinska University Hospital of Stockholm (Sweden). Collaboration with Peter Arner, Mats Eriksson, Erik Arner, Mikael Rydén and Kirsty L. Spalding, on the study of dynamics of human adipose lipid turnover in health and metabolic disease.

8.3. International Initiatives

8.3.1. Inria Associate Teams

8.3.1.1. Modeling leukemia

Title: Modeling quiescence and drug resistance in Chronic Myeloid Leukemia

Inria principal investigator: Thomas Lepoutre

International Partner (Institution - Laboratory - Researcher):

University of Maryland (United States), Center for Scientific Computation and Mathematical Modeling.

Leukemia is the most famous disease of the blood cell formation process (hematopoiesis). Chronic myeloid leukemia results in a uncontrolled proliferation of abnormal blood cells. As the hematopoiesis involves stem cells (not accessible to observations), mathematical modeling is here a great tool to test hypothesis. We will join the expertise of Inria team DRACULA specialized on the modeling of blood cell formation and the Center for Scientific Computation and Applied Mathematical Modeling (CSCAMM, University of Maryland, College Park). The theoretical and modeling experience of team DRACULA and the numerical expertise combined with the links with experimentalists of members of CSCAMM will allow us to study deeply evolution of leukemia. We will especially focus on the behavior of leukemic stem cells and their possibility of becoming quiescent (dormant). Then we will study (using the knowledge obtained on leukemic stem cells) the phenomenon of drug resistance and its propagation over time and finally the mechanisms of multidrug resistance.

8.3.2. Participation In other International Programs

8.3.2.1. M3CD

Program: Euromediterranean 3+3

Title: Mathematical Models and Methods in Cell Dynamics

Inria principal investigator: Mostafa Adimy

International Partners (Institution - Laboratory - Researcher):

Institut Pasteur de Tunis (Tunisia) - Slimane Ben Miled

Consiglio Nazionale delle Ricerche- Istituto per le Applicazioni del Calcolo Mauro Picone (Italy) - Istituto per le Applicazioni del Calcolo Mauro Picone - Roberto Natalini

Cadi Ayyad University (Morocco) - Populations Dynamics Laboratory - Moulay Lhassan Hbid

Duration: Jan 2012 - Dec 2015

The aim of this project is to establish a network working on mathematical and computational models in cell dynamics. This network consists of five groups which have already established close bilateral relations. Those are the Inria teams Bang and Dracula in Paris and Lyon, France, the team IAC-CNR in Rome, Italy, the laboratory of Mathematical Population Dynamics (LMDP) from the university of Marrakech in Morocco, and the team of Mathematical Modelling and Computing in Biology (MoMinBi) from the Pasteur Institute in Tunis. Modelling cell dynamics and related processes is one of the main subjects of interest for the partners for many years. The issues addressed in the present project can be divided into five parts:

1) Analysis of structured models in cell population dynamics ;

2) Dynamics of normal and pathological haematopoiesis ;

3) Dynamics of Darwinian adaptation, in particular by drug resistance in competing cell or parasite populations, healthy and pathological / pathogenic (cancer, bacteria, parasites) ;

4) Dynamics of chemical and physical determinants of filament formation and intracellular spatial organisation of the cytoskeleton conformation ;

5) Coupling of the molecular mechanisms of control of the cell division cycle and cell proliferation.

The first part has been developed for many years by all the partners in this project. It tackles issues related to cell dynamics and biological mechanisms, physiological and chemical properties of cells and cell populations. The other four aspects of the project have been studied in the past by the Inria teams "Bang" and "Dracula" (**2**, **4**, **5**) and the IAC-CNR team (Rome), or are a rapidly emergent theme in Bang (**3**, cell Darwinism) with possible and natural connections with the other teams, in particular IAC-CNR and MoMinBi in Tunisia. Themes (**2**, **4**, **5**) have also been initiated (for their fundamental part) in a recent collaboration between Dracula and the teams from Morocco and Tunisia. The objectives of the present project are to pursue and deepen the study of cell proliferation dynamics and cellular mechanisms using structured models that take into account some new structure variables. The development of computer models will also be investigated in this project. Training and research activities related to these topics are currently underway between the Inria teams and the teams from Marrakech and Tunis, and between the Italian team and Bang. Two co-supervised theses are currently in progress, a Spring school on this subject will be organised by the partners in 2012. This program comes at the right time to give a new impetus to this collaboration. It will lead to the establishment of a multi-site laboratory expertise in population dynamics modelling, especially in cellular dynamics. This project will also allow the teams from Morocco and Tunisia to use their knowledge on mathematics applied to cell dynamics.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

Evgenia Babushkina

Subject: Numerical simulations of blood flows and blood coagulation

Date: from Apr 2013 until Jul 2013

Institution: St. Petersburg State University (Russia (Russian Federation))

8.4.1.2. Visits of other international scientists

- Malay Banerjee - Kanpur, India - from May 2013 until June 2013.
- Dana-Adriana Botesteanu - University of Maryland, USA - from May 2013 until June 2013
- Peter Kim - University of Sydney, Australia - from January 2013 until February 2013
- Nemanja Kosovalic - York University, Canada - March 2013
- Michael Mackey - McGill University, Canada - February 2013
- Jianhong Wu - York University, Canada - March 2013

M3DISIM Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

The team is part of the Mechanics and Living Systems Initiative (Opération Mécanique et Systèmes du Vivant), a joint operation – focused on biomechanical modeling – between the LadHyx and LMS labs (CNRS and Ecole Polytechnique), and Inria.

7.2. European Initiatives

7.2.1. FP7 Projects

7.2.1.1. VPH-Share

Title: VPH-Share
Type: COOPERATION
Defi: Towards sustainable and personalised healthcare
Instrument: Integrated Project
Objectif: Virtual Physiological Human
Duration: March 2011 - February 2015
Coordinator: Univ. Sheffield (UK)
Other partners: Cyfronet (Cracow), University College London, Istituto Ortopedico Rizzoli (Bologna), NHS, IBM Israel, Univ. Auckland, Agència d'Informació, Avaluació i Qualitat en Salut (Barcelona), Biocomputing Competence Centre (Milano), Universitat Pompeu Fabra (Barcelona), Philips Research, TUE (Eindhoven), Sheffield Teaching Hospitals, Atos Origin (Madrid), the Open University (UK), Univ. Vienna, King's College London, Empirica (Bonn), Fundació Clínic (Barcelona), Univ. Amsterdam
See also: http://vph-share.org/
Abstract: VPH-Share aims at developing the organisational fabric (the infostructure) and integrate the optimised services to expose and share data and knowledge, to jointly develop multiscale models for the composition of new VPH workflows, and to facilitate collaborations within the VPH community. Within this project, the Macs team is in charge of developing some high-performance data assimilation software tools.

7.2.1.2. VP2HF

Title: Computer model derived indices for optimal patient-specific treatment selection and planning in Heart Failure
Type: COOPERATION
Defi: ICT for Health, Ageing Well, Inclusion and Governance
Instrument: Specific Targeted Research Project
Objectif: Virtual Physiological Human
Duration: October 2013 - September 2016
Coordinator: King's College London (UK)
Abstract: Heart failure (HF) is one of the major health issues in Europe affecting 6 million patients and growing substantially because of the ageing population and improving survival following myocardial infarction. The poor short to medium term prognosis of these patients means that, treatments such as cardiac re-synchronisation therapy and mitral valve repair can have substantial impact. However, these therapies, are ineffective in up to 50% of 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.

MASAIE Project-Team

6. Partnerships and Cooperations

6.1. International Initiatives

6.1.1. Inria International Labs

MASAIE is the Inria EPI partner of GRIMCAPE (LIRIMA). It also has strong collaboration with M2IPE2S (LIRIMA). Two PhD students (Diaby and Diouf) are members of M2IPE2S.

G. Sallet has participated to "Journées du LIRIMA", Rabat, Morocco, September 17th-19th, 2013.

6.1.2. Participation In other International Programs

6.1.2.1. CAPES-COFECUB

MASAIE is the french correspondent in a cooperation program with Brazil. This project, funded by CAPES-COFECUB, "new methods in epidemiology and early detection of events" has begun in January 2011.
A Brazilian network has been built in 2011, and it is composed of

- FGV (Fundação Getulio Vargas) Rio de Janeiro. Principal investigator: Jair Koiller.
- UFF (Universidade Federal Fluminense) Rio de Janeiro. Principal investigator: Max Oliveira de Souza.
- UNICAMP (Universidade Estadual de Campinas) Campinas. Principal investigator: Hyun Mo Yang.
- Fondation Oswaldo Cruz (Fiocruz, Rio). Principal investigator: Claudia Codeço.
- IMPA Rio de Janeiro. Principal investigator: Jorge Zubelli.

6.1.2.2. PAES-UEMOA

A research project on Bilharzia was deposed November 2, 2012, by the universities of Ouagadougou and Gaston Berger of Saint-Louis, in the framework of PAES(projet d'appui à l'enseignement supérieur) of UEMOA (Union Economique et Monétaire de l'Afrique de l'Ouest). MASAIE is an important component of this network. This project has been accepted July, 1, 2012 and funded with 30 000 000 CFA (XOF) ($\approx$ 45 000 euro).
The Phd thesis of Lena Tendeng and M. Diaby (MASAIE and UGB St Louis) are part of this project.

6.2. International Research Visitors

6.2.1. Visits of International Scientists

Jorge Zubelli, professor at IMPA, Rio de Janeiro, Brazil, december 2013. We started a collaboration on the analysis of PDE models for stage-structured intra-host models.

6.2.2. Visits to International Teams

In the framework of CAPES-COFECUB, G. Sallet has visited FGV and UFF (Rio de Janeiro) from March 2 to March 11, and from November 4 to November 16, 2013. A. Iggidr has visited FGV and UFF (Rio de Janeiro) and UNICAMP (Sao Paulo) from April 19 to May 12 and from October 22 to November 12, 2013.

MODEMIC Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. Numev

Within the Labex Numev (Solutions Numériques, Matérielles et Modélisation pour L'Environnement et le Vivant [6]), the team is the coordinator since 2012 of a working group on Modeling and numerical probabilities for ecology and biology with the team EPS of I3M (Univ. Montpellier 2) [7].

7.1.2. LBE

An new interlab seminar about the modeling of bioprocesses has been launched in July 2013 under the responsibility of J. Harmand, involving Biocore and Modemic Inria project-teams [8].

7.2. National Initiatives

7.2.1. ANR project "DISCO"

DISCO (Multi-scale modeling bioDIversity Structure COupling in biofilms) is a project funded by the ANR SYSCOMM since the end of 2009, that ended in May 2013. Modemic has been the coordinator and other partners were Irstea LISC (Clermont-Ferrand), Irstea HBAN (Antony), Inra LBE (Narbonne) and CNRS/UMPC LPMTC (Paris VI). The objectives were to develop and study computational and mathematical models of biofilm dynamics, taking into account the biodiversity (distribution of bacteria species) and the spatial structure. The project had a strong multi-disciplinary dimension, gathering specialists of IBM study and reduction techniques, mathematical analysis of ecosystems modeling, multi-scale modeling of complex structures and dynamics, wastewater engineering and biodiversity measurements through DNA fingerprints, and solid waste biodegradation and microscopic biofilm structure imaging. During the project, several kinds of models (individual-based up to deterministic continuous) have be developed and confronted to experimental data at both micro and macroscopic scales. For the closing of the projet, the team has organized a one day meeting in Paris, combining a project restitution and and international workshop [9].

7.2.2. RNSC project "MnMs"

This year, a partial support of the continuation of the ANR DISCO has been been funded for two years by the RNSC (National Network on Complex Systems). The MnMs (Numerical Models for Microbial ecosystems) project [10] aims at studying how to articulate existing models (discrete, continuous, deterministic, stochastic...) in a multi-scale framework with interactions between various scales. The team is the coordinator and the other partners are Irstea LISC (Clermont-Ferrand) and CNRS/UMPC LPMTC (Paris VI).

We organized a joint seminar with the project DyLeRBio of the RNSC (M. Desroches, Sisyphe/Mycenae projet-team) in Montpellier (September 30, October 1-2 2013) [11].

[6] http://www.lirmm.fr/numev
[7] http://www-sop.inria.fr/members/Fabien.Campillo/gt-modelisation/
[8] https://sites.google.com/site/journeesthematiquesdulbe/home
[9] https://sites.google.com/site/anrdisco/
[10] http://www-sop.inria.fr/members/Fabien.Campillo/mnms/
[11] http://www-sop.inria.fr/members/Fabien.Campillo/projects/mnms/

7.2.3. Inra-MEM program project "ENOC"

Since 2012, the team is the coordinator of the ENOC project with the LBE lab (Inra Narbonne) [[12]], funded the by Inra meta-program MEM (metagenomics of microbial ecosystems). This two-years project proposes a multidisciplinary approach shared by microbial ecologists and mathematicians for the reverse modeling of metagenomic data for microbial resource management. The final objective is to develop a generic approach for predicting ecosystem performance from an unknown inoculum.

7.2.4. Inra-CEPIA project "New perspectives for the MSCF"

A new project submitted to the Inra Dept. CEPIA, entitled "New perspectives for the Multi-Stage Continuous Fermentor (MSCF): Study of fermentations with disturbances, and development of a control law", in which the Montpellier Units SPO and Mistea are involved has been accepted in 2013 and will last 2 years. It is the continuation of the work made within the CAFE project (see Section 7.4) about the control of a wine fermentation process. The goal of the project is to study the fermentations with addition nitrogen. From the control point of view, we will study the control of both the sugar concentration and the CO_2 production rate in each of the 4 reactors of a MSCF.

7.2.5. CNRS-PEPS project "ASYDE"

The team participates to the CNRS PEPS "ASYDE" (Analyse de systèmes de digesteurs biologiques) launched in 2013 for two years, with the objective to develop tools for the analysis and reduction of the models (flat systems, Lyapunov functions, delayed equations...) in microbial ecology. The project is coordinated by the L2S (CNRS/Supélec, Gif-sur-Yvette), with Modemic, LBE (Inra Narbonne) and MIA (Inra Jouy) as partners.

7.2.6. Inria Project Lab "Algae in Silico"

Modemic is a partner of the proposal of the Inria Project Lab "Algae in Silico" launched by Biocore Inria project-team.

7.3. European Initiatives

7.3.1. FP7 Projects

Program: Food, Agriculture and Fisheries, and Biotechnology (Theme 2)
Project acronym: CAFE
Project title: Computer-Aided Food processes for control Engineering
Duration: 2009-2013
Coordinator: CESAME, UCL (Louvain-la-Neuve, Belgium)
Other partners: Alctra, BIV SA, C-Tech Innovation, Irstea, Consejo Superior de Investigaciones Cientificas (CSIC), Wageningen Univ. and Research centre, Institut des Sciences et Industries du Vivant et de l'Environnement Agro Paris Tech, Inra, Povltavske Mlekarny AS, Psutec SPRL, Societa di Progettazione Elettronica e Software S.C.R.L. SPES, Telstar Technologies SLU, The Univ. of Manchester, Univ. Degli Studi di Roma Tor Vergata, X-Flow BV.
Abstract: This is a Large collaborative project, whose objective is to provide new paradigms for the smart control of food processes, on the basis of four typical processes in the areas of bio-conversion, separation, preservation and structuring (resp. wine making, micro-filtration of food beverages, freeze-drying of lactic acid bacteria and ice cream crystallization. The novelty of the project lies in the capacity of combining PAT (Process Analytic Technology) and sensing devices with models and simulation. The team works on the control of multi-stage bioreactors (for wine making) and the regulation of ice quality (ice cream crystallization).
Web-site: http://www.cafe-project.org/

The CAFE project ended in March 2013 (see deliverables [66], [67], [68]). An industrial conference has been organized by the consortium in February 2013 at Irstea (Antony, France),. During the conference, which representatives of several industries in food processing attended, a live demonstration of the designed control law has been performed.

[12] https://sites.google.com/site/enocprojetreversemodelling/

7.4. International Initiatives

7.4.1. Inria International Partners

7.4.1.1. Declared Inria International Partners

From 2010 to 2012, the Inria associated-team Dymecos (DYnamical Microbial and Environmental eCOSystems) has associated the team with three main partners in Chile: UMR CNRS CMM (Santiago), Math. Dept. of UTFSM (Valparaiso) and EIB-PUCV (Valparaiso). A continuation of this associated-team has been submitted for 2014. Within the Inria CIRIC Center in Chile, the team has co-supervised in 2013 the postdoctoral stay of M. Sebbah (part-time in Chile, part-time in France).

7.4.1.2. Informal International Partners

The team has a long term collaboration with Prof. D. Dochain from CESAME (Univ. Louvain-la-Neuve).

7.4.2. Inria International Labs

Lirima STIC-Mada [[13]] since 2010 (Madagascar). The purpose of the project was to develop land use dynamical models corresponding to plots located on the edge of the forest corridor linking the two national parks of Ranomafana and Andringitra in Madagascar. We use both Markov and semi-Markov models to infer the land-use dynamics. The main contribution was the co-advising of a PhD student, Angelo Raherinirina who defended his thesis in August 2013. This work is done in collaboration with IRD in Madagascar.

Lirima NuWat (Numerics for water treatment research) [[14]] 2013-... (Tlemcen, Algeria and Gamma Team/UMR Mistea). NuWat focuses on the numerical Modeling and simulation of microbial ecosystems and their application in biotechnology with a focus on solutions considered as promising for countries of the Maghreb, for instance in waste-water treatment systems and its reuse in agriculture under semi-arid climates. NuWat handles the two following related topics: (1) the elaboration of numerical hybrid models for simulation of bacterial ecosystems combining discrete models (for small size populations) and continuous models (for large size populations, substrate and environment); (2) the systematic numerical and software development for biotechnology process control.

CIRIC-Chile. The future of our collaboration with Chile within the BIONATURE line is not entirely in our hands and relies much on CIRIC's policy regarding fundamental research. Anyway we shall try to continue our fruitful collaboration in modeling and optimal control within the CIRIC project, and ficus more on transfer applications.

7.4.3. Participation In other International Programs

7.4.3.1. TREASURE (Treatment and Sustainable Reuse of Effluents in semiarid climates)

Program: Euromediterranean 3+3

Title: Treatment and Sustainable Reuse of Effluents in semiarid climates

Inria principal investigator: Modemic (J. Harmand),

Partners: Centre de Biotechnology de Sfax, Department of environmental engineering (Tunisia), Ecole Nationale des Ingénieurs de Tunis, Dept. de Mathématiques (Tunisia), Institut National de la Recherche Agronomique, Dept. EA, MICA et MIA (France), National Research Center, Water Pollution Control (Egypt), Univ. of Patras, Process Control Laboratory (Greece), Univ. of Tlemcen, Automatic control (Algeria), Univ. of santiago de compostella, Environmental engineering (Spain) Université Cadi Ayyad de Marrakech, Faculté des Sciences de Semlalia, Dépt. de Mathématiques (Morocco), Centre National de Recherche sur l'Eau et l'Energie, Université Française d'Egypte (Egypt)

Duration: Jan 2012 - Dec 2015

[13] http://www.Lirima.uninet.cm/index.php/recherche/equipes-de-recherche/stic-mada
[14] https://project.inria.fr/nuwat/

Abstract: The TREASURE network aims at integrating knowledge on the modeling, the control and the optimization of biological systems for the treatment and reuse of wastewater in countries submitted to semi-arid climates under both socio-economical and agronomic constraints within the actual context of global changes. A special focus of the actual project concerns the integration of technical skills together with socio-economical and agronomic studies for the integrated solutions developed within the network to be evaluated and tested in practice in the partner's countries and, as possible as it may be within the context of the actual research network, valorizing these proposed technologies with the help of industrial on site in partners from South.

Web-site: https://project.inria.fr/treasure

7.4.3.2. CIB (Centre Interfacultaire Bernoulli)

A very old collaboration of Inria with ecologists (the COREV network presently animated by R. Arditi) initiated (at the beginning of the 90s) by J-L. Gouzé and C. Lobry within the framework of Comore Inria project-team, pursued then by Mere and Comore raised very recently an important success: the half-year "Mathematics and computer sciences in theoretical ecology" which we co-organize with R. Arditi (associated with D. de Angelis and L. Ginzburg) at the Federal Polytechnical School of Lausanne (Centre Interfacultaire Bernoulli). The organization of this half-year (in July-December 2014) and the preparation of the acts will mobilize a great part of our activity for the coming two years. It should gather around sixty specialists during a half-dozen workshops. If additional funds are obtained from other sponsors we hope to welcome for the totality of the semester half a dozen post-doc.

7.5. International Research Visitors

Imme Van Den Berg (Univ. of Évora, Portugal) from Oct. 2013 until Feb. 2014: Construction, analysis and simulation of population dynamics models.

Nihel Ben Amar (ENIT, Tunis, Tunisia) from September 2013 to October 2013: Bioprocess modeling.

Boumédiène Benyahia (Univ. Tlemcen, Algeria) from January 2013 to October 2013: Bioprocess modelling.

Abdoudramane Guiro (Univ. Ougadougou, Burkina Fasso) from October 2013 to December 2013: Construction, analysis and simulation of dynamical models of populations.

7.5.1. Visits to International Teams

Coralie Fritsch as obtained a grant in the context of the Agreenium program [[15]] to visit Pr. Otso Ovaskainen's mathematical biology group (Univ. of Helsinki) from September to December 2013.

[15] http://www.agreenium.org

NUMED Project-Team

6. Partnerships and Cooperations

6.1. National Initiatives

6.1.1. ANR

Vincent Calvez is head of on ingoing ANR contract on cell mobility.

6.1.2. Competitivity Clusters

Vincent Calvez organized a special semester on mathematical biology within Lyon mathematical in spring 2013. and computer science LABEX Milion.

6.2. European Initiatives

6.2.1. FP7 Projects

6.2.1.1. DDMoRE

Member: Benjamin Ribba.

REO Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

7.1.1.1. ANR Project "M3RS"

Participants: Laurent Boudin, Muriel Boulakia, Céline Grandmont [Principal Investigator], Irène Vignon-Clementel.

Period: 2008-2013.
This project, coordinated by C. Grandmont, aims at studying mathematical and numerical issues raised by the modeling of the lungs.

7.1.1.2. ANR Project "Epsilon"

Participant: Marina Vidrascu [local coordinator].

Period: 2009-2013
This project, coordinated by Jean-Jacques Marigo (LMS-Ecole polytechnique) aims to study Domain decomposition and multi-scale computations of singularities in mechanical structures.

7.1.1.3. ANR Project "EXIFSI"

Participants: Benoit Fabrèges, Miguel Ángel Fernández Varela [Principal Investigator], Mikel Landajuela Larma, Marina Vidrascu.

Period: 2012-2016
The aim of this project, coordinated by Miguel Àngel Fernández Varela, is to study mathematically and numerically new numerical methods for incompressible fluid-sructure interaction.

7.1.1.4. ANR Project "CARDIOXCOMP"

Participants: Muriel Boulakia, Jean-Frédéric Gerbeau [Principal Investigator], Fabien Raphel.

Period: 2013-2013.
This project, coordinated by Jean-Frédéric Gerbeau, is carried out in the framework of a joint laboratory ("LabCom" call of ANR) with the software company NOTOCORD. The focus is the mathematical modeling of a device measuring the electrical activity of cardiomyocytes. The overall objective of CardioXcomp is to enrich NOTOCORD's software with modelling and simulation solutions and provide to pharmacology research a completely new set incorporating state of the art signal processing and numerical simulation.

7.1.1.5. ANR Project "iFLOW"

Participants: Chloé Audebert, Jean-Frédéric Gerbeau, Irène Vignon-Clementel [co-Principal Investigator].

Period: 2013-2017.
This ANR-tecsan, co-managed by Eric Vibert (Paul Brousse Hospital) and Irene Vignon-Clementel, aims at developing an Intraoperative Fluorescent Liver Optimization Workflow to better understand the relationship between architecture, perfusion and function in hepatectomy.

7.2. European Initiatives

7.2.1. FP7 Projects

7.2.1.1. REVAMMAD

Type: PEOPLE

Instrument: Marie Curie Initial Training Network

Duration: April 2013 - March 2017

Coordinator: Andrew Hunter, University of Lincoln (UK)

Partners: See the web site

Inria contact: J-F Gerbeau

Abstract: REVAMMAD is a European Union project aimed at combatting some of the EU's most prevalent chronic medical conditions using retinal imaging. The project aims to train a new generation of interdisciplinary scientists for the academic, clinical and industrial sectors, and to trigger a new wave of biomedical interventions. The role of REO team within this consortium is to propose a mathematical model and a simulation tool for the retina hemodynamics.

7.3. International Initiatives

7.3.1. Inria Associate Teams

Participants: Grégory Arbia, Miguel Ángel Fernández Varela, Jean-Frédéric Gerbeau, Céline Grandmont, Jessica Oakes, Irène Vignon-Clementel [coordinator].

Period: 2008-2013

CARDIO: The aim of this project is to foster the collaboration between the Cardiovascular Biomechanics Research Laboratory (CVBRL) of C.A. Taylor (Stanford University, USA) and colleagues such as Dr. Feinstein, and the project-team REO, through research on cardiovascular and respiratory related topics (boundary conditions for complex flow, patient-specific modeling of congenital heart disease, image-based fluid solid interaction, postprocessing of numerical simulations). The associated team has been extended to other partners: team-project MACS at Inria, the Marsden group at University of California in San Diego and the and the Shadden group at University of California in Berkeley.. CA Figueroa is now at KCL, UK.

7.3.2. Trans-Atlantic Network of Excellence for Cardiovascular Research

Participants: Grégory Arbia, Jean-Frédéric Gerbeau, Irène Vignon-Clementel [correspondant].

Period: 2010-2015

This network, funded by the Leducq fondation, is working on the multi-scale modeling of single ventricle hearts for clinical decision support [3].

7.3.3. German BMBF national project Lungsys II

Participant: Irène Vignon-Clementel.

Period: 2012-2015 "Systems Biology of Lung Cancer "Dynamic Properties of Early Spread and Therapeutic Options". In collaboration with Dirk Drasdo EPI Bang, Inria & Paris 6 UPMC

7.4. International Research Visitors

7.4.1. Internships

- Stephanie Lindsey, PhD student at Cornell University, Aug 2013 - February 2014

[3] http://modelingventricle.clemson.edu/home

SISYPHE Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR project EBONSI: Extended Block-Oriented Nonlinear System Identification

Participants: Boyi Ni, Michel Sorine, Qinghua Zhang.

The main idea of block-oriented nonlinear system identification is to model complex systems with interconnected simple blocks. Such models cover many industrial applications and are simple enough for theoretic studies. In EBONSI we extend classical block-oriented nonlinear models to new model structures motivated by applications, and relax some traditional restrictions on experimental conditions. This international project is jointly funded by the French ANR and the Chinese National Natural Science Foundation (NSFC) from 2011 to 2014. The partners are SISYPHE (project leader), the Centre de Recherche en Automatique de Nancy (CRAN), and the Laboratory of Industrial Process Monitoring and Optimization of Peking University.

8.1.2. ANR project 0DEFECT: On-board fault diagnosis for wired networks

Participants: Mohamed Oumri, Michel Sorine, Qinghua Zhang.

Due to the increasing number of electric and electronic equipments in automotive vehicles, the reliability of electric connections is becoming more and more important. The project 0DEFECT aims at developing tools for on-board diagnosis of failures in electric wire connections in automotive systems. The project is funded by Agence Nationale de la Recherche (ANR) from 2009 to Jan 2013. The partners are CEA LIST (project leader), Renault Trucks, Freescale, PSA, Delphi, Supelec LGEP and Inria.

8.1.3. ANR project SODDA: Soft Defects Diagnosis in wired networks

Participants: Michel Sorine, Qinghua Zhang.

The need for detection, localization and characterization of defects in a cable network has led to the ANR projects SEEDS followed by 0-DEFECT in the automotive domain, INSCAN for cables along railways. These projects provide the foundations of diagnosis methods for cables – with a proof of feasibility in the case of hard defects (short-circuit, open circuit) - and some theoretical results on the associated inverse problems in the case of soft faults. They also made it possible to identify their limits. One of the principal limits of these methods, based on the principles of reflectometry, is the difficulty of detecting soft defects. If it was possible to detect and locate precisely these defects, that would help for preventive maintenance or prognosis. The objective of SODDA is to study the signatures of the soft defects, by combining theory and experiment, and to design and test innovative methods adapted to these signatures which are very difficult to detect. The project is run by an academic consortium, in close connection with an industrial board, responsible for keeping the work in realistic and relevant use cases. The Inria teams involved are POEMS and Sisyphe.

8.1.4. ANR project EPOQ2: Estimation PrOblems for Quantum & Quantumlike systems

Participants: Mazyar Mirrahimi, Pierre Rouchon, Michel Sorine.

The project EPOQ2 is an ANR "Young researcher" project led by Mazyar Mirrahimi (Sisyphe). Its goal is to address a class of inverse problems arising from either the emerging application domain of "quantum engineering" or from some classical applications where a natural quantization lead to quantum-like systems, as it is the case in particular for inverse scattering for transmission lines. This research is in collaboration with the Pierre Aigrain laboratory at ENS Paris, Michel Devoret and Rob Schoelkopf at Yale University and Pierre Rouchon from Ecole Nationale Supérieure des Mines de Paris.

8.1.5. Inria Large Scale Initiative Action REGATE

REGATE (REgulation of the GonAdoTropE axis) has been a 4-year Large Scale Initiative Action funded by Inria in May 2009 dedicated to the modeling, simulation and control of the gonadotrope axis. The action is coordinated by Frédérique Clément. The Inria participants to this action are researchers of 2 Inria research teams, Contraintes and Sisyphe. There are also participants from INRA, Université Libre de Bruxelles (Unité de Chronobiologie théorique), Université Paris 6 (Laboratoire Jacques-Louis Lions) and the Florida State University.

The closing meeting of REGATE has hold this year on April 9th. Beyond its academic achievements (see more details on the publication page of the website), REGATE has played a significant role on the national level, in the constitution of the transversal research group "Integrative and translational approaches of human and animal reproduction" (GdR REPRO), that was initiated by ITMO (Multi OrganizationThematic Institute)) BCDE (Cell Biology, Development and Evolution).

8.2. European Initiatives

8.2.1. Collaborations in European Programs, except FP7

MODRIO: Model Driven Physical Systems Operation. This ITEA 2 (Information Technology for European Advancement) project is joined by partners from Austria, Belgium, Finland, France, Germany, Italy and Sweden. See the complete list on the MODRIO page of the ITEA 2 call 6 website. The involved Inria project-teams are PARKAS, S4 and SISYPHE. It is coordinated by EDF, France.

To meet the evermore stringent safety and environmental regulations for power plants and transportation vehicles, system operators need new techniques to improve system diagnosis and operation. Open standards are necessary for different teams to cooperate by sharing compatible information and data. The objective of the MODRIO project is to extend modeling and simulation tools based on open standards from system design to system diagnosis and operation.

ERNSI: European Research Network System Identification. The SISYPHE project-team is involved in the activities of the European Research Network on System Identification (ERNSI) federating major European research teams on system identification. See the website of ERNSI. Funded as a SCIENCE project (1992 - 1995), HCM Project (1993-1996), TMR Project (1998 - 2003), this network, currently coordinated by Bo Wahlberg, Automatic Control, KTH, Stockholm, is still very active.
Partners: KTH (Sweden), Inria (France), TUD (Technische Universität Darmstadt), TUW (Vienna University of Technology), UCAM-DENG (University of Cambridge), ELEC (Vrije Universiteit Brussel), ULIN (Sweden), UNIPD (Italy).

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Declared Inria International Partners

Collaborations in Neuroscience & Neuroendocrinology:

- Boston University: joint publications [87], [92] (with John Burke, Tasso Kaper and Mark Kramer).
- University of Sevilla (Spain): joint publications [43] (with Emilio Freire and Enrique Ponce), participation in PhD examination boards (Mathieu Desroches).
- Joint publications with individual collaborators: Thomas Stiehl (IWR Heidelberg) [39] ; David Avitabile (School of Mathematical Sciences, University of Notthingham) [83] and Serafim Rodrigues (Centre for Robotics and Neural Systems, Plymouth University) [83], [7].
- Florida State University: joint work on GnRH decoding, with Richard Bertram and Joël Tabak, in the framework of the doctoral committee of Patrick Fletcher.

Collaborations in Quantum engineering:

The collaborations with the teams of Michel Devoret and Robert Schoelkopf, enforced through a two-year sabbatical visit of Mazyar Mirrahimi at Yale university, have led to a set of contributions ranging from the theoretical analysis and performance optimization of ongoing experiments on weak quantum measurements [47] and preparation of non-classical field states through single photon Kerr effect [49] to the design of new experiments on single qubit cooling by reservoir engineering techniques [46] and development of new quantum gates allowing the transfer of quantum information from a superconducting qubit to a cavity mode [111].

Collaborations in Classical engineering:

Long-term collaboration of Qinghua Zhang with Lennart Ljung (Linköping University, Sweden) and Peter Lindskog (NIRA Dynamics, Sweden) that led to the development of the System Identification ToolBox (SITB) is one of the main Matlab toolboxes commercialized by The Mathworks and several papers.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Koen TIELS, Vrije Universiteit Brussel, Department of Fundamental Electricity and Instrumentation, from the group of Johan SCHOUKENS, has visited us during October 2013.

8.4.2. Visits to International Teams

Mazyar Mirrahimi spent four months in the Quantronics Laboratory of Michel Devoret and in the Rob Schoelkopf Lab at Yale University.