RESEARCH CENTER

FIELD
Digital Health, Biology and Earth

Activity Report 2014

Section Partnerships and Cooperations

Edition: 2015-06-01

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ABS Project-Team

6. Partnerships and Cooperations

6.1. National Initiatives

6.1.1. Projets Exploratoires Pluridisciplinaires from CNRS/Inria/INSERM

Title: Novel approaches to characterizing flexible macromolecular systems in biology

Modeling Large Protein Assemblies with Toleranced Models
Type: Projet Exploratoire Pluri-disciplinaire (PEPS) CNRS / Inria / INSERM
Duration: one year
Coordinator: C. Robert (IBPC / CNRS)
Other partner(s): F. Cazals (Inria Sophia Antipolis Méditerranée)
Abstract: A central problem in structural biology consists of modeling the dynamics and thermodynamics of macro-molecular assemblies involving a large number of atoms (thousands to hundreds of thousands). This requires understanding the structure of the potential and free energy landscapes (PEL and FEL) of the system. A number of approaches have been developed from the physical perspective, in particular to sample the PEL of the systems scrutinized (molecular dynamics, Monte Carlo based methods). The goal of this project is orthogonal, since our aim is to enhance the processing of samplings generated by the aforementioned approaches. Our methods aim at analyzing and comparing sampled PEL and FEL, using novel methods from computational geometry, computational topology, and optimization. These methods should foster our understanding of the behavior of macro-molecular assemblies, and in the long run, they should also trigger the development of more efficient sampling algorithms.

6.2. International Initiatives

6.2.1. Participation In other International Programs

F. Cazals (Inria ABS), I. Emiris (Prof., Univ. of Athens) and S. Theodoridis (Prof., Univ. of Athens) collaborate in the scope of an Inria COLOR entitled *Discriminating and classifying in high-dimensional spaces*.

The scientific goal was to study methods and algorithms in high dimensional spaces, revolving around three problems: approximate nearest neighbors, polytope volume approximations, and classification - discrimination in high high-dimensional Spaces.

The long-term plan is to examine whether the work done so far can be combined with work by other European teams targeting a European research proposal. F. Cazals and I. Emiris participate in a FET-Open STREP proposal, entitled *Exploring the Geometry of Data*, including high-dimensional geometry, machine learning, and statisctical methods. More precisely, the collaborations proposed between the two groups bootstraps on the achievements of the COLOR, as they aim at exploring (i) incremental nearest neighbor methods in metric spaces, (ii) sampling methods for polytope volume approximation and high-dimensional space exploration, and (iii) applications in biophysics (protein docking and energy landscape exploration).

6.3. International Research Visitors

6.3.1. Visits of International Scientists

- Fasseli Coulibaly, Monash University, September 2014.

6.3.1.1. Internships

- R. Tetley, from the MSc program *Computational biology and biomedicine* from the Univ. of Nice, completed his MSc internship under the guidance of F. Cazals, on the topic *Bootstrap algorithms for structural alignments, with applications in structural virology*. Romain is now following-up as a PhD student.
- D. Shah, second year student from the IIT Bombay, completed a summer internship on the topic *Improving scoring functions for protein docking*.

AMIB Project-Team

6. Partnerships and Cooperations

6.1. National Initiatives

6.1.1. ANR

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

6.1.2. PEPS

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

6.1.3. FRM

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

- Approche comparatives haut-débit pour la modelisation de l'architecture 3D des ARN à partir de données experimentales
- 2015–2018
- Y. Ponty, A. Denise
- B. Sargueil (Paris V – Experimental partner), J. Waldispuhl

6.2. European Initiatives

6.2.1. Collaborations in European Programs, except FP7 & H2020

ANR International program

- Fast and efficient sampling of structures in RNA folding landscapes
- RNALands (ANR-14-CE34-0011)
- 01/10/2014-30/09/2018
- Y. Ponty, A. Denise, M. Regnier
- EPI BONSAI/INRIA Inria Lille - Nord Europe, Vienna University (Austria)

6.3. International Initiatives

- Capes Biologie systémique du cancer (051/2013) porté par Sandro José de Souza (Univ. Federal do Rio Grande do Norte, Brésil)
- Sabine Peres
- 2014-2018

6.3.1. Inria Associate Teams

6.3.1.1. ITSNAP

Title: Intelligent Techniques for Structure of Nucleic Acids and Proteins

International Partner (Institution - Laboratory - Researcher):

Stanford University (ÉTATS-UNIS)

Duration: 2009 - 2014

See also: http://pages.saclay.inria.fr/julie.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.

6.3.2. Inria International Partners

6.3.2.1. Declared Inria International Partners

Title: CARNAGE: Combinatorics of Assembly and RNA in GEnomes

International Partner (Institution - Laboratory - Researcher):

State Research Institute of Genetics and Selection of Industrial Microorganisms (Russia (Russian Federation)) - Bioinformatics laboratory - V. Makeev and 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.

6.3.2.2. 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.

6.3.3. Participation In other International Programs

Henry van den Bedem and J. Bernauer presented their work at the Inria BIS 2014 Workshop in Paris https://project.inria.fr/inria-siliconvalley/workshops/bis2014/.

6.4. International Research Visitors

6.4.1. Visits of International Scientists

J. Holub

Subject: Word automata

Institution: Praha University (Czech Republic)

E. Furletova

Subject: word enumeration

Institution: Institute of Mathematical Problems in Biology (Russia)

6.4.1.1. Internships

Jan Lin Chan

Subject: Exceptional words in *Archae* genomes

Date: 01/06/2014 - 11/08/2014

Institution: NUS (Singapour)

Funding: INRIA

Supervision: M. Régnier

Damien Busatto-Gaston

Subject: de Bruijn graphs and assembly

Date: 01/06/2014 - 14/07/2014

Institution: ENS-Lyon (France)

Funding: INRIA

Supervision: M. Régnier

Robert Huang

Subject: Repeats in genomic sequences

Date: 01/06/2014 - 25/08/2014

Institution: Berkeley (USA)

Funding: ECOLE POLYTECHNIQUE

Supervision: M. Régnier

Hanlun Jiang

Subject : conformational dynamics of the RNA-induced silencing complex

Date: 01/06/2014 - 25/08/2014

Institution: HKUST (Hong-Kong)

Funding: MRE

Supervision: J. Bernauer

Stéphanie Kamgnia Wonkap

Subject : Extraction de motifs dans les graphes de workflows scientifiques

Date: 01/06/2014 - 30/06/2014

Institution: Univ. Rennes

Funding: INRIA

Supervision: Ch. Froidevaux and S. Cohen-Boulakia

6.4.2. Visits to International Teams

6.4.2.1. Sabbatical programme

Julie Bernauer

Date: Feb 2014 - Jul 2014

Institution: Stanford University (USA)

6.4.2.2. Research stays abroad

Sarah Cohen-Boulakia

Date: Apr 2014

Institution: University of Pennsylvania (USA)

Date: Dec 2014

Institution: Humboldt University of Berlin (Germany)

Yann Ponty

Date: Sep 2013 - Sep 2015

Institution: Simon Fraser University (Canada)

Sabine Peres

Date: Dec 2014

Institution: Friedrich-Schiller-University Jena (Germany)

Alice Heliou

Date: Feb-Apr 2014

Institution: King's College (UK)

Date: December 2014

Institution: Vavilov Institute of General Genetics (Russia)

Amélie Heliou

Date: Mar-May 2014

Institution: Stanford University (USA)

Antoine Soulé

Date: Half-time 2014

Institution: McGill University (Canada)

BAMBOO Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. 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

7.1.2. Colib'read

- Title: Methods for efficient detection and visualization of biological information from non assembled NGS data
- Coordinator: P. Peterlongo
- 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/

7.1.3. 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

7.1.4. Effets de l'environnement sur la stabilité des éléments transposables

- Title: Effets de l'environnement sur la stabilité des éléments transposables
- Coordinator: C. Vieira
- BAMBOO participant(s): C. Vieira
- Type: Fondation pour la Recherche Médicale (FRM) (2014-2016)
- Web page: Not available

7.1.5. ExHyb

- Title: Exploring genomic stability in hybrids
- Coordinator: C. Vieira
- BAMBOO participant(s): C. Vieira
- Type: ANR (2014-2018)
- Web page: Not available

7.1.6. IMetSym

- Title: Immune and Metabolic Control in Intracellular Symbiosis of Insects

- Coordinator: A Heddi
- BAMBOO participant(s): H. Charles, S. Colella
- Type: ANR Blanc (2014-2017)
- Web page: Not available

7.1.7. ImmunSymbArt

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

7.1.8. 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

7.1.9. SpeciAphid

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

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

7.2.1.1. BacHBerry

Title: BACterial Hosts for production of Bioactive phenolics from bERRY fruits

Coordinator: Jochen Förster, DTU Danemark

BAMBOO participant(s): R. Andrade, L. Bulteau, A. Julien-Laferriére, V. Lacroix, D. Parrot, M.-F. Sagot, A. Viari, M. Wannagat

Type: FP7 - KBBE (2013-2016)

Web page: http://www.bachberry.eu/

7.2.1.2. 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

7.2.1.3. 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

7.2.1.4. 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

7.2.1.5. 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: Not available

7.2.1.6. 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: Not available

7.3. International Initiatives

7.3.1. 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.

7.3.2. 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.

7.3.3. Participation In other International Programs

BAMBOO is coordinator 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 coordinates another project with Brazil. This is a 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.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

During 2014, the team had 4 international scientists visiting our group for at least one week. These included:

- Franciele Maboni, Federal University of Rio Grande do Sul, Porto Alegre, Brazil, two visits of, respectively, 15 days and 1 week;
- Maria Cristina Motta, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil, two visits of approximately 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 of 10 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.

BEAGLE Project-Team

6. Partnerships and Cooperations

6.1. Regional Initiatives

6.1.1. Labex Ecofect Call

- IntraCell-X-Evo (2014-2015): Experimental evolution of an intracellular bacterium within its host cell. Supervisor: Thomas Henry, INSERM Lyon. Participants: Eric Tannier.

6.2. National Initiatives

6.2.1. ANR

- Stochagene (2011-2014). Objective: identify the molecular basis of the stochasticity of gene expression in eukaryotic cells. Partners: CGPhyMC (O Gandrillon, Lyon, Leader), Genethon (A Paldi, Evry). Participants: G Beslon, H Berry, G Kaneko
- Ancestrome: phylogenetic reconstruction of ancestral "-omes", a five-year project (2012-2017), call "Bioinformatics" of the "Investissements d'avenir". Supervisor: V Daubin (CNRS, LBBE, Lyon) ; with Institut Pasteur, ENS Paris, ISEM (Univ Montpellier 2) Participant: E Tannier.
- Foster: Spatiotemporal data mining: application to the understanding and monitoring of soil erosion (2011-2014). Supervisor: N Selmaoui and F Flouvat (PPME Univ. Nouvelle Caledonie); with LISTIC Univ. Savoie, ICube Univ. Strasbourg, BlueCham Company. Participant: C Rigotti.
- Dopaciumcity (2014-2017) (Dopamine modulation of calcium influx underlying synaptic plasticity): a 4-year project (2014-2017) funded by a grant from the ANR-NSF-NIH Call for French-US Projects in Computational Neuroscience. With L. Venance, College de France, CIRB, CNRS/UMR 7241 - INSERM U1050, Paris, France and K Blackwell, Krasnow Institute of Advanced Studies, George Mason University, Fairfax, VA, USA. Supervisor: L Venance (for France) and K.L. Blackwell (for US). Participants: H Berry, I Prokin, A Foncelle

6.3. European Initiatives

6.3.1. FP7 & H2020 Projects

6.3.1.1. EvoEvo

Type: FP7

Defi: Future and Emerging Technologies

Instrument: Specific Targeted Research Project

Objectif: FET Proactive: Evolving Living Technologies

Duration: September 2013 - August 2016

Coordinator: Guillaume Beslon

Partner: Université Joseph Fourier (France, D. Schneider), Utrecht University (Netherland, 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 study this process of "evolution of evolution" and use this knowledge to develop new evolutionary approaches in information science. 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.

6.3.1.2. Neuron-Astro-Nets

Type: FP7

Defi: NC

Instrument: Marie Curie International Outgoing Fellowships for Career Development

Objectif: NC

Duration: (2013-2017)

Coordinator: H. Berry, M. De Pittà (Inria)

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

Inria contact: Maurizio DE PITTA

Abstract: This project aims at developing a new model of synaptic plasticity that takes into account astrocyte signaling, its extension to astrocytes-synapse biochemical interactions in ensembles of synapses enwrapped by the same astrocyte and, eventually, to the firing of a single neuron or networks.

6.4. International Initiatives

6.4.1. Inria International Partners

6.4.1.1. Declared Inria International Partners

- Nadia El-Mabrouk, from the University of Montreal in Canada, came as an Inria invited researcher in 2012 and 2013. Since then we have several co-authored papers, including one submitted this year, and a co-edited book.
- Cedric Chauve from Simon Fraser University in Vancouver, Canada, is a very regular collaborator of Eric Tannier. We still have a publication in preparation. Cedric was visiting the LBBE lab in june 2014. We obtained a PIMS (Pacific Institute of Mathematics Studies) grant for a visit in 2015.
- Istvan Miklos, from the Renyi Institute in Budapest, is a regular collaborator of Eric Tannier, and we have a co-publication in 2014 [22].
- Joao Meidanis, from the University of Campinas in Brazil, is a collaborator of Eric Tannier. Priscila Biller, supervised by J. Meidanis, is spending 12 months in the BEAGLE team.

6.4.1.2. Informal International Partners

- Wolfgang Banzhaf (New Foundland Memorial University, Canada). Together with Wolfgang Banzhaf, we initiated a theoretical work on the concept of "open-endedness". We are currently writing a collective position paper to precisely define this currently informal concept and to design minimal conditions to simulate it in silico.

6.4.2. Participation In other International Programs

- Dopaciumcity (2014-2016): Dopamine modulation of calcium influx underlying synaptic plasticity. Partners: George Mason University, Fairfax, VA, USA (Kim L. Blackwell, US project leader) Collège de France, Paris, France (Laurent Venance, French project leader) Inria Rhône-Alpes, France, (H. Berry) from the ANR-NSF-NIH Call for French-US Projects in Computational Neuroscience.

- User-friendly Phylogenomics (2014): Bayesian simultaneous reconstruction of gene trees and species trees. France Berkeley Fund. Inria Participants: Eric Tannier. 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.
- 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 Computtional 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.

6.5. International Research Visitors

6.5.1. Visits of International Scientists

- Sergei Fedotov (Department of Mathematics, University of Manchester, UK) was a visiting professor in BEAGLE from June 5 to June 17, 2014. Collaboration with H. Berry and A. Mateos-Gonzalez

6.5.1.1. Internships

- Priscilla Biller spends a year in the BEAGLE team, during her Ph-D preparation in University of Campinas, Brazil

6.5.2. Visits to International Teams

- G Beslon spent a week in New Foundland Memorial University (July 2014) to attend a workshop on the concept of "open-endedness".
- C Rocabert spent 10 days in Utrecht University to collaborate with the bioinformatics and theoretical biology group. The objective was to exchange ideas to develop and integrated evolutionary model.
- H. Berry was invited to the BioMedTech Institute of Tampere University of Technology for one week (8-12 Dec. 2014)

BIGS Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

Project "Handle your heart" Creation of a drug prescription support software for the treatment of heart failure, in collaboration with the University Hospital of Nancy, headed by J.-M. Monnez.

7.2. National Initiatives

- *Truffinet* (2014), TRUFFles' microbial interaction Inference by NETwork analysis, Funding organism: PEPS CNRS-Université de Lorraine, Leader: A. Muller-Gueudin. Collaboration with IECL (Anne Gégout-Petit), CRAN (S. Martin, C. Morarescu), INRA (A. Deveau).
- *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 multiform, Funding organism: Institut National du Cancer (INCa), Leader: M. Barberi-Heyob (CRAN, U. Lorraine), T. Bastogne.
- GDR 3477 Géométrie Stochastique, Leaders: Pierre Calka, David Coupier, Viet Chi Tran, C. Lacaux.
- GDR 3475 Analyse Multifractale, Leader: Stéphane Jaffard (C. Lacaux).
- *PhotoBrain* (2015-17), AGuIX® theranostic nanoparticles for vascular-targeted interstitial photodynamic therapy of brain tumors, Funding organism: EuroNanoMed II, Leader: M. Barberi-Heyob (CRAN).
- (2014-16), A library of Near-InfraRed absorbing photosensitizers: tailoring and assessing photophysical and synergetic photodynamic properties, Funding organism: PHC Bosphore - Campus France, Leader: M. Barberi-Heyob (CRAN).

7.3. International Research Visitors

7.3.1. Visits of International Scientists

2014/05/11-2014/05/25: visit of Gennady Samorodnitsky (Cornell, USA) to C. Lacaux.

7.3.2. Visits to International Teams

7.3.2.1. Sabbatical programme

S. Tindel was on sabbatical at the University of Kansas from August 2013 to June 2014, working on inference for Gaussian systems with D. Nualart and Y. Hu.

BONSAI Project-Team

8. Partnerships and Cooperations

8.1. 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. The project led to the recruitment of Amandine Perrin in 2014.
- SIRIC OncoLille supports our research in collaboration with Lille hospital on quantification of lymphocyte rearrangements, funding the contract of Marc Duez in 2014.

8.2. National Initiatives

8.2.1. ANR

- 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 (2014): 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 *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. There are two partners: UMR 8199 (Génomique et maladie métabolique, Ph Froguel, O. Sand, part of the LIGAN sequencing platform) and BONSAI.

8.2.2. ADT

- ADT biosciences resources (2012-2014): 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. The engineer hired from 2012 to 2014 in Lille finished its contract at fall. The portal is available at http://ibr.genouest.org.

8.3. European Initiatives

8.3.1. Collaborations in European Programs, except FP7 & H2020

- International ANR RNAlands (2014-2017): National funding from the French Agency Research (call *International call*). The subject is fast and efficient sampling of structures in RNA Folding Landscapes. The project gathers three partners: Amib from Inria Saclay, the Theoretical Biochemistry Group from Universität Wien and Bonsai.
- EuroClonality-NGS: This working group belongs to the ESLHO (European Scientific foundation for Laboratory HematoOncology), which aims at standardizing laboratory diagnostics focused on lymphoid malignancies, it is also responsible for quality controls of European laboratories. The EuroClonality-NGS working group itself is dedicated to provide new standards using high-throughput sequencing.

8.4. International Initiatives

8.4.1. Inria Associate Teams

8.4.1.1. CG-ALCODE

The title of the project is "Comparative Genomics for the analysis of gene structure evolution: ALternative CODing in Eukaryote genes through alternative splicing, transcription, and translation.". The project involves partners from EPI BONSAI and from the Université du Québec À Montréal (UQÀM, Canada), from year 2014 to year 2017 (see also: http://thales.math.uqam.ca/~cgalcode/).

The aim of this Associated Team is the development of comparative genomics models and methods for the analysis of eukaryotes gene structure evolution. The goal is to answer very important questions arising from recent discoveries on the major role played by alternative transcription, splicing, and translation, in the functional diversification of eukaryote genes.

8.4.2. Inria International Partners

8.4.2.1. Informal International Partners

- *Novo Nordisk Foundation Center for Biosustainability, Technical University of Denmark:* Collaboration with Tilmann Weber on nonribosomal peptides.
- *Computational Biology Research Center, Tokyo*: Collaboration with Martin C. Frith on transition spaced seeds [3].
- *Department of Statistics of the North Carolina State University (Raleigh)*: Collaboration with Donald E.K. Martin one spaced seeds coverage [6].
- *Institut für Biophysik und physikalische Biochemie', University of Regensburg*: Collaboration with Rainer Merkl on ancestral sequence inference and synthesis.
- *University of Bielefeld*: Collaboration with Robert Giegerich on RNA bioinformatics [4].

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Anne Bergeron, professor, UQÀM, Canada (from July 7 to July 11 2014).
- Paul Guertin, UQÁM (from July 7 to July 24).

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, Vincent Picard, Santiago Videla.

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

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). In addition, the team participates to a collaboration program with the Biocore and Ange teams, together with Ifremer-Nantes, focused on the understanding on micro-algae (thesis of Julie Laniau).

7.1.3. Regional partnership in agriculture and bio-medical domains

Participants: Aymeric Antoine-Lorquin, Catherine Belleannée, Charles Bettembourg, François Coste, Jean Coquet, Olivier Dameron, Victorien Delannée, Jacques Nicolas, Anne Siegel, Valentin Wucher, Nathalie Théret.

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 V. Wucher [13] was supported by collaborations with the IGEPP laboratory. The post-doc of Charles Bettembourg nows stregthens these collaborations. This collaboration is also reinforced by collaboration within ANR contracts (MirNadapt, FatInteger).

We also have a strong and long term collaboration in the bio-medical domain, namely with the IRSET laboratory at Univ. Rennes 1/Irset, acted by the co-supervised Ph-D theses of V. Delannée (Metagenotox project, funded by Anses) and J. Coquet. This partnership was reinforced in the former years by the ANR contract Biotempo ended at the end of 2014.

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, Marie Chevallier, Damien Eveillard, Gaëlle Garet, Jacques Nicolas, 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. The program is co-funded by Inria and CORFO-chile from 2012 to 2022. 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 2016.

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, Yann Guitton, 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, Olivier Dameron, Vincent Picard, Sylvain Prigent, Nathalie Théret, 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 Nov. 2014. Teams involved include LINA (Nantes), I3S (Nice), DIMPP (Montpellier), Contraintes/Lifeware 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, 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 Mirnadapt

Participants: Jacques Nicolas, Catherine Belleannée, Anne Siegel, Olivier Dameron, Valentin Wucher, Charles Bettembourg.

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 was strengthened by a co-tutored PhD thesis (V. Wucher) defended in Nov. 2014 [13]. 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.

7.2.3.3. ANR Samosa

Participants: Jacques Nicolas, Catherine Belleannée, Anne Siegel, Aymeric Antoine-Lorquin, Jérémie Bourdon, François Coste.

Oceans are particularly affected by global change, which can cause e.g. increases in average sea temperature and in UV radiation fluxes onto ocean surface or a shrinkage of nutrient-rich areas. This raises the question of the capacity of marine photosynthetic microorganisms to cope with these environmental changes both at short term (physiological plasticity) and long term (e.g. gene alterations or acquisitions causing changes in fitness in a specific niche). Synechococcus cyanobacteria are among the most pertinent biological models to tackle this question, because of their ubiquity and wide abundance in the field, which allows them to be studied at all levels of organization from genes to the global ocean.

The SAMOSA project is funded by ANR from 2014 to 2018, coordinated by F. Gaczarek at the Station Biologique de Roscoff/UPMC/CNRS. The goal of the project is to develop a systems biology approach to characterize and model the main acclimation (i.e., physiological) and adaptation (i.e. evolutionary) mechanisms involved in the differential responses of Synechococcus clades/ecotypes to environmental fluctuations, with the goal to better predict their respective adaptability, and hence dynamics and distribution, in the context of global change. For this purpose, following intensive omics experimental protocol driven by our colleagues from « Station Biologique de Roscoff », we aim at constructing a gene network model sufficiently flexible to allow the integration of transcriptomic and physiological data.

7.2.4. Programs funded by research institutions

7.2.4.1. ADT Complex-biomarkers

Participants: Jeanne Cambefort, Guillaume Collet, Marie Chevallier, Anne Siegel.

This project started in Oct. 2014 and aims at designing a working environment based on workflows to assist molecular biologists to integrate large-scale omics data on non-classical species. The main goal of the workflows will be to facilitate the identification of set of regulators involved in the response of a species when challenged by an environmental stress. Applications target extremophile biotechnologies (biomining) and marine biology (micro-algae).

7.2.4.2. ANSES Mecagenotox

Participants: Victorien Delannée, Anne Siegel, Nathalie Théret.

The objective of Mecagenotox project is to characterize and model the human liver ability to bioactivate environmental contaminants during liver chronic diseases in order to assess individual susceptibility. Indeed, liver pathologies which result in the development of fibrosis are associated with a severe dysfunction of liver functions that may lead to increased susceptibility against contaminants. In this project funded by ANSES and coordinated by S. Langouet at IRSET/inserm (Univ. Rennes 1), we will combine cell biology approaches, biochemistry, biophysics, analytical chemistry and bioinformatics to 1) understand how the tension forces induced by the development of liver fibrosis alter the susceptibility of hepatocytes to certain genotoxic chemicals (especially Heterocyclic Aromatic Amines) and 2) model the behavior of xenobiotic metabolism during the liver fibrosis. Our main goal is to identify "sensitive" biomolecules in the network and to understand more comprehensively bioactivation of environmental contaminants involved in the onset of hepatocellular carcinoma.

7.2.4.3. 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 - 2016

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 2016. 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 (2012) and the co-supervised of A. Aravena (2010-2013) contributed 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. In 2014, Marie Chevallier joined the team as an engineer to reinforce software resulting from common collaborations.

7.4.3. Participation in other International Programs

7.4.3.1. International joint supervision of PhD

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

- **Algeria**. Badji Mokhtar - Annaba University [M. Zekri]
- **Austria**. Graz university [M. Weltzer]
- **Chile**. Centro de Modelimiento Matematico, Santiago [A. Maass, P. Bordron, M.P. Cortez]
- **Germany**. Department of Computer Science, Potsdam [T. Schaub]
- **Germany**. Frei Universitat Berlin [A. Bockmayr]

7.5.1.1. Internships

Francisco Dorr

Date: Mar 2014 - Aug 2014

Institution: Universidad de Buenos Aires (Argentina)

7.5.2. Visits to International Teams

7.5.2.1. Shorts visits

- **Chile**. Centro de Modelimiento Matematico, Santiago. *Applications of ASP*. Nov. 2014 (1 to 2 weeks) [J. Bourdon, M. Chevallier, D. Eveillard, A. Siegel]

7.5.2.2. Explorer programme

Prigent Sylvain

Date: Mar 2014 - Apr 2014

Institution: FUB (Germany)

Videla Santiago

Date: Mar 2014 - May 2014

Institution: University of Potsdam (Germany)

Picard Vincent

Date: Sep 2014 - Nov 2014

Institution: The University of Tokyo, Japanese-French Laboratory for Informatics(Japan)

GENSCALE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. DGASP: Discrete Geometry Problem solve with ASP

Participants: Douglas Goncalves, Antonio Mucherino.

This project was 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 (Dyliss team, IRISA).

8.1.2. KoriKlast2: Intensive Sequence comparison

Participants: Sébastien Brillet, Erwan Drezen, Dominique Lavenier, Ivaylo Petrov.

This is a collaborative project funded by Région Bretagne (18 months, from June 2014) with 3 partners: the Korilog Company, the bioinformatics computing center of Roscoff and the GenScale team. The purpose is (1) to improve the KLAST software with new alignment methods developed by GenScale; (2) to extend the capabilities of KLAST toward metagenomic processing; (3) to develop a cloud version targeting huge sequence comparison processing.

8.1.3. Collaboration with IGDR (Insitute of Genetic and Development of Rennes)

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

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

8.1.4. Partnership with INRA

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

The GenScale team has 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 three INRA engineers (F. Legeai, F. Moreews, S. Alves Carvalho). In particular, the collaboration with the IGEPP team includes several research projects in which Genscale is a formal partner: PEAPOL and SPECIAPHID projects.

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. Project FATINTEGER

Participants: Dominique Lavenier, François Moreews.

Coordinateur: F. Gondret
Duration: 36 months (Mar. 2012 - feb. 2015)
Partners: PEGASE Inra Rennes, CNRS IRISA Rennes, AgroCampus Ouest LMA-IRMAR Rennes

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. GenScale is involved in the design of the workflow for processing the genomic data.

8.2.1.2. Project SPECIAPHID: Speciation of pea aphids

Participants: Claire Lemaitre, Anaïs Gouin, Fabrice Legeai.

Coordinator: J-C. Simon (Inra)
Duration: 36 months (Jan. 2012 – Dec 2014)
Partners: IGEPP Inra Rennes, CBGP Inra Montpellier, BF2I Inra Lyon.

The SPECIAPHID project aims to understand the adaptation and speciation of pea aphids by re-sequencing and comparing the genomes of numerous aphid individuals. The role of Genscale is to apply and develop new methods to detect variation between re-sequenced genomes, and in particular complex variants such as structural ones.

8.2.1.3. Project ADA-SPODO: Genetic variation of Spodoptera Frugiperda

Participants: Claire Lemaitre, Fabrice Legeai, Anaïs Gouin, Dominique Lavenier, Pierre Peterlongo.

Coordinator: E. D'Alençon (Inra, Montpellier)
Duration: 39 months (Oct. 2012 – Dec 2015)
Partners: DGIMI Inra Montpellier, CBGP Inra Montpellier, URGI Inra Versailles, Genscale Inria/IRISA Rennes.

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 postgenomic and regulatory data.

8.2.1.4. Project COLIB'READ: Advanced algorithms for NGS data

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

Coordinator: P. Peterlongo (Inria, GenScale, Rennes)
Duration: 36 months (Mar. 2013 – Feb. 2016)
Partners: LIRMM Montpellier, Bamboo Inria Lyon, Genscale Inria/IRISA Rennes.

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. The goal is to avoid the assembly step that often leads to a significant loss of information, or generates chimerical results due to complex heuristics. Instead, the strategy proposes a set of innovative approaches that bypass the assembly phase, and that does not require the availability of a reference genome. https://colibread.inria.fr/

8.2.1.5. Project GATB: Genome Analysis Tool Box

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

Coordinator: D. Lavenier (Inria/Irisa, GenScale, Rennes)
Duration: 24 months (Feb. 2013 – Jan. 2015)
Partners: GenScale Inria/IRISA, Rennes – DTI Inria, Rennes.

This project aims to develop algorithms and tools for genome analysis based on an compact data structure having a very low memory footprint allowing end-users to process huge volume of genomic data on a simple desktop computer. The GATB is structured around a C++ library from which many efficient NGS tools can be developed. GATB has been published and used outside Genscale (LIRMM, Inria Bamboo team). http://gatb.inria.fr

8.2.1.6. Project HydroGen: Metagenomic applied to ocean life study

Participants: Dominique Lavenier, Pierre Peterlongo, Claire Lemaitre, Guillaume Rizk, Gaëtan Benoit.

Coordinator: D. Lavenier (Inria/Irisa, GenScale, Rennes)
Duration: 42 months (Nov. 2014 – Apr. 2018)
Partners: CEA (GenosScope, Evry), INRA (AgroParisTech, Paris – MIG, Jouy-en-Jossas).

The HydroGen project aims to design new statistical and computational tools to measure and analyze biodiversity through comparative metagenomic approaches. The support application is the study of ocean biodiversity based on the analysis of seawater samples available from the Tara Oceans expedition.

8.2.2. PIA: Programme Investissement d'Avenir

8.2.2.1. RAPSODYN: Optimization of the rapeseed oil content and yield under low nitrogen

Participants: Dominique Lavenier, Claire Lemaitre, Pierre Peterlongo.

Coordinator: N. Nessi (Inra, IGEPP, Rennes)
The objective of the Rapsodyn project is the optimization of the rapeseed oil content and yield under low nitrogen input. GenScale is involved in the bioinformatics work package to elaborate advanced tools dedicated to polymorphism and application to the rapeseed plant.

8.2.2.2. France Génomique: Bio-informatics and Genomic Analysis

Participants: Laurent Bouri, Dominique Lavenier.

Coordinator: J. Weissenbach (Genoscope, Evry)
France Génomique gathers resources from the main French platforms in genomic and bio-informatics. It offers to the scientific community an access to these resources, a high level of expertise and the possibilities to participate in ambitious national and international projects. The GenScale team is involved in the work package "assembly" to provide expertise and to design new assembly tools for the 3rd generation sequencing.

8.2.3. Programs from research institutions

8.2.3.1. Inria ADT Mapsembler

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

The Mapsembler project aims at finalizing and at 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/

8.2.3.2. Mastodons CNRS Program SéPhHaDé: Computational Challenge of High Throughput Sequencing and Phenotyping in Life Science

Participants: Dominique Lavenier, Erwan Drezen, Ba Diep Nguyen.

Coordinator: E. Rivals (Lirmm, Montpellier)
Duration: 3 years (2012-2014)
Partners: Lirmm et Inria Montpellier, GenScale IRISA/Inria Rennes, Bamboo LIFL, Lille, INRA Montpellier , ISEM, IPMC Nice, CIRAD Montpellier, LSIS Aix Marseille, Tela Botanica Montpellier, UPMC Banyuls/Mer, CEA Evry, LITIS Rouen

This project deals with the management of huge volume of data generated (1) by the new sequencing technologies (2) by the collection of information for phenotyping living organisms. In 2014, GenScale has developed a methodology to compare metagenomic datasets to protein databanks.

8.3. International Initiatives

8.3.1. Inria International Partners

8.3.1.1. Informal International Partners

- Brazil
  - IMECC, UNICAMP, Campinas
  - COPPE, Federal University of Rio de Janeiro
  - University federal of Minas Gerais
- USA
  - Information Sciences Group (CCS-3), Los Alamos National Laboratory (LANL), Los Alamos.
  - Baylor College of Medicine, Houston
- China
  - StateKey Laboratory of Silkworm Genome Biology at the SouthWest University, Chongqing, China
- Vietnam
  - University of Cantho
- Europe
  - Bulgarian Academy of Science (BAS), Sofia, Bulgaria
  - The Genome Analysis Center, Norwich, UK
  - University of Sheffield, UK
  - University of York, UK

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Stephen Richards, Assistant Professor, Baylor College of Medicine, Houston, USA, June 2014. Stephen Richards is responsible for the sequencing and bioinformatics analysis of the genomes of arthropods. During his visit, he worked on the improvement of the pea aphid genome assembly.
- Ba Diep Nguyen, Assistant Professor, Cantho University, Vietnam Nov. 2014 to Jan. 2015 During his visit, Ba Diep Nguyen worked on the design of a new methodology for comparing metagenomic samples to protein databank.

8.4.2. Visits to International Teams

8.4.2.1. Research stays abroad

- Rumen Andonov, Professor, Information Sciences Group (CCS-3) from Los Alamos National Laboratory (LANL), Los Alamos, USA. Jan. 2014 to Aug. 2014. R. Andonov collaborates with LANL on various research projects related to solving hard combinatorial optimization problems on very large graphs and their applications in Bioinformatics. Two applications were on the focus of this cooperation during 2014: the scaffolding problem in NGS and structural classification of proteins.

IBIS Project-Team

7. Partnerships and Cooperations

7.1. National initiatives

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

Project name	GeMCo – Model reduction, experimental validation, and control for the gene expression machinery in *E. coli*
Coordinator IBIS participants Type Web page	M. Chaves E. Cinquemani, J. Geiselmann, C. Gomez Balderas-Barillot, E. Grac, H. de Jong, S. Lacour, C. Pinel, D. Ropers ANR Blanc (2010-2014) 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 IBIS participants Type Web page	H. de Jong E. Cinquemani, J. Geiselmann, C. Gomez Balderas-Barillot, E. Grac, H. de Jong, S. Lacour, Y. Markowicz, C. Pinel, D. Ropers Bioinformatics call, Investissements d'Avenir program (2012-2016) 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 IBIS participants Type Web page	M. Cocaign-Bousquet (Inra, LISBP), B. Enjalbert (INSA, LISBP), D. Ropers M. Morin, D. Ropers Contrat Jeune Scientifique Inra-Inria (2012-2016) http://www.inra.fr/les_hommes_et_les_femmes/rejoignez_nous/completer_sa_formation/le_recrutement_de_doctorants/cjs__1/inra_inria

7.2. 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.

7.3. International research visitors

Visiting PhD student	Andres Gonzalez Vargas (University of Pavia, Italy)
Subject	Stochastic modeling and identification of regulatory networks

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

LIFEWARE Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR Projects

- ANR Blanc Hyclock (2014-2018) on "Hybrid modeling of time for Circadian Clock Biology and Chronopharmacology", coordinated by F. Delaunay (CNRS, Nice), F. Lévi (INSERM Paris-Sud), G. Bernot (CNRS I3S, Nice), O. Roux (Ecle Centrale Nantes).
- ANR Blanc STOCH-MC (2014-2018) on "Stochastic Models: Scalable Model Checking", coordinated by Blaise Genest (Inria Rennes), with Grégory Batt, Wieslaw Zielonka (LIAFA), and Hugo Gimbert (LaBRI).
- ANR Investissement Avenir ICEBERG project (2011-2016) "From population models to model populations", coordinated by Grégory Batt, with Pascal Hersen (MSC lab, Paris Diderot Univ./CNRS), Reiner Veitia (Institut Jacques Monod, Paris Diderot Univ./CNRS), Olivier Gandrillon (BM2A lab, Lyon Univ./CNRS), Cédric Lhoussaine (LIFL/CNRS), and Jean Krivine (PPS lab, Paris Diderot Univ./CNRS).
- ANR Cosinus Syne2arti project (2010-2014) "From synthetic gene networks to artificial tissues" coordinated by Grégory Batt, with Oded Maler (CNRS Verimag), Dirk Drasdo (EPI Mamba), and Ron Weiss (MIT).
- ANR Blanc BIOTEMPO project (2010-2014) coordinated by Anne Siegel (EPI DYLISS), with Ovidiu Radulescu (U. Montpellier), O. Roux (Ecole Centrale de Nantes), Irina Rusu (U. Nantes).
- ANR Blanc NET-WMS-2 (2011-2015) on "constraint optimization in Wharehouse Management Systems", coordinated by F. Fages, with N. Beldiceanu (Ecole des Mines de Nantes, EPI TASC), and Abder Aggoun (KLS optim).

8.1.2. BPI-OSEO BioIntelligence Project

- OSEO-BPI Biointelligence project (2009-2014) coordinated by Dassault-Systèmes, with Sobios, Aureus pharma, Ipsen, Pierre Fabre, Sanofi-Aventis, Servier, Bayer CropScience, INSERM, Genopole Evry, EPI Orpailleur.

8.1.3. GENCI Contract

- GENCI (2009-) attribution of 300000 computation hours per year on the Jade cluster of 10000 cores of GENCI at CINES, Montpellier. Used for hardest parameter search problems in BIOCHAM-parallel.

8.2. International Initiatives

8.2.1. Inria Associate Teams

8.2.1.1. TISHOM

Title: Artificial tissue homeostasis: combining synthetic and computational biology approaches
Inria principal investigator: Grégory Batt
International Partner (Institution - Laboratory - Researcher):
Massachusetts Institute of Technology (United States) - Weiss Lab
Duration: 2012 - 2014

Cell-based gene therapy aims at creating and transplanting genetically-modified cells into a patient in order to treat an illness. Ideally, actively-growing cells are used to form a self-maintaining tissue in the patient, thus permanently curing the disease. Still, before any real therapeutic use, many important issues need to be addressed. In particular, one should guarantee tissue homeostasis, that is, that the size of the newly-introduced tissue remains within admissible bounds. The TISHOM project focused on developing methods and tools to facilitate the design and effective construction of artificial tissues.

In the context of his PhD, Xavier Duportet worked on three projects on engineering human cells. The first one, dealing with developing tools to facilitate the engineering of mammalian cells, has been published [7]. The two others deal with the development of communication systems and still need to be finalized. This experimental work raised a number of more theoretical questions, that were investigated by François Bertaux, together with Szymon Stoma. Two problems have been investigated. The first one dealt with accounting for protein fluctuations for the analysis of signal transduction systems over long time scales and has been published [4]. The second one dealt with the multiscale simulation of tissues and is still under way. During the course of the project, a third line of research emerged, to assist the design of a patterning system currently developed by the Weiss lab. On the computational side, the major issues have been addressed. On the experimental side, additional constructions and characterizations are still needed.

Lastly, the associated team also helped to organize the workshop Design, optimization and control in systems and synthetic biology. Nearly 200 researchers and students attended this event. Although of relatively modest size, this event was attended by a number of leaders of the field and had a significant international visibility.

8.2.2. Inria International Partners

8.2.2.1. Collaboration with National Taiwan University

Since 2012, we have a collaboration with Prof. Jie-Hong Jiang, National Taiwan University first on hybrid simulations of biochemical reaction systems and now on the design of a compiler of digital programs and analog circuits in biochemical reactions. Our preliminary results and common publications on this topic [15], [16] are encouraging but a lot of work is needed to minimize the number of necessary species and reactions. Our aim, in partnership with Franck Molina (CNRS, Sysdiag, Montpellier) is to design a biosensor using our biochemical programming compiler, implement the generated code in a liposome using a microfluidic device, and test its efficacy *in vitro*.

8.3. International Research Visitors

8.3.1. Invited Professors

Prof. Alexander Bockmayr from Freie Universitat, Berlin, Germany, visited us from January to March 2014 for common work on constraint-based methods in computational systems biology, and teaching in our MPRI Master C2.19 course on computational methods for systems and synthetic biology.

MAGNOME Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

MAGNOME works with the ISVV and local industry to develop analyses and tools for rationalizing wine starter strain selection using genomics.

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 & H2020 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 International Partners

8.4.1.1. Informal International Partners

MAGNOME collaborates with Rodrigo Assar Cuevas at the University of Chile, Santiago, Chile and Joaquín Fernandez at the University of Rosario, Rosario, Argentina on hierarchical hybrid modeling using quantized state systems.

MAGNOME collaborates with Nicolás Loira at the University of Chile on methods for inferring genome-scale metabolic models.

MORPHEME Project-Team

6. Partnerships and Cooperations

6.1. Regional Initiatives

- iBV, "Genetics of mouse brain development" (Michèle Studer 's group): morphological analysis of neurons within the layer V of mice cortex
- TIRO group (CEA, UNS, Lacassagne center): histopathology analysis
- TIRO group (CEA, UNS, Lacassagne center): dynamics of iodin in the stomachal wall

6.2. National Initiatives

6.2.1. LABEX SIGNALIFE

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

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

Florence Besse and Grégoire Malandain participated in the selection committee for LabeX PhD programme students.

6.2.2. ANR MOTIMO

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

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)

6.2.3. 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.

6.2.4. ANR DIG-EM

Participants: Grégoire Malandain, Xavier Descombes.

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

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

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

6.2.5. ANR PhaseQuant

Participants: Grégoire Malandain, Eric Debreuve.

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

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

6.2.6. 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.

6.3. International Initiatives

6.3.1. Participation In other International Programs

We have obtained a CNRS/RAS project between IITP Moscow (S. Komech, E. Pechersky and E. Zhizhina) and Morpheme team (X. Descombes, A. Razetti).

6.4. International Research Visitors

6.4.1. Visits of International Scientists

Elena Zhizhina, Evgueny Pechersky and Serguei Komech from IITP Moscow (Russian Academy of Science) was invited one week in november.

Sonia Chaibi, PhD student at Badji Mokhtar-Annaba University (Algeria) has visited the Morpheme team during two months (january-february).

6.4.1.1. Internships

Tarun Yellamraju : IIT Bombay, Bachelor. Marked poiont process, graph cut and attractive interactions. Supervisors: X. Descombes.

6.4.2. Visits to International Teams

Xavier Descombes has visited the IITP in Moscow during one week in july within a CNRS/RAS program.

SERPICO Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

ENSAI-CREST: Statistical methods and models for image registration, Vincent Briane PhD thesis is co-funded by Inria and ENSAI-CREST and co-supervised by Myriam Vimond (ENSAI-CREST)

BioGenOuest: Advisory committee of the Biogenouest engineer S. Prigent in charge of the organization of image processing services for Biogenouest bio-imaging facilities.

8.2. National Initiatives

8.2.1. 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

8.2.2. France-BioImaging project

Participants: Charles Kervrann, Patrick Bouthemy, Tinaherinantenaina Rakotoarivelo, Thierry Pécot, Geoffrey Dieffenbach, Emmanuel Moebel, Perrine Paul-Gilloteaux.

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, ANR (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. 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 8.2.2 .

8.4. International Initiatives

8.4.1. Inria International Partners

8.4.1.1. Informal International Partners

Collaboration with UT Southwestern Medical Center, Dallas (TX), Prof. G. Danuser, on object tracking in video-microscopy.

Collaboration with University of California - San Francisco (USA), J. Sedat and D. Agard, on image deconvolution in light microscopy.

Collaboration with Imaging Systems Lab, Department of Electrical Engineering, Indian Institute of Science, Bangalore, India (Prof. Muthuvel Arigovindan) on image deconvolution in fluorescence imaging.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

8.5.1.1. Internships

Deepak George Skariah: Internship, Imaging Systems Lab, Department of Electrical Engineering, Indian Institute of Science, Bangalore, India.

VIRTUAL PLANTS Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. 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. In 2014, we organized a two-day workshop devoted to the modeling of plant development from the cellular to the organ scale.

7.1.2. MecaFruit3D

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

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

The fruit cuticle plays a major role in fruit development and shelf-life. It is involved in water losses, cracking, and protection against stress, and thus it may have major economic impacts. Objectives of the project are to better understand the multiple roles of the fruit cuticle in the control of fleshy fruit growth and quality. The project relies on a previously developed computational functional-structural tomato fruit model (Cieslak et al. 2011; 2012), that predicts the transport and accumulation of water and dry matter to various fruit tissues through a complex 3D vasculature network. This architecture-based model will serve as the backbone of a new approach for studying fruit development where interactions and feedback loops between turgor driven processes and cuticle mechanical constraints will be analysed and modelled. A collection of cuticle tomato mutants available at INRA Bordeaux will be used to validate the hypotheses.

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

7.1.3. 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 for 2D root system reconstruction from images developed in the RhizoPolis project (Agropolis foundation) to deal with large scale and high-thoughput analysis. For this we develop the project in the following directions:

1. make the analysis software more robust to various acquisition conditions using visual data mining technologies developped at Zenith.
2. Improve interoperability with other software and within the OpenAlea ecosystem.
3. Improve the reconstruction quality and its evaluation.

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

7.2. National Initiatives

7.2.1. ANR

7.2.1.1. 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.

7.2.1.2. HydroRoot

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

Funding: ANR (Contractor for Virtual Plants: Cirad, From 2012 to 2015)

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.

7.2.2. Other national grants

7.2.2.1. 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

7.2.2.2. 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

7.2.2.3. SCOOP

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

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

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

7.2.2.4. 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 .

7.2.2.5. Morphogenetics

Participants: Christophe Godin, Frédéric Boudon, Christophe Pradal, Grégoire Malandain, François Faure, Jan Traas, François Parcy, Arezki Boudaoud.

Funding: Inria Project Lab (From 2013 to 2016)

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), UMR PCV (Grenoble).

7.2.2.6. 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

7.3. International Initiatives

7.3.1. Inria International Partners

7.3.1.1. 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. [57].

An important collaboration with the CIRAD reserach unit HortSys of et the Reunion island and in particular Frédéric Normand has been established for several years. 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 year. This is a tripartite collaboration that also involves Pierre-Eric Lauri of the AGAP/AFEF team.

We have for several years a strong partnership with Ted de Jong group at UC Davis concerning the influence of various agronomic practices (water stress, pruning) on fruit tree branching and production [24]. This is a tripartite collaboration that also involves Evelyne Costes of the AGAP/AFEF team.

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

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

7.3.2. Participation In other International Programs

7.3.2.1. BioSensors

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

7.4. International Research Visitors

7.4.1. Visits of International Scientists

The team received several visitors from foreign research groups in 2014:

- 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.
- Pierre Barbier, post-doc researcher at the University of Bern visited the team for a few days in February.
- Yoan Coudert, from University of Cambridge, UK, visited the team for a few days days in April.

- Xavier Sirault, from High Resolution Plant Phenomics Centre at CSIRO, visited the team for one week.
- David Ford, Professor at the University of Washington, USA, visited the team for a few days days in December.

7.4.2. Visits to International Teams

7.4.2.1. Research stays abroad

- During the year, Frédéric Boudon visited Frédéric Normand of the UR Hortsys at the CIRAD La Réunion five weeks in April.
- Sarah Cohen-Boulakia has spent one month at the University of Pennsylvania (Philadelphia, April 2014) and one week at the Humboldt University of Berlin (December 2014).

ARAMIS Project-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, 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 cognitive 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.

8.1.1.2. ANR PREV-DEMALS

Participants: Olivier Colliot [Correspondant], Marie Chupin, Stanley Durrleman, Anne Bertrand.

Project acronym: PREV-DEMALS

Project title: Predict to prevent frontotemporal lobar degeneration (FTLD) and amyotrophic lateral sclerosis (ALS)

Duration: Avr 2015 - Avr 2019

Amount: 487k€

Coordinator: Isabelle Le Ber

Other partners: ICM, AP-HP, CHR de Lille, CHU Limoges, CHU Rouen, Laboratory of Biomedical Imaging

Abstract: The project focuses on C9ORF72, the most frequent genetic form of frontotemporal lobar degeneration (FTLD) and amyotrophic lateral sclerosis (ALS). Since 2006, major discoveries have helped elucidate the pathological bases and linked FTLD and ALS: 1) TDP-43 aggregates in neurons and 2) C9ORF72 mutations in both disorders. Two major pathological subtypes are now defined in FTLD, FTLD-TDP and FTLD-TAU. C9ORF72 mutations (associated to FTLD-TDP) are the most frequent genetic causes of FTLD (15%), FTLD-ALS (65%) and ALS (40%). No curative treatment actually exists, but therapeutics emerged against tau aggregation. The objectives of the project are to develop appropriate cognitive, brain imaging markers and peripheral biomarkers of the early phase of FTLD, to follow disease progression and to guide future targeted therapeutic trials. To address this questions, we will conduct a multimodal study (cognition, brain structural MRI, brain metabolism - FDG-PET) in C9ORF72 families. The cohort will be followed at 3-time points (M0, M18, M36). Longitudinal analyses will aim at characterizing the trajectory of decline across time. Brain structural changes will be evaluated by 1) morphometric analysis to assess global brain atrophy, cortical thickness and study of the cortical sulci; 2) functional connectivity analysis of resting-state MR data; 3) structural connectivity analysis of diffusion-weighted MRI. Brain metabolism will be evaluated with FDG-PET. We will use the most recent RNA sequencing technology to detect gene expression and RNA splicing alterations in lymphocytes of patients and presymptomatic carriers. The discovery of new markers involved in FTLD will have practical consequences for early and accurate diagnosis of FLD and ALS disease.

8.1.2. IHU

8.1.2.1. General program

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.

8.1.2.2. Internal Research projects

Participants: Mario Chavez, Fabrizio de Vico Fallani.

Project title: Non-invasive manipulation of brain synchrony to enhance brain function and rehabilitate faulty cognition in humans: A proof of concept

Founded in 2014

Coordinator: Antoni Valero Cabre

The long-term goal of this project is to develop the use of non-invasive manipulation of abnormal cerebral oscillations underlying cognitive activity to restore brain function in neurological patients. Cognitive functions emerge from large distributed networks organized in space and time. The short-term goal of this application is to study the causal role played by oscillatory activity in visual awareness and test whether their manipulation by non-invasive brain stimulation has the potential to restore its function in stroke patients.

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, Sonia Djobeir, Hugo Dary, Ludovic Fillon, Takoua Kaaouana, Alexandre Routier, Sophie Lecomte, Mathieu Dubois.

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. National Networks

- GdR Statistics and Medicine - http://gdr.statsante.fr/Accueil.html

8.1.5. Other National Programs

8.1.5.1. Programme Hospitalier de Recherche Clinique (PHRC)

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

- PHRC 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 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 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)

8.1.5.2. Institut Universitaire d'Ingénierie pour la Santé (IUIS)

Participants: Mario Chavez, Xavier Navarro.

Project acronym: DYSPEV

Project title: Dépistage de la dyspnée par potentiels évoqués visuels

Founded in 2014

Amount: 38K€

Coordinator: Thomas Similowski

Other partners: UPMC, Inserm UMR 1158

Abstract: Steady state visual evoked potentials (SSVEP) have been widely utilized in brain computer interfacing (BCI) in last years. In this project, we explore the possibilities of SSVEP to manage the communication between patients suffering from respiratory disorders and health care providers. By imposing different breathing constraints, we use a SSVEP-based brain computer interface to help those subjects to communicate their breathing sensations (breathing well/breathing bad).

8.2. European Initiatives

8.2.1. FP7 & H2020 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 analyzing 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 generalized 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. Inria International Partners

8.3.1.1. Non-contractual 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 a collaborations with the Departement of Mathematics, at Queen Mary University of London, UK (Prof. V. Latora); and the Physics Department of the Universitat de Barcelona, Spain (Prof. Albert Diaz-Guilera)

F. De Vico Fallani has a collaboration with the University Sapienza, Rome, Italy (Profs. Fabio and Claudio Babiloni) and with the IRCCS Fondazione Santa Lucia, Rome, Italy (M. Molinari and D. Mattia).

8.4. International Research Visitors

8.4.1. Visits to International Teams

8.4.1.1. Research stays abroad

M. Chavez spent 45 days as visiting researcher in the Physics Department of the Universitat de Barcelona, Spain (February, 2014)

ASCLEPIOS Project-Team

7. Partnerships and Cooperations

7.1. European Initiatives

7.1.1. FP7 & H2020 Projects

7.1.1.1. MD PAEDIGREE

Type: FP7

Defi: ICT for Health, Ageing Well, Inclusion and Governance

Instrument: Integrated Project

Objectif: Virtual Physiological Human

Duration: March 2013 - February 2017

Coordinator: Ospedale Pediatrico Bambino Gesu, Rome, Italy.

Partner: 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).

Inria contact: Xavier Pennec

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

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.

7.1.1.2. VP2HF

Type: FP7

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)

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: Maxime Sermesant

See also: http://vp2hf.eu/

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.

7.1.1.3. MedYMA

Type: FP7

Instrument: ERC Advanced Grant

Duration: April 2012 - March 2017

Coordinator: Inria (France)

Inria contact: Nicholas Ayache

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 enerative 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.

7.1.2. Inria International Partners

7.1.2.1. 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.

7.1.2.2. Informal International Partners

7.1.2.2.1. 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.

7.1.2.2.2. 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.

7.1.2.2.3. Other International Hospitals

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

7.2. International Research Visitors

7.2.1. Visits to International Teams

7.2.1.1. Research stays abroad

- Chloé Audigier spent 3 months at Siemens, Princeton, USA from September 22, 2014 to January 30, 2015.
- Jan Margeta spent 3 months at Microsoft Research, Cambrige, UK from July 1, 2014 to September 23, 2014.

ATHENA Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Projets Blancs 2014: Axe Interdisciplinaire de Recherche à l'échelle du pôle Nice - Sophia Antipolis

8.1.1.1. Real time detection of morpho-phonological computation in the brain

Participants: Maureen Clerc, Rachid Deriche, Théodore Papadopoulo, Demian Wassermann, Fabien Mathy [Université de Nice-Sophia Antipolis], Tobias Sheer [Université de Nice-Sophia Antipolis], Lucas Drevillon.

Duration: *June 2014 to November 2014*

The overall idea of this project is that current work [78] shows that it is possible to discriminate between morphological (i.e. concatenative) and phonological activity that is produced by the brain upon linguistic stimuli. That is, the experimental setup provides an on-line diagnostic for the presence or absence of phonological computation in the production of words.

On the neuroimaging side, the long-term challenge is to reproduce Sahin et al.'s [78] experiment with non-invasive methods (see the following section). If successful, the study will show that a processing sequence predicted on linguistic grounds is implemented in the brain in fine-grained spatiotemporally patterned activity. From the neuroimaging point of view, the development of such non-invasive methods that can accurately identify events in known regions will have an important impact on both computer science and neuroscience. Replacing deep electrode probes (implanted in the patient's brain) with algorithms to map cognitive processes onto brain activation will help developing new applications of functional neuroimaging. Note that results could also turn out to foster clinical tools in the diagnosis of patients affected by white matter abnormalities and altered structure-function relationships in the connectional anatomy of language.

This project aimed to perform a feasibility study for this research area. More precisely to investigate whether current neuroimaging technologies are able to provide the tools for the proposed linguistic analysis.

8.1.2. ARSLA-funded clinical study with Nice University Hospital

Participants: Maureen Clerc, Théodore Papadopoulo, Loïc Mahé, Asya Metelkina, Violaine Guy [Nice University Hospital], Claude Desnuelle [Nice University Hospital].

We are partners of Nice University Hospital in a project funded by "Association pour la Recherche sur la Sclérose Latérale Amyotrophique" (ARSLA), thanks to which we are conducting a clinical feasibility study on a Brain Computer Interface system called the P300 speller (see section New Results on Brain Computer Interfaces).

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. ANR CO-ADAPT

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

Duration: *December 2009 to April 2014*

The partners of this project were the INSERM U1028 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 was to study the co-adaptation between a user and a BCI system in the course of training and operation. The quality of the interface was judged according to several criteria (reliability, learning curve, error correction, bit rate). BCI were 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.

The aim of CO-ADAPT was 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).

This project has led to many concrete realizations, e.g. an international BCI Challenge on detecting Error Potentials, and software (CoAdapt P300 stimulator).

8.2.1.2. 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.

8.2.1.3. 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 were :

- 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 were 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 operated 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 was investigated, which includes astrocytes at this "mesoscopic" level and operates in networks of connected regions. Moreover, models in physiological and pathological conditions were compared, which is a step towards a better understanding of mechanisms underlying epileptic condition.

8.2.1.4. ANR VIBRATIONS

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

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.

8.2.2. ADT

8.2.2.1. ADT BOLIS

Participants: Théodore Papadopoulo, Juliette Leblond [APICS], Jean-Paul Marmorat [APICS].

Duration:*December 2014 to December 2016* ADT BOLIS aims to build a sofware platform dedicated to inverse source localisation, building upon the elements of software found in FindSources3D. The platform will be modular, ergonomic, accessible and interactive. It will offer a detailed visualisation of the processing steps and the results.

8.2.2.2. ADT OpenViBE-X

Participants: Théodore Papadopoulo, Maureen Clerc, Nathanaël Foy.

Duration: *October 2014 to October 2016*

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

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

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

8.2.2.3. 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 was 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 also supported the research made in four Inria teams (ATHENA, HYBRID, NEUROSYS and POTIOC) on hot topics such as adaptive or hybrid BCIs. In September 2014, the partners of this ADT organized a workshop on OpenViBE at the 6th international conference on Brain Computer Interfaces in Graz.

8.2.2.4. 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.

8.3. European Initiatives

8.3.1. ChildBrain ETN

Duration: *March 2015 to March 2019*

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

Program: European Training Network

Project acronym: ChildBrain

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

Duration: mois année début - mois année fin

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

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

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

8.4. International Initiatives

8.4.1. Inria Associate Teams

8.4.1.1. BRAINCONNECTIVITIES

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

International Partner (Institution - Laboratory - Researcher):

Ecole de Technologie Supérieure, Université du Québec, (CANADA)

Duration: Jan. 2012 - Dec. 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.

8.4.2. Inria International Partners

8.4.2.1. 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 on EEG/MEG source localisation.

8.4.3. Participation In other International Programs

- Programme Samuel de Champlain - Université de Sherbrooke, Canada.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Thinhinane Megherbi (USTHB, Algiers) visited ATHENA from May 30 until June 30, 2014.
- Kevin Whittingstall (Université de Sherbrooke) visited ATHENA from June 2 until June 5, 2014.
- Cristina Campi (Genoa University) visited ATHENA on March 28, 2014.

8.5.1.1. Internships

- Hughes Thomas (Queens's University, Ontario) visited ATHENA from May 5h until July 31
- Russel Taylor (Queens's University, Ontario) visited ATHENA from May 5th until July 31

DEMAR Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. AOI PARK DEMAR

Participants: Christine Azevedo Coste, Benoît Sijobert.

Appel d'Offre Interne (AOI) CGS Merri (CHU Montpellier). Development and evaluation of Freezing detection system in parkinson disease.

7.1.2. LABEX NUMEV

Participants: Christine Azevedo Coste, Christian Geny, Benjamin Gilles.

A M2 internship will be funded by the NUMEV Labex on the dynamic cartography of tremor using muscular echography.

7.2. National Initiatives

7.2.1. 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 national initiative is to favor the scientific collaboration and technological transfer of the innovation between DEMAR and MXM.

Innovation Lab "SoftStim" has ended in december 2014. The aim of this project was 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.

The industrial transfer has been achieved, notably through the design and realization of prototypes of neural stimulators.

7.2.2. BCI-LIFT: an Inria Project-Lab

Participants: Mitsuhiro Hayashibe BCI-LIFT is a large-scale 4-year research initiative (officially under peer-review evaluation) whose aim is to reach a next generation of non-invasive Brain-Computer Interfaces (BCI), more specifically BCI that are easier to appropriate, more efficient, and suit a larger number of people.

7.2.3. 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).

7.2.4. ADT SENSAS - SENSBIO

Participants: Christine Azevedo-Coste, David Andreu, Benoît Sijobert.

SENSAS is an Inria ADT (Actions de Développement Technologique), implying several Inria project teams on the âSENSor network ApplicationSâ 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.

7.2.5. INTENSE project

Participants: David Guiraud, Olivier Rossel, Melissa Dali, Christine Azevedo-Coste, David Andreu, Jérémy Salles, Guy Cathébras, 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.

7.2.6. INSEP FFS

Participants: Christine Azevedo Coste, Benoît Sijobert, Roger Pissard-Gibollet.

INSEP (Institut National du Sport, de l'Expertise et de la Performance) supports the project "Impact of the gaze direction on the skier trajectory" leaded by the Fédération Française de Ski (FFS).

7.3. European Initiatives

7.3.1. FP7 & H2020 Projects

Program: FP7

Project acronym: EPIONE

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

Duration: 2013-2017

Coordinator: AAU (Aalborg, Denmark)

Other partners: 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)

Abstract: http://project-epione.eu/
Participants: David Guiraud, David Andreu, Thomas Guiho, Arthur Hiairrassarry, Christine Azevedo Coste, Pawel Maciejasz.

7.4. International Initiatives

7.4.1. Inria Associate Teams

7.4.1.1. NEUROPHYS4NEUROREHAB

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

International Partner (Institution - Laboratory - Researcher):

IITH (INDE)

Duration: 2014 - 2016

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

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

7.4.2. Inria International Partners

Technology artificial and natural control assisted by electrical stimulation in functional transfers for subjects with disabilities after spinal cord injury
Inria principal investigator: Christine Azevedo Coste
International partner: Faculty of Ceilandia/ University of Brasilia - Emerson Fachin Martins, leader of the NTAAI-team. Nucleus of Assistive Technology, Accessibility and Innovation.
CAPES, Scholarship: BEX 3160/13-0 (Montpellier/France - December 2013 - February 2015)
CAPES, Appel: 88881.068134/2014-01 (2015 - 2017)

Around 90 million people acquired disabilities from Spinal Cord Injury (SCI) worldwide. The options available to stand up individuals with SCI without orthotics devices do not provide a functional upright position. The wheelchairs and seats to verticalize do not ensure an active participation based in a technology-human interaction. Moreover, the Verticalization devices are rarely used outside. The present international collaboration initiates a series of collaborations between the DEMAR-team and the NTAAI-team based on academic mobility of students and researchers. The general aim of this project is investigated technologies based in the functional electrical stimulation to promote functional transfers of the individuals with disabilities after SCI.

7.4.2.1. Informal International Partners

Katja Mombaur, Heidelberg University (Germany). Research Group Optimization in Robotics and Biomechanics, IWR Robotics Lab.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

Emerson Fachin Martins. Brazilian program: Science without borders (Ciências sem fronteiras) CAPES, Scholarship: BEX 3160/13-0 (Montpellier/France - December 2013 - February 2015)

7.5.1.1. Internships

Mitsuhiro Hayashibe supervised Saugat Bhattacharyya on "Study on Probabilistic nature of Motor Imagery Electroencephalography signals for control", PhD internship, Svaagata.eu: experience Europe as an Indian Erasmus Mundus, Jadavpur University, Kolkata, India, from Oct. 2014 to Jun. 2015.
Mitsuhiro Hayashibe supervised Roberto Baptista on "Framework for Automatic Assessment of Human Motion for Rehabilitation", PhD internship, bourse d'etudes du Gouvernement Bresilien, Fondation Capes, Universidade de Brasilia (UnB), Brasil, from May 2014 to Apr. 2015.

7.5.2. Visits to International Teams

Mitsuhiro Hayashibe was Visiting Researcher at RIKEN BSI-TOYOYA research institute and worked on "Tacit Synergetic Motor Learning for rehabilitation" (Jul.-Aug. 2014).
M. Hayashibe was invited to talk at International Workshop on Human Assistive Systems Based on Human Modeling in Tokyo, on December 14, 2014, organized by Prof. Toshiaki Tsuji, Saitama University, Prof. Yuichi Kurita, Hiroshima University

GALEN Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Excellence Clusters

- Program: DIGITEO (Chair)

  Project acronym: SubSample

  Project title: Identification and prediction of Salient brain States through probabilistic structure learning towards fusion of imaging and genomic date

  Duration: 01/2012-12/2015

  Coordinator: ECP - FR
- Program: DIGITEO (OMTE)

  Project acronym: Curator

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

  Duration: 01/2013-01/2015

  Coordinator: ECP - FR
- Program: DIGITEO
  - Project acronym: SOPRANO
  - Project title: Structured Output Prediction on Large Scale Neuroscience Data
  - Duration: 3/2013-3/2016
  - Coordinator: Ecole Centrale Paris - FR
- Program: MEDICEN

  Project acronym: ADOC

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

  Duration: 11/2011-09/2015

  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: ANR JCJC

  Project acronym: LearnCost

  Project title: Learning Model Constraints for Structured Prediction

  Duration: 2014-2018

  Coordinator: Inria Saclay - 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 & H2020 Projects

8.3.1.1. DIOCLES

Type: FP7

Instrument: European Research Council

Duration: September 2011 - August 2016

Coordinator: Nikos Paragios

Partner: Ecole Centrale de Paris (FR)

Inria contact: Nikos Paragios

8.3.1.2. MOBOT

Type: FP7

Defi: Cognitive Systems and Robotics

Instrument: Specific Targeted Research Project

Objectif: Cognitive Systems and Robotics

Duration: February 2013 - January 2016

Coordinator: Angelika Peer

Partner: University of Bristol (UK)

Inria contact: Iasonas Kokkinos

8.3.1.3. I-SUPPORT

Type: H2020

Defi: Cognitive Systems and Robotics

Instrument: Specific Targeted Research Project

Objectif: Cognitive Systems and Robotics

Duration: March 2015 - February 2018

Coordinator: Rafa Lopez

Partner: Robotnik Automation (Spain)

Inria contact: Iasonas Kokkinos

8.3.1.4. RECONFIG

Type: FP7

Defi: Cognitive Systems and Robotics
Instrument: Specific Targeted Research Project
Objectif: Cognitive Systems and Robotics
Duration: February 2013 - January 2016
Coordinator: Dimos Dimarogonas
Partner: KTH (SE)
Inria contact: Iasonas Kokkinos

8.3.1.5. Strategie

Type: FP7
Instrument: Career Integration Grant
Duration: January 2014 - December 2017
Coordinator: Inria
Inria contact: Matthew Blaschko

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
International Partner (Institution - Laboratory - Researcher):
Stanford University (ÉTATS-UNIS)
Duration: 2012 - 2014
See also: http://cvn.ecp.fr/personnel/pawan/research/splendid.html

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 Engineering Science. Collaboration Topic: Structured prediction 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
- University of Colorado, Department of Computer Science (USA) - Research with the Autonomous Robotics & Perception Group. Collaboration topic: Large scale video segmentation using efficient approximations to a graph Laplacian.

Asia

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

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Professor Maragos, Petros: Technical University of Athens, GR (October 2014)

8.5.1.1. Internships

- Gastounioti, Aimilia: Technical University of Athens, GR (from February until June 2014)
- Trulls, Eduard: Universitat Politècnica de Catalunya, ES (from June until October 2014)
- Vedantam, Shanmukha Ramakrishna: Virginia Tech, USA (from June 2014 until August 2014)]

8.5.2. Visits to International Teams

- Ferrante, Enzo: Stanford University, USA (from June to September 2014)

8.5.2.1. Research stays abroad

- Boussaid, Haithem: University of Pennsylvania, USA (from June to September 2014)
- Togkas, Stavros: Oxford University, UK (from August to November 2014)

MNEMOSYNE Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

As our team just settled in Bordeaux, it was an important priority for our early years of activity to initiate local collaborations, at the regional level.

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

The aim of this project (partly funding the PhD of Meropi Topalidou) is to investigate decision making at intermediate level in order to establish the link between motor primitives and higher level actions. The question is to understand how continuous complex motor sequences can be dynamically represented as actions such that they can be manipulated to resolve conflict when several actions are possible. This PhD work will require an extensive review of the literature and more specifically literature that promote a global view on decision making. The DANA modeling framework will be used for the design of distributed, numerical and adaptive models using rate based neuron models. The model will ideally be embodied into a simulator or a robotic platform in order to solve a simple taks such as for example, foraging or grasping, with a continuous component at the motor level.

7.1.2. Project of the Department Sciences and Technologies of the University of Bordeaux: Pinokio

In collaboration with school of engineers ENSEIRB and the support of the Department Sciences and Technologies of the University of Bordeaux, we've built a prototype of a motorized lamp equipped with a camera and leds. It can move autonomously and track faces with dedicated algorithms. The goal of this project is to have a dedicated robotic platform to study motor interaction and to investigate decision making in order to establish the link between motor primitives and higher level actions.

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

The neurotransmitter dopamine (DA) plays a key role in basal ganglia (BG) circuits. However, despite the fundamental importance of DA in those circuits, the electrophysiological effects of dopamine on target neurons are largely unknown. Furthermore, contrary to classical models that only view the globus pallidus (GP) as a relay station of the indirect pathway, our neuroscientist colleagues at IMN have discovered a novel GP cell-type called the Arkypallidal (Arky-GP) neurons that only project to striatum in a very dense way. Arky-GP cells represent a novel BG pathway that might contribute massively to the GABAergic inhibition in striatum. In this project, we would like to explore for the first time whether DA has a direct action on Arky-GP neurons through D2 DA receptors. To do so, this project is based on multidisciplinary approaches that bring together 3 teams of IMN with different but complementary expertise (anatomical, in vivo electrophysiology, optogenetic manipulation, and computational modeling).

7.1.4. Collaboration with the Neurocentre Magendie on parameter optimization: Neurobees

The development of computational models of neurons and networks typically involves tuning of the numerical parameters to fit experimental results. This fitting is necessary to obtain consistent neural activity and therefore consistent action potential genesis and timing which play a key role in neural information encoding. However his task requires the exploration of multidimensional parameter spaces which are rarely accessible to analytical approaches. Moreover, if the parameter tuning can sometimes be manually completed it is more convenient to use automated optimization algorithms at least for two reasons: (i) to apply an homogeneous processing to all the calculation and parameter space exploration which alleviates operator influence and (ii) to avoid a tedious and uncertain result from human operators when the dimensionality increases. In computational

neuroscience, the optimization algorithms are often applied to cell scale models to mimic the electrical activity of their biological counterpart. Most of the time, it is necessary for the neuroscientist to quantify biophysical parameters such as dynamic conductances, ionic concentrations or even neuronal structure to understand the neuron dynamic properties. In this field, there is an important need for innovative optimization tools. We have recently developed with neuroscientists of the Bordeaux Magendie Neurocentre, a new multi-agent algorithm in line with ABC (Artificial Bee Colony) paradigm. This algorithm whose principle is based on honeybees food foraging has been successfully applied to several neural modeling optimization problems. We have applied it to several benchmarks and it has shown significantly higher performances in computing optimal parameter values in comparison with the previous optimization tools. A method paper summarizing all these results will be submitted at the begining of 2015.

7.1.5. Collaboration with IMS on GSM signal effects: JNNS (Julia Neural networks Simulator)

In collaboration with IMS (Laboratory of Material and System Integration, in Bordeaux) we have developed a electrophysiological setup aiming at the investigation of the effects of GSM (Global System for Mobile communications) signal on neural living tissue [15]. Our biological model consists in a cortical cell culture growing on a multi-electrode array. A first series of observations have been published showing a significant effect of these wavelengths on primary neural cell cultures spontaneous electrical activity. We are now looking for the action mechanism and site which could explain the observed effects. Along with these experimental investigations, modeling studies are considered. A spiking neuron network model is developed, taking into account biological features of the cell culture and exhibiting similar excitatory/inhibitory connectivity ratios as well as spontaneous bursting activity and a model of the recording setup (extracellular electrodes). To optimize the model development and notably the simulation speed, we have implemented the model using the Julia language. This tool is also be developed following the NeuroML initiative standards.

7.2. National Initiatives

7.2.1. ANR

7.2.1.1. ANR project KEOPS

Participants: Frédéric Alexandre, Thierry Viéville.

We were 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, that ended in december 2014. The project was addressing 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. Results concerning the thalamus and the retina evoked in § 6.3 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 (*cf.* the ECOS project in § 7.3).

7.3. International Initiatives

7.3.1. Project BGaL with India

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

7.3.2. Project ECOS-Sud with Chile

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

7.4. International Research Visitors

7.4.1. Internships

P Mehta Hima

Date: June - Dec 2014

Institution: Univ. Hyderabad (India)

7.4.2. Visits to International Teams

M. Topalidou, N. Rougier and F. Alexandre visited IIIT of Hyderabad (India) from 7 to 12 Dec. 2014 (*cf.* the BGaL project in § 7.3).

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 & H2020 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, Cambridge; Debreceni Egyetem, Debrecen; Technische Universität Dresden, Dresden; CNRS-UNIC, Gif-sur-Yvette; CNRS-INCM, Marseille; CNRS-ISM, Marseille; TUG, Graz; Ruprecht-Karls-Universität Heidelberg, Heidelberg; Forschungszentrum Ju¨lich GmbH, Jülich; EPFL LCN, Lausanne; EPFL-BBP, Lausanne; The University Of Manchester, Manchester; KTH, Stockholm; Universität Zuürich, Zuürich

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 future 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)

Objectif: NC

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

Objectif: NC

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

Objectif: NC

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

6.3. International Initiatives

6.3.1. Participation In other International Programs

6.3.1.1. ANR KEOPS

Title: 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

Researcher: Maria-Jose ESCOBAR

Duration: 2011 - 2014

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

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 scenarios2 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

- Paul Bressloff, Professor of mathematics at the University of Utah won an international chair at Inria (2013-2017).
- Michele Migliore, Research Scientist at the Institute of Biophysics, National Research Council, Palermo, Italy. Funded by the "Axe Interdisciplinaire de Recherche de l'Université de Nice – Sophia Antipolis".
- Cyan O'Donnell, Postdoc at the Computational Neurobiology Laboratory in the Salk Institute, Califorina, from 9th July until 19th July 2014. Funded by the "Axe Interdisciplinaire de Recherche de l'Université de Nice – Sophia Antipolis".

6.4.1.1. Internships

- Cesar Ravello, pHd student with A. Palacios, Centro Interdisciplinario de Neurociencia de Valparaíso, Univ de Valparaíso, Valparaíso, Chile. From May 2014 until Jun 2014
- Ruben Herzog, Master student in Valparaiso, with A. Palacios, Centro Interdisciplinario de Neurociencia de Valparaíso, Univ de Valparaíso, Valparaíso. From November, 12th 2014 until November 14th 2014.

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 three-year multi-site project (2012–2015) 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 2014) 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 the motor areas 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 & H2020 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 from University of Barcelona for three months in fall 2015. Contact is Axel Hutt.

7.3.2. Collaborations in European Programs, except FP7 & H2020

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.

7.3.3. Collaborations with Major European Organizations

Lifestyle Research Association (LIRA): Philips (Netherlands), Fraunhofer (Germany), Inria

Sleep is an essential part of a healthy life, but many people have trouble getting enough uninterrupted sleep. Special sensors installed in a mobile phone or bed can analyze activities, stress patterns and sleep sequences and provide ideas for new strategies and, eventually, products that support a healthier night's sleep. NEUROSYS has a Postdoc project running merging all sensor signals in a single data analysis technique to improve existing sleep monitors.

7.4. International Initiatives

7.4.1. Inria International Partners

7.4.1.1. 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).
- In the collaboration with Jérémy Lefebvre (University of Lausanne), we have been working out together a stochastic delayed neural field analysis leading to new insights into the effects of additive noise (A. Hutt).
- The collaboration with Peter beim Graben (Humboldt University Berlin) on recurrence data analysis has led to analysis techniques to detect meta-stable states in EEG-signals (A. Hutt).
- We have an ongoing collaboration with Pr. Motoharu Yoshida at the Ruhr University Bochum, Germany, aiming 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 of 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 professor LieJune Shiau (University of Houston, June) to discuss future collaborations on the modeling of neural populations based on single neuron properties in the presence of anaesthetic drugs. In addition, Motoharu Yoshida (Ruhr-Universität Bochum, Germany) visited our lab, gave a seminar and we discussed our current collaboration about memory and persistent firing cells of the hippocampus.

7.5.2. Visits to International Teams

7.5.2.1. Research stays abroad

Axel Hutt has stayed for 1 month at the Humboldt University Berlin to enforce the collaboration with Peter beim Graben (October - November).

PARIETAL Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. iConnectom project

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

This is a Digiteo project (2014-2017).

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

8.1.2. 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 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, e.g. for relapse prediction.

8.1.3. Medilearn/braincodes Inria-MSR project

Participants: Bertrand Thirion [Correspondant], Gaël Varoquaux, Andrés Hoyos Idrobo.

Neuroimaging is accumulating large functional MRI datasets that display –among artefacts and noise– brain activation patterns giving access to a meaningful representation of brain spatial organization. This ongoing accumulation is intensified via new large-scale international initiatives such as the *Human Connectome Project* (www.humanconnectomeproject.org). but also to existing open repositories of functional neuroimaging datasets (https://openfmri.org/) or http://www.fmridc.org/. These datasets represent a very significant resource for the community, but require new analytic approaches in order to be fully exploited. The MediLearn/BrainCodes project strives to provide a synthetic picture of the brain substrate of human cognition and its pathologies. In practice, this can be achieved by learning from large-scale datasets a brain atlas that summarizes adequately these functional activation maps drawing from a large number of protocols and subjects. Once learned, such an atlas is extremely useful to understand the large-scale functional organization of the brain: it is a tool for understanding *brain segregation*, the different encoding of many cognitive parameters into different brain regions, as well as *brain integration*, *i.e.* how remote brain regions co-activate across subjects and experiments.

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. 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.

8.2.1.2. 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 (2010-2014).

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.

8.2.1.3. 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 structures from brain imaging. With regards to neuroimaging methods development, NiConnect provides systematic comparisons and evaluations of connectivity biomarkers and a software library embedding best-performing state-of-the-art approaches. Finally, with regards to medical applications, the NiConnect project also plays a support role in on going medical studies and clinical trials on neurodegenerative diseases.
- **Consortium**
  - Parietal Inria research team: applied mathematics and computer science to model the brain from MRI
  - LIF INSERM research team: medical image data analysis and modeling for clinical applications
  - CATI center: medical image processing center for large scale brain imaging studies
  - Henri-Mondor hospital neurosurgery and neuroradiology: clinical teams conducting research on treatments for neurodegenerative diseases, in particular Huntington and Parkinson diseases
  - Logilab: consulting in scientific computing

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. HBP

Type: FP7

Defi: Future and Emerging Technologies

Instrument: Collaborative Project with Coordination and Support Action

Objectif: FET Flagships

Duration: October 2013 - March 2016

Coordinator: Henry Markram (EPFL, Switzerland)

Partners: 86 partners, https://www.humanbrainproject.eu/fr/discover/the-community/partners

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 realization motivates the Human Brain Project – an EU Flagship initiative in which over 80 partners will work together to realize 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 prioritizing 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, modeled 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 realize 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 (2013-2016) followed by an operational phase (2016-2023). Bertrand Thirion is responsible for the 2.1.1 task, *Anatomo-functional mapping of the human brain*.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

Gaspar Pizarro made a three months internship (January-March 2014), funded by Inria Chile and Conycit. His research topic was *Improving the fit of functional MRI data through the use of sparse linear models.*.

8.4.1.2. Other visitors

Danilo Bzdok (Forschungszentrum Jülich, institue of neuroscience and medicine) visited Parietal several months in 2014 (February-March, then September-), to develop collaborations on the use of machine learning techniques to model behavioral variables and find data-driven characterization of brain diseases.

8.4.2. Visits to International Teams

8.4.2.1. Research stays abroad

As part of the SubSample Digiteo chair, Alexandre Abraham spent six months in the USA at Stony Brook University and Nathan Klein Institute.

POPIX Team

8. Partnerships and Cooperations

8.1. European Initiatives

8.1.1. FP7 & H2020 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; Takeda, 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.

8.2. International Initiatives

8.2.1. Inria International Partners

8.2.1.1. Informal International Partners

POPIX has a collaboration with the Faculty of Pharmacy of Manchester University (UK). Marc Lavielle is invited every year to give a one day course about mixed effects models and the MONOLIX software.

POPIX has a collaboration with the Faculty of Pharmacy of Buffalo university (USA). Marc Lavielle is invited every year to give a 2 days course about mixed effects models and the MONOLIX software.

8.2.2. Participation In other International Programs

Indo French Centre for the promotion of advanced research (CEFIPRA): Marc Lavielle was invited to participate to the the IFCAM Workshop in Statistics and Mathematical Biology, in Bangalore (August 2014).

SHACRA Project-Team

7. Partnerships and Cooperations

7.1. National Collaborations

The team is collaborating with many national partners, such as:

- the Oscar Lambret Hospital in the context of the interactive inverse FEM simulation (Luis Shiapacasse, Nick Reynaert and Eric Lartigau),
- CHR Lille (Laurent Thines),
- the radiology department of Nancy Hospital within the IDeaS project,
- the TeamC research lab,
- the Inria ASCLEPIOS research team,
- the Inria EVASION research team,
- the Inria MARGRIT research team,
- the Inria LAGADIC research team.

7.2. National Initiatives

7.2.1. Sofa, OR

In December 2014, a new ADT national initiative started. The objective of this ADT is twofold: first, we aim at achieving a level of quality and robustness compatible with IEC 62304 for the core of SOFA and a reduced set of components. This does not include the certification of the code itself, but rather the implementation of a comprehensive development process that will enable the certification by companies wishing to integrate this code into their systems. The second objective is to add new features specific to the needs of using intra-operative: interoperability with equipment from the operating room, acquisition and real-time processing of full HD video streams, data assimilation and predictive filters, path planning, visualization for augmented reality, or user interfaces dedicated to the operating room.

7.2.2. RESET

At the end of the year, the team has been awarded a new ANR project: RESET. This project will start in March 2015. Its objective is to develop a high-fidelity training system for retinal surgery. Retina surgery is an increasingly performed procedure for the treatment of a wide spectrum of retinal pathologies. Yet, as most micro-surgical techniques, it requires long training periods before being mastered. This simulator will be built upon our strong scientific expertise in the field of real-time simulation, and our success story for technology transfer in the field of cataract surgery simulation (MSICS simulation developed for the HelpMeSee foundation).

7.2.3. 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.

7.2.4. 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.

7.2.5. 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.

7.2.6. 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.

7.3. European Initiatives

7.3.1. RASimAs

2014 was the first year of the RASimAs project (STREP project funded under FP7) during which we developed new models of the biomechanics of the leg and arm, as well as the simulation of the insertion of the anaesthesiology needle. 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.

See http://rasimas.imib.rwth-aachen.de for more details.

7.4. International Initiatives

7.4.1. Informal International Partners

The team is collaborating with:

- the King's College of London,
- Aachen University (Germany),
- Bangor University (United Kingdom),
- Universidad Rey Juan Carlos (Spain),
- Foundation for Research and Technology Hellas (Greece),
- SenseGraphics (Sweden).

SISTM Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

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

8.2. National Initiatives

8.2.1. Labex Vaccine Research Institute (VRI)

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

8.2.2. Expert Appraisals

Coordination with Jean Weissenbach of the presidential plan of 100 M€ for “Systems biology” (RT)

Deputy director of the Institut de Recherche en Santé Publique IRESP (RT)

8.3. International Initiatives

8.3.1. Participation In other International Programs

RT is participating to the EUROCOORD network on HIV cohort collaborations as :

a member of the scientific committee of IWHOD International Workshop on HIV Observational Databases from 2013,

a project leader on defining references for the CD4 count response to antiretrovirals.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

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

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

Steve Self and Peter Gilbert in Seattle (HVTN HIV vaccine Trial Network),

Marcus Altfeld (Immunologists, Hambourg & Harvard).

This group in collaboration with other teams in Europe is writing a response to the H2020 call PHC 2 – 2015: Understanding diseases: systems medicine.

8.4.2. Visits to International Teams

8.4.2.1. Sabbatical programme

BL is on sabbatical in Queensland University, Australia.

8.4.2.2. Research stays abroad

Chloé Pasin is visiting Steve Self at HVTN, Seattle.

Boris Hejblum visited François Caron at Oxford University, United-Kingdom.

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 2014, 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, i.e. 30k€. Two projects including brain MRI were selected. The EPMR-MA project led by the neuropsychologist Pierre-Yves Jonin, and co-funded by Fondation de l'avenir in 2014, will evaluate memory effects in healthy adults and in patients presenting cognitive impairments using BOLD fMRI, ASL and Diffusion MRI. The second project is a complementary funding for the project led by Dr Fabienne Pelé (see below).

8.1.3. Projet Fondation de France : PERINE

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

This study evaluates the effect of prenatal exposure to neurotoxicants on the developing brain. Following previous studies in the PELAGIE cohort this MRI study involves ASL, Diffusion and working memory as well as motor inhibition BOLD fMRI together with neuropsychological tests in children. Inclusions have started in November 2014 and will continue over 2 years.

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

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

initial duration: 12 months from November 2012. Project extended in 2014.

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 started in early 2013. The project was extended in 2014 to recruit more patients.

8.1.5. 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. Project extended in 2014.

A complementary funding (20 000€) was obtained to support a new research project on rehabilitation of stroke patients. The fMRI protocol was setup, the task developed and validation on volunteers is ongoing. Patient inclusions started in spring 2013. This project was also extended to 2014 to recruit more patients. Group analysis on the control group was performed and a paper will be submitted soon.

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. ANR "Neurological and Psychiatric diseases" NUCLEIPARK

Participants: Christian Barillot, Sylvain Prima.

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. [35]. 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, Caudate, 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. This project involves three partners: NeuroSpin, Inria (Athena and Visages) and UPMC (University Pierre and Marie Curie, Paris) including Inserm U678 and the CENIR.

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. TRANSLATE-MS-REPAIR

Participants: 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" [0]. 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

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

(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, Florent Leray, Michael Kain, Yao Yao.

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.

8.2.3. Collaboration with the CEA (Commissariat à l'Energie Atomique) : Imaging data quality control in the context of dementia

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

duration: 12 months from September 2014.

Dementia, in particular Alzheimer Disease (AD), affects about 900,000 people in France. As an early and reliable diagnosis remains a difficult task, neuroimaging plays a crucial in assisted-diagnosis by analyzing structural and functional brain abnormalities associated wiht the disease. The "Centre pour l'Acquisition et le Traitement des Images (CATI)" has created a national network of neuroimaging centers in order to promote clinical research on MA using advanced imaging techniques. Visages and the Neurinfo platform are recognized in the CATI for their expertise in Arterial Spin Labeling, both on the acquisition and the post-processing sides. In this context and in the frame of the Alzheimer plan, a collaboration contract was signed between Inria and CEA, the coordinator for the CATI, in order to host an engineer at Inria for a year. This engineer develops control quality tools and advanced post-processing techniques for ASL to be used in nation-wide clinical studies coordinated by the CATI.

8.3. European Initiatives

8.3.1. FP7 & H2020 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

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

Duration: December 2010 - 2016

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

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

Inria contact: C. Kervrann, C. Barillot

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 & H2020

Program: COST

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

Project title: Arterial spin labeling 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 Labeling (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. The Visages team is involved in the workgroups ASL data acquisition (E. Bannier), ASL data analysis (C. Barillot, I. Corouge, P. Maurel) and clinical validation of ASL in cognitive impairment (J.-C. Ferré).

8.4. International Initiatives

8.4.1. Inria Associate Teams

8.4.1.1. BARBANT

Title: Boston and Rennes, Brain image Analysis Team

International Partner (Institution - Laboratory - Researcher):

Boston Children's Hospital (ÉTATS-UNIS)

Duration: 2012 - 2014

See also: http://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. In 2014, two workshops were organized (one in Rennes, one in Boston), and several publications were accepted /submitted in diffusion imaging. An extension for three more years has been applied for in December 2014.

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.
- From November 2014 to February 2015, Hrishikesh Deshpande visits Duke University (in Durham, North Carolina, United States) to collaborate with Professor Guillermo Sapiro on classification using Dictionary Learning. This visit was partially founded by a mobility grant from the doctoral school MATISSE.
- Maia Proisy was co-supervised by UCL and Visages (Pr Jean-Christophe Ferré), during her 6 months visit at UCL for her master research work. In this collaboration was investigated and implemented a pCASL sequence at 3T for measuring brain CBF in neonates at risk of hypoxic-ischemic encephalopathy. This work was also designed to establish a pCASL protocol for further study. Arterial Spin Labelling was a part of an ongoing study (The UCH Baby Brain Study - London), led by Prof Nicola Robertson and Dr Cristina Uria-Avellanal. Imaging data acquisition and processing was made by scientist from the UCL Institute of Neurology - London (Magdalena Sokolska and Prof Xavier Golay).

ANGE Project-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.

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.

8.1.3. LRC Manon (2010–2014 and 2014–2018)

Participants: Edwige Godlewski, Yohan Penel, Nicolas Seguin.

CEA and Laboratory Jacques-Louis Lions launched a collaboration in order to carry out studies about complex fluids (modelling, numerical simulations and optimisation), in particular about compressible two-phase flows. This includes the derivation of strategies for model coupling, for instance in the case of an asymptotic hierarchy of models. This collaboration was recently renewed for another 4-year partnership.

8.2. National Initiatives

8.2.1. ANR MIMOSA (2014–2017)

Participants: Nora Aïssiouene, Marie-Odile Bristeau, Anne Mangeney, Jacques Sainte-Marie.

Program: ANR Défi 1 "Gestion sobre des ressources et adaptation au changement climatique"

Project acronym: MIMOSA

Project title: Microseism MOdeling and Seismic Applications

Coordinator: Eleonore Stutzmann (IPGP)

Seismic noise is recorded by broadband seismometers in the absence of earthquakes. It is generated by the atmosphere-ocean system with different mechanisms in the different frequency bands. Even though some mechanisms have been known for decades, an integrated understanding of the noise in the broadband period band 1-300sec is still missing. Using novel theoretical, numerical and signal processing methods, this project will provide a unified understanding of the noise sources and quantitative models for broadband noise. Conversely, we will be able to interpret seismic noise in terms of ocean wave properties. This first analysis step will lead to the identification and characterization of source events, which we will use to improve noise tomography, and seismic monitoring.

8.2.2. ANR LANDQUAKES (2012–2016)

Program: ANR Blanc "Mathématiques et interactions"

Project acronym: LANDQUAKES

Project title: Modélisation des glissements de terrain et des ondes sismiques générées pour détecter et comprendre les instabilités gravitaires

Coordinator: 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.

A. Mangeney is also involved in the CARIB ANR program (2014–2017) entitled “Comprendre les processus de construction et de destruction des volcans de l’Arc des Petites Antilles”.

8.2.3. GdR EGRIN (2013–2017)

Participants: Anne Mangeney, 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 and A. Mangeney is a member of the committee. The scientific goals of this project are the modelling, analysis and simulation of complex fluids by means of reduced-complexity models in the framework of geophysical flows.

8.2.4. ADT Inlgae, Inria Project Lab “Algae in Silico”

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

In the framework of the ADT Inlgae (2013–2014), we developed in collaboration with the BIOCORE Inria project-team a simulation tool for microalgae culture. It lead to the recruitment of R. Hamouda as a young engineer.

An Inria Project Lab “Algae in Silico” is planned in collaboration with BIOCORE. It concerns microalgae culture for biofuel production and the aim is to provide an integrated platform for numerical simulation “from genes to industrial processes”.

8.2.5. 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.

8.2.6. Statistical Inference for Structure Health Monitoring (I4S)

Participant: Nicolas Seguin.

The I4S team results from a collaboration between Ifsttar and Inria. N. Seguin is funded by this team. His work consists in providing 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.

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

The scienfitic group (GIS in French), which includes Inria, 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. Inria International Partners

8.4.1.1. 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, ...

CASTOR Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- ANEMOS : ANR-11-MONU-002

  ANEMOS : Advanced Numeric for Elms : Models and Optimized Strategies associates JAD Laboratory/Inria (Nice, Manager), IRFM-CEA (Cadarache), Maison de la Simulation (Saclay) and Inria EPI Bacchus (Bordeaux). 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 to qualify 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 IODISSEE : 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).

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

- EUROfusion Grant agreement number 633053. Enabling Research program.
  - JOREK, BOUT++ non-linear MHD modelling of MHD instabilities and their control in existing tokamaks and ITER.
  - Synergetic numerical-experimental approach to fundamental aspects of turbulent transport in the tokamak edge. Grant agreement number 633053.
- EUROfusion WPCD (Working Package Code Development)
  - ACT1: Extended equilibrium and stability chain (participation)
  - ACT2: Free boundary equilibrium and control (participation and coordination)

8.3. International Initiatives

8.3.1. Inria Associate Teams

8.3.1.1. AMOSS

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

International Partner (Institution - Laboratory - Researcher):

NCKU (TAIWAN)

Our objective here is to generalize the promising modeling strategy proposed by S. Gavrilyuk (2012-2013) to genuinely 3D shear flows and also take into account the curvature effects related to topography. Special care will be exercised to ensure that the numerical methodology can take full advantage of massively parallel computational platforms and serve as a practical engineering tool. Cross validations will be achieved by experiments and numerical simulations with applications to landslides.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

In the context of the AMoSS Team :

- Key-Ming Shyue of the National Taiwan University, Juilly 3 to July 13 2014, Numerical Methods: Implicit and Thinc interpolation.
- Chih-Yu Kuo, Associate Research Fellow, Research Center for Applied Sciences, Academia Sinica, Taipei, Taiwan,
- Chyan-Deng Jan, Professor, National Cheng Kung University, Tainan, Taiwan. Workshop on the Modeling of dry granular flows, CIRM Marseille: September 8 to September 13 2014.

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.

8.2. European Initiatives

8.2.1. Collaborations in European Programs, except FP7 & H2020

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/en/index.html, 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.

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

7.2.1.1. COKLYCO

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

International Partner (Institution - Laboratory - Researcher):

Kyoto (JAPON)

Duration: 2014 -

See also: https://team.inria.fr/coffee/?page_id=323

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

7.2.2. Participation In other International Programs

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" http://www.gdre-us.cnrs-mrs.fr/spip.php?rubrique8

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

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

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

FLUMINANCE Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. 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.

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

Participant: Cédric Herzet.

duration 48 months. The GERONIMO project which starts in March 2014 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 at 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.

8.1.3. INSU-LEFE: Toward new methods for the estimation of sub-meso scale oceanic streams

Participant: 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 collaboration with the Laboratoire de Météorologie Dynamique, Ecole Normale Supérieure, Paris.

8.1.4. INSU-LEFE: MODELER

Participant: Etienne Mémin.

duration 24 months. This project with MeteoFrance aims at exploring error modeling and stochastic parameterization in geophysical flow dynamics. The theory explored in this context should enable the construction of unified image data assimilation strategies.

8.2. International Initiatives

8.2.1. Inria International Partners

8.2.1.1. Informal International Partners

Universidad de Buenos Aires (ARGENTINA) We have maintained academic exchanges with the group of Guillermo Artana.

Chico California State University (USA), We have pursue our collaboration with the group of Shane Mayor on the GPU implementation of wavelet based motion estimator for Lidar data. This code is developped in coproperty between Inria and Chico.

8.2.2. Participation In other International Programs

SticAMSUD project Voiceproduction leaded by Denisse Sciamarella (CNRS, LIMSI)

KALIFFE Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

Our group participates to the following ANR projects with different colleagues of us in Lyon

- ANR STAB on stability for the asymptotic behavior of PDEs, stochastic processes and their discretization. The Principal Investigator is I. Gentil (UCB Lyon) and F. Filbet is a participant.
- ANR BOND on boundaries, numerics and dispersion. The Principal Investigator is S. Benzoni (UCB Lyon) and L. M. Rodrigues is a participant.
- ANR de groupe "*Highly-Efficient ATmospheric modelling*" (HEAT), 2014–2018. The Principal Investigator is Th. Dubos and D. Le Roux is a participant.

On the other hand, we have submitted a projet on the call 2015 on adapted dynamic and multi-scale methods. F. Filbet, M. Bergot are participants.

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

This is the last year of the ERC Project Nusikimo devoted to the mathematical and numerical analysis in statistical physics with a special interest to applications in Plasma Physics (CEA-CELIA laboratory in Bordeaux, where the Mega-Joule Laser is built) and micro-technology with MEMS (university of Catania). Our project gathers young researchers in applied mathematics from the group in Mathematical Modelling and Scientific Computing in Lyon.

7.2.2. Collaborations in European Programs, except FP7 & H2020

Program: Eurofusion - Enabling Research Project for the implementation of the fusion roadmap

Project acronym: Verification of global gyrokinetic code.

Project title: Verification of global gyrokinetic codes and development of new algorithms for gyrokinetic and kinetic codes.

Duration: 1 year.

Coordinator: E. Sonnendrücker.

Other partners: Max Planck Intitute (Garching, Germany).

Abstract: The aim of this proposal the improvement of the numerical methods for gyrokinetic models and to investigate new ideas towards fully kinetic simulations of tokamaks and stellarators. It consists of three main parts: the first is devoted to the definition of verification models that enable to verify that the implemented codes are a good approximation to a given continuous model and that contain the most challenging numerical problems in the most simple possible setting. New benchmarks of the codes will also be performed. The second part is devoted to the improvement of each category of codes and the third to experimenting new ideas that can lead to better codes in the longer term

7.3. International Initiatives

7.3.1. Inria International Partners

Our team is a partner on the CoKLyCo project. It is the acronym of the project COffee-Kyoto-LYon-COperation. The project if funded by Inria, through its International Affairs programs and the Japan Society for the Promotion of Science (JSPS), through the cooperation program AYAME (Wink: Ayame means iris. . .).

Kinetic theory plays a central role in many areas of mathematical physics, from nanoscales to continuum mechanics. It is an indispensable tool in the mathematical description of applications in physical science from its origin in dilute gases, to wide applications such as semiconductors, polymers, cells, plasma, galaxies, traffic networking, and swarming. Many challenges remain in both the analysis and efficient computational techniques for such problems. The project is concerned with the modeling of rarefied gas dynamics for Micro-Electro-Mechanical Systems. The design of such devices with tiny scales leads to new questions related to the intricate particles/structures interactions. Strongly motivated by the specific technological content, we wish to develop original computational tools, based on rigorous mathematical basis. This project is therefore concerned with the mathematical analysis and the numerical simulation of systems of PDEs of kinetic type, or their hydrodynamic counter-part, set in a moving domain. In 2014, we started working on several aspects of these questions, owing to a couple of visits and meetings during conferences, like the one in CIRM, Nov, 2014.

7.3.1.1. Informal International Partners

- F. Filbet collaborates with J. M. Qiu from the University of Houston on positive method for Vlasov type models.
- F. Filbet collaborates with G. Russo and S. Boscarino at University of Catania (Italy) on high order numerical schemes for time evolution equation and with L. Pareschi at the University of Ferrara (Italy) on spectral methods for Boltzmann equations [7].
- L. M. Rodrigues collaborates with M. Johnson (Kansas University) and K. Zumbrun (Indiana University) and their group on stability issues and asymptotic model reduction.

LEMON Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

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

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

8.2. International Initiatives

8.2.1. Inria International Labs

Antoine ROUSSEAU visited Inria Chile in April, 2014 (2 weeks, see Associate Teams below) in order to prepare an application for a research center on marine energies in Chile.
This application is coordinated by DCNS Energies Marines and also involves Inria Chile and PUC University (Santiago).

8.2.2. Inria Associate Teams

Antoine ROUSSEAU collaborates with the ANESTOC partners (TOSCA at Inria Sophia and Rolando Rebolledo at PUC, Santiago, Chile) on the stochastic analysis of renewable energies. Together with Mireille Bossy (TOSCA), AR supervises the research of two engineers in Chile: Jacques Morice and Cristián Paris.

Antoine ROUSSEAU collaborates with the DYNECOS2 partners (MODEMIC at Inria Sophia and Hector Ramirez at CMM, Santiago, Chile) on the bioremediation of natural resources.

In the framework for these two collaborations, AR visited Inria Chile in April, 2014 (2 weeks). See the TOSCA (resp. MODEMIC) project team activity report for more information on the ANESTOC (resp. DYNECOS) associate team.

8.2.3. Inria International Partners

8.2.3.1. Informal International Partners

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

Vincent GUINOT collaborates with S. Soares-Frazao (Unité de Génie Civil, Université catholique de Louvain, Belgium)

Fabien MARCHE and Antoine ROUSSEAU collaborate with R. Cienfuegos (PUC University, Santiago, Chile)

MAGIQUE-3D Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

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

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. In 2014 the second phase of DIP has begun. Lionel Boillot has been hired as engineer to work on the DIP platform.

8.2.2. Micro-local analysis of wave equations

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

8.2.3. Partnership with the department DMAE of ONERA

title: Modeling of multiperforated plates

Coordinator: Sébastien Tordeux

Other partners: Department DMAE of ONERA

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

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

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

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. 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.

Two members of MAGIQUE-3D (Julien Diaz and Victor Péron) participated to the last Workshop of HPC-GA in Grenoble on October 2014.

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.

In this framework, Rabia Djellouli visited Magique 3D in December 2014

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 Graduate 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 Computação Científica), COPPE/UFRJ (Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia/Alberto Luiz Coimbra Institute for Graduate 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 Computação Departamento de Computação, Universidade Federal do Ceará). The French partners are research teams from several Inria research centers.

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, 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 in

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

An international workshop on “Computational Geophysics” gathering around 50 participants has been organized in Novosibirsk in the framework of GEO3D in September 2014

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Serguey Solovyev spent two months in MAGIQUE-3D in march 2014 and in December 2014.
- Mounir Tlemcani spent one month in MAGIQUE-3D in May 2014.
- Laurent Gizon
- Rabia Djellouli spent two weeks in MAGIQUE-3D in December 2014.

MOISE Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- 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).
- N. Feyeux PhD is sponsored by the action ARC3 Environment of the Region Rhone-Alpes.

8.1.1. Collaborations with Various Regional Research Teams

- LGGE Grenoble, Edge team (C. Ritz, O. Gagliardini, F. Gillet-Chaulet, G. Durand), see paragraphs 6.3.2 .
- LTHE, A.C. Favre: hydrological risk assessment.
- LTHE, Thierry Lebel, Théo Vischel: tracking of mesoscale convective systems,
- LTHE, MISTIS, LJK: AGIR project. Clémentine Prieur obtained the funding for a thesis on risk assessment.
- Univ. Lyon 1 collaboration with V. Maume-Deschamps.
- LGGE, MEOM team : 6.2.3 ,6.3.1 ,6.2.3.1 ,6.2.5 , 6.2.1 , 6.1.1 .

8.2. National Initiatives

8.2.1. Interactions with other Inria Project-Teams or Actions

Participants	Inria Project-Team	Research topic	Link
M. Nodet C.Prieur, P. Tencaliec	LEMON MISTIS	Life-Fluid coupling hydrological risk assessment	https://team.inria.fr/lemon/ 6.6
L. Gilquin, C. Helbert, C.Prieur, A. Vidard	STEEP	Calibration and sensitivity analysis for LUTI models	6.8
C.Prieur, L. Viry	GRAAL	Grid deployment for the study of West African Monsoon	6.4
A. Vidard M. Nodet F.X. Le Dimet	CLIME, FLUMINANCE	Image assimilation	6.2.3
A. Vidard, M. Nodet, E.Kazantsev	SCIPORT	Ocean Adjoint Modelling	6.3.1 ,6.2.5

8.2.2. Collaborations with other Research Teams in France

Participants	Research Team	Research topic	Link
C. Prieur	IMT Toulouse, EDF	Sensitivity analysis	6.4.1
C. Helbert, S. Nanty, C. Prieur	CEA Cadarache	Sensitivity analysis	6.4.1
C. Prieur	ICJ Lyon 1, CEDRIC 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	6.3.1
A. Vidard	LOCEAN (Paris)	Ocean Adjoint Modelling	6.3.1
A. Vidard	LPO (Brest), CERFACS	Ocean data assimilation	6.3.1
F. Lemarié, L. Debreu	Ifremer (Brest), LEGOS (Toulouse), LOCEAN (Paris), UPS (Toulouse), SHOM (Toulouse)	Numerical schemes for ocean modelling	6.1.1
F. Lemarié	LPO (Brest), Meteo France (Toulouse), Mercator-Ocean (Toulouse)	Atmospheric boundary layer modeling	6.1.2
L. Debreu, F. Lemarié	LMD (Paris), CNRM (Toulouse), LSCE (Saclay)	Numerical schemes for atmospheric modelling	6.1.1
E. Blayo, F. Lemarié	LSCE (Saclay)	Coupling methods for climate models	6.1.2

8.2.3. Other National Initiatives

- C. Prieur chairs GdR MASCOT NUM, in which are also involved M. Nodet, E. Blayo, C. Helbert, L. Viry, S. Nanty, L. Gilquin.

  http://www.gdr-mascotnum.fr/doku.php
- C. Prieur is the leader of the LEFE/MANU project MULTIRISK (2014-2016) on multivariate risk analysis, which gathers experts from Lyon 1 University, CNAM, LSCE and Grenoble University mainly.
- M. Nodet is involved in GDR Calcul and GDR Ondes.
- 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 6.3.1 .
- 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)
- 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 .

8.2.4. ANR

- A 4-year ANR contract: ANR TOMMI (Transport Optimal et Modèles Multiphysiques de l'Image), see paragraphs 6.2.3.2 ,6.2.3 .

- A 4 year ANR contract (2011-2015): ANR COMODO (Communauté de Modélisation Océanographique) on the thematic "Numerical Methods in Ocean Modelling". (coordinator L. Debreu) 6.1.1
- A 4-year ANR contract (2014-2018) : ANR HEAT (Highly Efficient Atmospheric modelling) on the development of numerical schemes for atmospheric models (coordinator: T. Dubos, LMD)
- 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 & H2020 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: 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.

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

World leading Numerical Weather Center, that include an ocean analysis section in order to provide ocean initial condition for 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.

8.4. International Initiatives

8.4.1. Inria International Partners

8.4.1.1. Declared Inria International Partners

Jose R. León (UCV, Caracas) was funded for a 1,5 months invitation.

8.4.2. Participation In other International Programs

- C. Prieur collaborates with Jose R. León (UCV, Central University of Caracas).
- C. Prieur is leader of a project ECOS Nord with Venezuela (2012-2015).

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Jose-Raphael Leon-Ramos, Caracas University, 3 months
- Victor Shutyaev, Russian Academy of Sciences, 2 weeks

8.5.2. Visits to International Teams

8.5.2.1. Research stays abroad

- M. Nodet visited the University of Reading Data Assimilation group and gave a seminar.
- F.-X. Le Dimet visited the Florida State University, department of meteorology and oceanography during three weeks in June 2014 (Invitation of Prof. Xiaolei Zou). One seminar given on assimilation of images 6.2.3 .
- F.-X. Le Dimet visited the Harbin Institute of Technology, department of mathematics during one month in October 2014 (Invitation of Prof. Jianwei Ma). A serie of four one-hour seminars has been delivered on variational methods in data assimilation.

POMDAPI Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

GT Elfic (Labex DigiCosme, 2014–2016): "Programmes d'éléments finis formellement vérifiés", with TOCCATA (Inria Saclay - Île-de-France), LIX (École Polytechnique), CEA LIST, LIPN (Université de Paris 13), and LMAC (Université de Technologie de Compiègne).

7.2. National Initiatives

ANR DEDALES (2014–2017): "Algebraic and Geometric Domain Decomposition for Subsurface Flow". The project aims at developing high performance software for the simulation of two phase flow in porous media. The project will specifically target parallel computers where each node is itself composed of a large number of processing cores, such as are found in new generation many-core architectures. The partners are HIEPACS, Laboratoire Analyse, Géométrie et Application, Maison de la Simulationand Andra. The coordinator of the project is M. Kern.

ANR GEOPOR (2014–2017): "Geometrical approach for porous media flows: theory and numerics", with Laboratoire Jacques-Louis Lions (Université de Paris 6).

ANR MANIF (2011–2014): "Mathematical and numerical issues in first-principle molecular simulation", with CERMICS (École Nationale des Ponts et Chaussées), and Laboratoire Jacques-Louis Lions (Université de Paris 6).

C2S@Exa (Computer and Computational Sciences at Exascale, 2011–2015) is an Inria Project Lab (IPL). This national initiative aims at the development of numerical modeling methodologies that fully exploit the processing capabilities of modern massively parallel architectures in the context of a number of selected applications related to important scientific and technological challenges for the quality and the security of life in our society. This project supports in particular the PhD of N. Birgle, supervised by. J. Jaffré, which is part of an Inria-Andra collaboration.

Projet P (2011–2015) is funded by the French FUI (*Fonds Unique Interministériel*). 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 modelization semantics. This project supports the work of C. Franchini, under the supervision of P. Weis.

7.3. European Initiatives

7.3.1. Collaborations in European Programs, except FP7 & H2020

Program: Research, Development and Innovation Council of the Czech Republic

Project acronym: MORE

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

Duration: September 2012–September 2017

Coordinator: Josef Málek, Charles University in Prague

Other partners: Institute of Mathematics, Academy of Sciences of the Czech Republic; Oxford Centre for Nonlinear Partial Differential Equations, Great Britain.

Abstract: A multidisciplinary project on nonlinear Navier–Stokes flows with implicit constitutive laws. It focuses on development of accurate, efficient, and robust numerical methods for simulations of the new class of implicit models, see http://more.karlin.mff.cuni.cz/.

7.4. International Initiatives

7.4.1. Participation In other International Programs

Pomdapi is part of the EuroMediterranean 3+3 program with the project HYDRINV (2012–2015): 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).

7.5. International Research Visitors

7.5.1. Visits of International Scientists

Todd Arbogast, professor, Center for Subsurface Modeling, The University of Texas at Austin. September 2014.

Peter Bastian, professor, Interdisciplinary Center for Scientific Computing, University of Heidelberg. June 2014.

H. Ben Ameur, professor at IPEST and member of ENIT-Lamsin, Tunis, Tunisia. June and December 2014.

G. D. Veerappa Gowda, professor, Tata Institute for Fundamental Research, Center for Applicable Mathematics, Bengalore. November-December 2014.

7.5.1.1. 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*.

7.5.2. Visits to International Teams

7.5.2.1. Research stays abroad

M. Vohralík, April 1st–May 9th. Research stay in the framework of the project MORE "Implicitly constituted material models: from theory through model reduction to efficient numerical methods", Charles University in Prague, see http://more.karlin.mff.cuni.cz/.

SAGE Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. 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 were organized in 2014. These workshops ended up with a proposal submitted in response to the Future and Emerging Technology (FET) call of H2020 Funding.

7.2. National Initiatives

7.2.1. ANR-MN: H2MNO4 project

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

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 6.4 , 5.1.1). ANR organized a review of the project in December 2014.

7.2.2. 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 final evaluation was in December 2014.

The team Sage was the leader of the Scientific Challenge Hydro: Multi-parametric intensive stochastic simulations for hydrogeology. The objective was to run multiparametric large scale simulations (see 6.4).

7.2.3. Inria Project Lab: C2S@EXA project

Participants: Édouard Canot, Jocelyne Erhel, Géraldine Pichot.

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 6.2 , 6.4 , 6.5). The team participated in several workshops.

7.2.4. 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 platform H2OLab. We obtained and used computing time on machines located at GENCI supercomputing centers. (see 6.2 , 6.4).

7.2.5. GDR MOMAS: project on reactive transport

Participant: Jocelyne Erhel.

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 6.4 , 6.5). The team participated in workshops.

7.3. European Initiatives

7.3.1. FP7 & H2020: EXA2CT project

Type: FP7

Challenge: Special action

Instrument: Specific Targeted Research Project

Objective: Exascale computing platforms, software and applications

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.

7.3.2. 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).

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.

7.4. International Initiatives

7.4.1. 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 Yaoundé, Cameroon - Norbert Noutchegueme

Duration: 2010-2014

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.

7.4.2. LIRIMA laboratory: EPIC team (Tunisia)

Participants: Édouard Canot, 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: 2011-2015

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

Abstract: The team deals with nonlinear and inverse problems.

7.4.3. 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.

7.4.4. ECOS Sud (Chili): ARPHYMAT project

Participant: Édouard Canot.

Program: CONICYT

Title: Processus de formation et transformation de structures de combustion archéologique : un regard interdisciplinaire

Inria principal investigator: Édouard CANOT

International Partner (Institution - Laboratory - Researcher): Universidad de Tarapaca (Chili)

Duration: Jan 2014 - Dec 2016

Abstract: Multidisciplinary study of prehistoric fire traces in South America, by means of different approaches: taphonomy of the soil, physical processes involved during the heat transfer, modeling and numerical simulations.

7.4.5. 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.

7.4.6. 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 7.4.5 , 7.4.2).

7.4.7. Informal International Partners

University of Purdue (USA)

High Performance Scientific Computing

University of San Diego (USA)

Hydrogeology

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- Emmanuel Kamgnia, University of Yaoundé, 2 months, March-April 2014
- Nabil Nassif, American University of Beirut, 1 week, May 2014
- Stratis Gallopoulos, Uiversity of Patras, 1 week, May 2014
- Ahmed Sameh, University of Purdue, 1 week, May 2014

7.5.2. Internships (Joint supervision of Ph-D students)

- Louis-Bernard Nguenang, University of Yaoundé, 4 months, April-July 2014
- Marwen ben Refifa, University of Tunis, 5 months, April-July and Sep 2014
- Salwa Mansour, Lebanese University, 8 months, Feb-Sep 2014

7.5.3. Visits to International Teams

- Édouard Canot, ENIT Tunis, Tunisia, 1 week, November 2014 (project HYDRINV)

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

Brian Morton

Date: May 2014 - Jul 2014

Institution: University of North Carolina at Chapel Hill (USA)

8.4.1.1. Internships

Jayasi Mehar

Date: May 2014 - Jul 2014

Institution: IIIT-D (Inde)

Solange Blundi

Date: Jul 2014 - Jan 2015

Institution: Universidad de Buenos Aires (Argentina)

Luciano Gervasoni

Date: Jun 2014 - Dec 2014

Institution: Universidad Nacional del Centro de la Provincia de Buenos Aires (Argentina)

Patricio Inzaghi

Date: Jul 2014 - Jan 2015

Institution: Universidad de Buenos Aires (Argentina)

Abdelrahman Ahmed Mohamed

Date: Mar 2014 - Jul 2014

Institution: Nile University (Egypt)

Iman Boukhriss

Date: Mar 2014 - Aug 2014

Institution: INSA (Lyon)

TONUS Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

- ANR project "PEPPSI" in Programme Blanc SIMI 9 – Sciences de l'ingénierie (Edition 2012) started in 2013. Participants : Giovanni Manfredi (coordinator), Edwin Chacon Golcher, Sever Hirstoaga.

8.1.2. Euratom-CEA projects

- Michel Mehrenberger and Philippe Helluy are local coordinators of the project FR FCM (CNRS Federation on Magnetic Confinement Fusion), within Euratom-CEA association, Title:"Numerical Methods for GYSELA", the goal is to help improving the numerical algorithms used by the GYSELA code developed at CEA Cadarache for the simulation of turbulence in magnetic fusion plasmas.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

The members of the team were in the following EUROfusion research projects:

E. Frénod, P. Helluy, S. Hirstoaga, M. Mehrenberger, L. Navoret were members of the project *CfP-WP14-ER-01/IPP-03*:

Max-Planck Institute for Plasma Physics, Garching (PI: Eric Sonnendrücker)

"Verification of global gyrokinetic codes and development of new algorithms for gyrokinetic and kinetic codes"

E. Frénod was member of the project *CfP-WP14-ER-01/Swiss Confederation-01*

École Polytechnique Fédérale de Lausanne (PI: Paolo Ricci)

"Synergetic numerical-experimental approach to fundamental aspects of turbulent transport in the tokamak edge"

E. Franck was member of the EUROfusion Enabling Research Project

CEA Cadarache, IRFM/SIPP/GP2B (PI: Marina Becoulet)

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

8.3. International Research Visitors

8.3.1. Visits to International Teams

8.3.1.1. Research stays abroad

Michel Mehrenberger was on secondment at the Max Planck Institute in Munich until September 1st, 2014.

Emmanuel Frénod was invited professor during May 2014 at the Institute of Natural Sciences, Shanghai Jiao Tong University, Shanghai - China.

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) coordinated by M. Chaves, and ran through April 2014.
- **ANR-Facteur 4:** The objective of this project (2012-2015) is to propose non OGM strains 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: 2013-2017) 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-Phycover:** The overall objective of the project (2014-2018) is to draw the scientific, technical and industrial contexts for an evolution of wastewater treatment plants, combining three modules: a high-rate algal pond dedicated to the treatment of municipal wastewater, an anaerobic digester, and a module aiming at enhancing the digestate valorization.
- **ANR-FunFit:** The objective of this project (2013-2017) is to develop a trait-based approach linking individual fitness of fungal plant pathogens to ecological strategies. The idea is to derive eco-epidemiological strategies from fitness optimization in colonized environments and during colonization, as well as understanding the coexistence of sibling species. This project is co-coordinated by F. Grognard.
- **ANR-TripTic:** The objective of this project (2014-2018) is to document the biological diversity in the genus of the minute wasps *Trichogramma*, and to study the behavioral and populational traits relevant to their use in biological control programs.
- **ANR-GESTER:** "Management of crop resistances to diseases in agricultural landscapes as a response to new constraints on pesticide use", ANR Agrobiosphère, 2011–2015. This project aims at producing allocation scenarios of resistant varieties at the scale of cultivated landscapes, that will allow to limit disease development while ensuring sustainable efficiency of genetic resistances. BIOCORE participates in this project via MIA, INRA Jouy-en-Josas.
- **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)
- **MIHMES:** "Multi-scale modelling, from animal Intra-Host to Metapopulation, of mechanisms of pathogen spread to Evaluate control Strategies", ANR – Investissement d'avenir, action Bioinformatique (ANR-10-BINF-07) & Fond Européen de Développement Régional des Pays-de-la-Loire (FEDER), 2012–2016. This project aims at producing scientific knowledge and methods for the management of endemic infectious animal diseases and veterinary public health risks. BIOCORE participates in this project via MIA, INRA Jouy-en-Josas.

- **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 Université Nice Sophia Antipolis.
- **Peps BMI 2013** -J-A Sepulchre (INLN CNRS UNS) - Projet "Pectolyse". Study of a virulence factor of a bacterium.
- **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 modeling of the process.
- **OPTIBIO:** This project is devoted to the analysis of optimal control problems related to bioprocesses. The project is funded by Programme Gaspard Monge pour L'Optimisation et la Recherche Opérationnelle and coordinated by T. Bayen (U. Montpellier 2).

8.1.2. INRA funding

- **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 provides the major part of the funding for the experiments held for Elsa Rousseau's thesis.
- **Coexistence:**. INRA-SPE is funding the project "Coexistence d'espèces cryptiques par différenciation temporelle de niches écologiques : de la théorie à l'application via l'exemple des oïdiums du chêne et de la vigne", which aims at understanding the co-existence of closely related plant pathogens in temperate environments. It is closely related to the FunFit ANR project.
- **K-Masstec:** "Knowledge-driven design of management strategies for stem canker specific resistance genes", INRA Metaprogramme SMaCH, PRESUME action, 2013–2016. The project aims at demonstrating that the knowledge issued from the understanding of the molecular interaction between distinct avirulence genes, and mainly the discovery of non-conventional gene-for-gene interactions, can be used to develop efficient strategies for the deployment of genetic resistance in the field.
- **PRRSeval:** "An integrated approach to PRRS (Porcine Reproductive and Respiratory Syndrome)", INRA Metaprogramme GISA, 2013–2015. PRRSeval has three main objectives: to develop a live-attenuated, miRNA-controlled vaccine effective to protect from emerging PRRSV strains; to identify and prioritize relevant parameters for dynamic epidemiology of herds based on in vivo profiling of PRRSV and vaccine response; and to consolidate and empower the existing French networks and collaborations with external partners and stakeholders. BIOCORE participates in this project via MIA, INRA Jouy-en-Josas.

8.1.3. Networks

- **M3D:** "Mathématiques et décision pour le développement durable", supported by the RNSC (Réseau National des Systèmes Complexes) and INRA, MIA department. BIOCORE participates in the M3D network. L. Mailleret and S. Touzeau are among the network's co-leaders.
- **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 modeling and control aspects of the processes involving anaerobic bacteria or microalgae.
- **GDR Invasions Biologiques:** The objectives of this GDR are to encourage multidisciplinary research approaches on invasion biology. It has five different thematic axes: 1) invasion biology scenarios, 2) biological invasions and ecosystem functioning, 3) environmental impact of invasive species, 4) modeling biological invasions, 5) socio-economics of invasion biology. L. Mailleret is a member of the scientific comittee of the GDR

- **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 & H2020 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):

Modeling 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 Labs

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.

8.3.2. Inria Associate Teams

8.3.2.1. GREENCORE

Title: Modelling and control for energy producing bioprocesses

International Partner (Institution - Laboratory - Researcher):

Communication and information Research and Innovation Center (CHILI)

Duration: 01/2014 - 12/2016

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

The worldwide increasing energy needs together with the ongoing demand for CO2 neutral fuels represent a renewed strong driving force for the production of energy derived from biological resources. In this scenario, the culture of oleaginous microalgae for biofuel and the anaerobic digestion to turn wastes into methane may offer an appealing solution. The main objective of our proposal is to join our expertise and tools, regarding these bioprocesses, in order to implement models and control strategies aiming to manage and finally optimize these key bioprocesses of industrial importance. By joining our expertises and experimental set-up, we want to demonstrate that closed loop control laws can significantly increase the productivity, ensure the bioprocess stability and decrease the environmental footprint of these systems. This project gathers experts in control theory and optimization (BIOCORE, UTFSM) together with experts in bioprocesses (PUCV and UFRO) and software development (CIRIC).

8.3.3. Inria International Partners

8.3.3.1. 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.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Benoit Chachuat (Imperial College, Department of chemical engineering, UK), 1 week;
- Claude Aflalo (Ben Gurion University of the Neguev, Israel), 1 week;
- Diego Oyarzún (Imperial College London), 1 week;
- Andrei Akhmetzhanov (Université de Montpellier II, F), 1 week.

8.5. Project-team seminar

BIOCORE organized a 3-day seminar in November in Saint-Etienne de Tinée. On this occasion, every member of the project-team presented his/her recent results and brainstorming sessions were organised. Alain Rapaport of the Inria MODEMIC team was invited as a guest speaker.

An additionnal 2-day seminar was dedicated to modeling and control of microalgae.

CARMEN Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

Modélisation of the multinodal date (years 2012–2015) funded by the Conseil Regional Aquitaine. Coordinator J.-F. Aujol (Pr University Bordeaux). The PhD of G. ravon is funded within this project: 3D reconstruction by inverse problem in cardiac optical mapping.

7.2. National Initiatives

7.2.1. IHU LIRYC

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

- For 2014: the salary of M. Potse, member of Carmen, is payed by the LIRYC..
- For 2012-2015: 1/2 PhD thesis associated to the project *Modélisation pour les données multimodales* (see section Regional Initiaves).

7.2.2. ANR HR-CEM

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

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

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

Based on these collaborations and new developments in structural and functional imaging of the heart available at LIRYC, we plan to reconsider the concepts behind the models in order to improve the accuracy and efficiency of simulations. Cardiac simulation software and high-resolution numerical models will be derived from experimental data from animal models. Validation will be performed by comparing of simulation output with experimentally recorded functional data. The validated numerical models will be made available to the community of researchers 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.

7.2.3. 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.

7.2.4. 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.

7.2.5. REO

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

7.2.6. MedicActiv

The CARMEN team cooperate in interaction with the MedicActiV project.

7.3. International Initiatives

7.3.1. 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.
- Cooperation with Laboratoire de Modélisation Mathématique et Numérique dans les Sciences de l'Ingénieur (LAMSIN in Tunisia.

7.4. International Research Visitors

7.4.1. Visits of International Scientists

In the framework of the EPIC project in the LIRIMA lab, N. Zemzemi has invited:

- Mohamed Jebalia assistant professor from LAMSIN Tunisia
- Moncef Mahjoub assistant professor from LAMSIN Tunisia
- Jamila Lassoued. Phd student from LAMSIN Tunisia
- Najib Fikal PHD student from University MohamedV, Moroco
- El Mahid El Guarmah assitant professor from University of Marrakech. Moroco.

7.4.2. Internships – Visiting PhD Students

- Carlos Chavez Borgesn, from may 2014 to Sep 2014,*Inverse Problem of Electrocardiography: estimating the location of cardiac isquemia in a 3D geometry*
- Ali Gharaviri, from Apr 2014 to May 2014
- Wajih Mbarki, until Aug 2014, *Analysis of an interaction problem in biomathematics: purk-inje/myocardium coupling in the heart*
- Jamila Lassoued, until Aug 2014, *Construction of reduced order methods for optimization problems in cardiac electrophysiology*

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", 2009-2014.
  Participants: Samuel Bernard, Fabien Crauste [Coordinator], Olivier Gandrillon, Thomas Lepoutre, Philippe Michel, Laurent Pujo-Menjouet, 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 from 2013 to 2015 is 198 keuros, including three one-year post-doc positions (one post-doc has been recruited in April 2014 (Xuefeng Gao)), and the members are Fabien Crauste and Olivier Gandrillon.
- 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".

8.1.2. Other projects

- Inria ADT : SiMuScale "Simulations Multi-Échelles de Populations Cellulaires", 2014-2016.
  Participants: Samuel Bernard [Coordinator], Fabien Crauste, David Parsons.
- Association France Alzheimer Sciences Médicales 2014 : PAMELA "Prion et Alzheimer : Modélisation et Expérimentation d'une Liaison Agressive", 2014. Partners: UR0892 VIM (Virologie et Immunologie Moléculaires), INRA Domaine de Vilvert, Jouy-en-Josas.
  Participants: Mostafa Adimy, Samuel Bernard, Thomas Lepoutre, Laurent Pujo-Menjouet [Coordinator], Léon Tine.

8.2. European Initiatives

8.2.1. Collaborations in European Programs, except FP7 & H2020

- Research program PHC POLONIUM (2014-2015) "Applications of reaction-diffusion equations in biology and medicine". Partners: Warsaw, Poland (Slawomir Bialecki, Jolanta Ciesielska, Bogdan Kazmierczak (coordinator), Marek Kochanczyk, Tomasz Lipniacki).
  Participants: Mostafa Adimy, Abdennasser Chekroun, Laurent Pujo-Menjouet [Coordinator], Alen Tosenberger, Vitaly Volpert.

8.2.2. 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. Modelling leukemia

Title: Modeling quiescence and drug resistance in Chronic Myeloid Leukemia

International Partner (Institution - Laboratory - Researcher):

Center for Scientific Computation And Mathematical Modelling, University of Maryland (United States).

Duration: 2013 - 2015.

See also: http://dracula.univ-lyon1.fr/modelling_leukemia.php

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.

8.3.2.2. FCRF

Program: Fonds France Canada pour la recherche (FFCR)- France Canada research fund (FCRF) "New research collaboration" 2014-2015.

Title: Mathematical modelling of megakaryopoiesis and applications to platelet related diseases

Participants: Mostafa Adimy, Fabien Crauste, Laurent Pujo-Menjouet [Coordinator].

International Partners : Canada (Jiguo Cao, Nemanja Kosovalic, Jianhong Wu).

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

Anass Bouchnita

Subject: Numerical simulations of blood flows and blood coagulation

Date: from March 2014 until May 2014

Institution: École Mohammadia d'Ingénieurs (EMI), Rabat, Morocco

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-M3DISIM.

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

7.2.1.1. VPH-Share

Type: FP7

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 integrating 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 M3DISIM team is in charge of developing some high-performance data assimilation software tools.

7.2.1.2. VP2HF

Type: FP7

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)

See also: http://vp2hf.eu/

Abstract: Heart failure (HF) is one of the major health issues in Europe affecting 6 million patients and growing substantially because of the aging population and improving survival following myocardial infarction. The poor short to medium term prognosis of these patients means that treatments such as cardiac re-synchronisation therapy and mitral valve repair can have substantial impact. However, these therapies are ineffective in up to 50% of the treated patients and involve significant morbidity and substantial cost. The primary aim of VP2HF is to bring together image and data processing tools with statistical and integrated biophysical models mainly developed in previous VPH projects, into a single clinical workflow to improve therapy selection and treatment optimisation in HF.

7.3. International Research Visitors

7.3.1. Visits of International Scientists

7.3.1.1. Internships

Alexendre Laurin [Simon Fraser Univ., Canada] Sébastien Imperiale [correspondant] Philippe Moireau Dominique Chapelle

In the context of an ongoing collaboration between the Aerospace Physiology lab (Simon Fraser University, Vancouver, Canada) and Inria (M3DISIM and Reo teams), Alexandre Laurin (PhD student) has been awarded some funding for a 2 months internship in the M3DISIM team, with the objective of initiating the modelling of seismocardiography (SCG) measurements. SCG consists in measuring displacements of the sternum and ribs generated by a heart beat using accelerometers placed on the thorax. In this context, linear elastodynamics equations are applicable to account for the transient propagation of motion from the heart to the sternum via the highly heterogeneous underlying materials (cartilage and bone). Specific care has been taken to solve the aforementioned equation in a realistic 3D geometry including the complete thoracic cage. Fully coupled simulations (beating heart with thorax deformation) are planned at the final stage of this modelling work in 2015.

MAMBA Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

DIGITEO Project (DIM LSC) ALMA

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

September 2014 - August 2017

Coordinator: Catherine Bonnet, Disco team, Saclay-IdF

Other partners: Inria Paris-Rocquencourt (Mamba team), France, L2S, France, UPMC (LJLL), St Antoine Hospital, Paris

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

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. ANR 2011-2014 Bimod.

It has been prolonged until 2015, time at which an international workshop in Paris on "Multi-scale and hybrid modelling in cell and cell population biology" is organised, with 25-30 speakers on invitations.

8.2.1.2. Submitted ANR 2015 call "Défi de tous les savoirs".

"Mathematical modelling of dynamics in interacting cell populations" (MMDICP) project submitted for 2015.

8.2.1.3. ANR Blanc 2014-2018 "Kibord".

This recently accepted project gather several members of the Mamba team together with the ENS Cachan and Université Paris-Dauphine on the mathematical study of PDE models with application to biology.

8.2.1.4. ANR 2014-2017 IFLOW.

Eric Vibert, Hopital Paul Brousse (coordinator). Partners: Inria REO, Hopital Toulouse, Dirk Drasdo. Objectives are simulation of liver perfusion after partial hepatectomy (PHx) with and without therapeutic manipulations to improve patients survival after PHx.

8.2.1.5. INSERM 2014 - 2016, INVADE.

Emmanuel Barillot, Institut Curie (coordinateur). Partners: Groups from Institut Curie, Dirk Drasdo. Objective is a model for a better understanding of breast cancer invasion.

8.3. European Initiatives

8.3.1. FP7 & H2020 Projects

8.3.1.1. NOTOX

Type: COOPERATION

Instrument: Integrated Project

Duration: January 2011 - December 2015

Inria contact: Dirk Drasdo

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 ("-omics data"). 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 SCREENTOX 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/

8.3.2. Collaborations with Major European Organizations

U. Klingmüller: DKFZ (German Cancer Center), Department for Systemsbiology (Germany)

Role of HGF in liver regeneration. Lung cancer.

K. Breuhahn: University Hospital of Heidelberg, Pathology (Germany)

Lung cancer invasion. Role of HGF in liver regeneration.

JG Hengstler: Leibniz Center, IfADo (Germany)

Liver research, toxicology, regeneration.

University of Leipzig, Interdisciplinary center for bioinformatics (Germany)

Projects on tissue regeneration, software

Nick Jagiella, Helmholz Center, Institute of Computational Biology

Image guided model parameterisation

8.4. International Initiatives

8.4.1. German Bundesministerium für Bildung und Forschung (BMBF) initiatives

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 available on the web site. 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/).

8.4.2. Participation In other International Programs

Participation in the EuroMed3+3 governed by Inria. The M3CD network (https://www.rocq.inria.fr/bang/M3CD_website/), coordinated by J. Clairambault, has continued and extended its activities, giving rise to new participations: Politecnico di Torino (M. Delitala), Universidad de Valladolid (Ó. Angulo), to stays of students (Y. Bourfia) and researchers (M. Adimy) and to the organisation of a new workshop in Marrakesh in January 2014. The mid-term report is available on the website. The University of Tlemcen (T. Touaoula) has joined in from January 2015.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

Invitation of Min Tang (Shanghai Jao Tong University, China) during one month at UPMC.

8.5.1.1. Internships

Eugenio Lella, Mathematics: Towards a spatio-temporal hybrid mathematical model to simulate drug toxicity in vitro. (2014, master thesis)

8.5.1.2. Research stays abroad

Nicolas Vauchelet stayed two months at IMPA, Rio de Janeiro, Brazil, in the framework of a teaching agreement between UPMC and IMPA.

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 participated to The "LIRIMA evaluation seminar", Paris, September 24-26, 2014.

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.

We work with a Brazilian network that has been built in 2011, and which 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.

This project, funded by CAPES-COFECUB, "new methods in epidemiology and early detection of events" began in January 2011 and finished in December 2013. However the collaboration with the Brazilian collaborators has continued and increased during 2014.

6.1.2.2. Paes-Uemoa

A research project on Bilharzia was submitted 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 Économique et Monétaire de l'Afrique de l'Ouest). MASAIE is an important component of this network. This project has been accepted in 2012 and funded with 30 000 000 CFA (XOF) ($\approx$ 45 000 euro). This project will finish on January 2015.
The PhD thesis of M. Diaby (MASAIE and UGB St Louis) is part of this project.

6.2. International Research Visitors

6.2.1. Visits of International Scientists

Max Oliveira de Souza, professor at Universidade Federal Fluminense, Rio de Janeiro, Brazil, January 2014.

6.2.2. Visits to International Teams

G. Sallet visited FGV and UFF (Rio de Janeiro) and UNESP (São José dos Campos, Sao Paulo) from November 10, 2014 to November 29, 2014. A. Iggidr visited FGV and UFF (Rio de Janeiro) from April 20, 2014 to May 11, 2014. A. Iggidr visited FGV and UFF (Rio de Janeiro) and UNESP (São José dos Campos, Sao Paulo) from November 7, 2014 to December 5, 2014.

MODEMIC Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. Labex Numev

Within the Labex Numev (Solutions Numériques, Matérielles et Modélisation pour L'Environnement et le Vivant [0]), the team is the coordinator since 2012 of a working group on Modelling and numerical probabilities for ecology and biology with Univ. Montpellier II, Univ. Montpellier I and CNRS ISEM.

A one day workshop on "Stochastic Models for Biology" has been organized in January with Pierre Pudlo (Univ. Montpellier II). The invited speakers were Nicolas Champagnat (Inria/Institut Élie Cartan), Jean-François Delmas (Ecole des Ponts ParisTech – CERMICS), and Michel Benaïm (Université de Neuchâtel).

7.1.2. Inter-teams seminar

J. Harmand is the coordinator of the inter-teams seminar about the modelling of bioprocesses [0], involving the labs INRA-LBE (Narbonne), UMR LISPB (Toulouse) and the two Inria project teams BIOCORE and MODEMIC.

A. Rapaport has been invited to participate to the "Séminaire au vert" of BIOCORE team in November 2014.

7.2. National Initiatives

7.2.1. RNSC project "MnMs"

The MnMs [0] (Numerical Models for Microbial ecosystems) project has been funded by the RNSC (National Network on Complex Systems) in 2013 for two years.

It aims at studying how to articulate existing models (discrete, continuous, deterministic, stochastic...) in a multi-scale framework with interactions between various scales. The team has been the coordinator and the other partners were Irstea LISC (Clermont-Ferrand) and CNRS/UMPC LPMTC (Paris VI).

7.2.2. Inria Project Lab "Algae in Silico"

MODEMIC is a partner of the proposal of the Inria Project Lab *Algae in Silico* launched last year by BIOCORE Inria project-team.

7.2.3. INRA-CEPIA project "New perspectives for the MSCF"

The project entitled *Multi-Stage Continuous Fermentor (MSCF): Study of fermentation with disturbances, and development of a control law* has been funded in 2013 by the INRA Dept. CEPIA for two years, in which the Montpellier Units SPO and Mistea are involved.

It is the continuation of the work initiated within the former European CAFE project about the control of a wine fermentation process. The goal of this project is to study the fermentation with nitrogen addition. From a control point of view, we study how to regulate both the sugar concentration and the CO_2 production rate in a series of four tanks of a MSCF, that mimics in continuous culture four important physiological states of a batch fermentation.

[0] http://www.lirmm.fr/numev
[0] https://sites.google.com/site/journeesthematiquesdulbe/
[0] http://www-sop.inria.fr/members/Fabien.Campillo/projects/mnms

7.2.4. PGMO "OPTIBIO"

OPTIBIO (New challenges in the optimal control of bioprocesses) is a new project funded by the french Fundation FMJH (Fondation Mathématique Jacques Hadamard) in 2014 for three years, within the program PGMO (Gaspard Monge Program for Optimization and operations research).

The project is coordinated by T. Bayen (ACSIOM, Univ. Montpellier II) and the other partners are: MODEMIC, Univ. Limoges, EPI COMMANDS (Saclay) and EPI BIOCORE (Sophia Antipolis).

The overall objective of this project is to address the optimization of bioprocesses over an *infinite horizon*. Infinite horizon optimal control is well suited for every problem where the time horizon is uncertain and can be expected to be large: e.g. economics models related to optimal growth and sustainable development, biological models such as the optimal control of interacting species and pest control, stabilization of controlled mechanical systems...The recent expectations of sustainable development raise new optimization problems that take into account auxiliary outputs, such as biogas production, that were neglected in the past. It appears that mathematical problems that come from the modelization of these processes are often difficult to solve, and one objective of the proposal is to develop new mathematical methods in order to address these issues. More precisely, the objective of the project is to study the following issues:

- Optimization of bioprocess over an infinite horizon.
- Development of accurate methods in order to deal with uncertainties that affects the chemostat model (uncertainties come from unknown parameters or noise from the measurements).
- Stabilization of the chemostat model including delay in the system.

7.2.5. INRA-MIA methodological networks

The team is involved in two new networks of the MIA (Applied Mathematics and Informatics) Department of INRA:

- MEDIA [0] (Modèles d'Équations DIfférentielles et Autres systèmes dynamiques pour l'écologie),
- REM [0] (RÉduction de Modèles),

that have been launched this year.

7.3. International Initiatives

7.3.1. Inria International Labs

Within the BioNature [0] operation program of CIRIC Center (Inria Chile), the team participates to the axis *Modeling, control and optimization of waste-water treatment processes and biogas production*, and more specifically to the research lines

- automation and control of anaerobic digestion,
- innovative technologies and modeling on wastewater and residues treatment.

In this framework, the team has co-supervised the postdoctoral stay of. M. Sebbah in Chile.

7.3.2. Inria Associate Teams

7.3.2.1. DYMECOS2

Title: Modelling of microbial ecosystems, bioprocesses control and numerical simulations

International Partner (Institution - Laboratory - Researcher):

Departamento de Ingeniería Matemática (DIM), Universidad de Chile

Centro de Modelamiento Matemático (CMM), UMi CNRS/ Universidad de Chile

[0] http://www.netvibes.com/reseaumiamedia
[0] https://sites.google.com/site/reseaurem2/
[0] http://www.bionature.cl

Departamento de Matematica, Universidad Tecnica Federico Santa Maria (UTFSM), Valparaiso (Chile)

Bionature, CIRIC, Inria Chile

Duration: 2014-2016

See also: https://sites.google.com/site/eadymecos/

The objective is to develop, from expert knowledge and experimental observations, models of microbial ecosystems that are simple enough to carry out the determination of explicit "control laws", and realistic enough to represent real bio-processes. One of the difficulties is to identify the limits of the validity of these models, in terms of spatial heterogeneity and microbial population size. We aim also outcomes of the modeling for the optimal design of waste-water treatment plants.

7.3.3. Inria International Partners

7.3.3.1. Declared Inria International Partners

LIRIMA NuWat [0] 2013-... (Tlemcen, Algeria and Tunis, Tunisia). 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. The project was initially developed in collaboration with the Univ. of Tlemcen but is now extended to the ENIT in Tunis, with an extension of the domain of application to system biology and biotechnologies.

7.3.3.2. Informal International Partners

CESAME, Univ. Louvain, Belgium : D. Dochain

3BIO, Univ. Mons, Belgium : A. Vande Wouver

Univ. Neuchâtel, Switzerland : M. Benaim

MOMAT, Univ. Madrid, Spain : B. Ivorra

Univ. Newcastle, U.K. : M. Wade

7.3.4. Participation In other International Programs

7.3.4.1. CIB (Centre Interfacultaire Bernoulli)

Program: Bernoulli workshops

Title: The role of mathematics and computer science in ecological theory

Inria principal investigator: MODEMIC (C. Lobry),

Partners: EPFL, Lausanne (Switzerland).

Duration: July 1 to December 31, 2014

Abstract: A former 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 the Inria project team COMORE, pursued then by MERE and COMORE raised an important event: 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 program lasted from July 1 to December 31, 2014. It gathered about 90 participants among them very well known scientists from Theoretical Ecology (S. Allesina, D. de Angelis, P. Chesson, J. Damuth, L. Ginzburg, R. Holt...) and from Mathematics (M. Benaïm, N. Berglund, M. and F. Diener, M. Krupa, A. Lam, W.M. Ni...).

Six one-week workshops where organized (one each month) on the following topics:

[0] https://project.inria.fr/nuwat/

- Non-adaptive selection: explaining macroscopic laws in ecology and evolution (Organizers: L. Ginzburg, R. Arditi, L.-F. Bersier).
- Dispersal and competition of populations and communities in spatially inhomogeneous environments (Organizer: D. DeAngelis).
- Validation of uncertain ecological models with imprecise data (Organizer : S. Ferson)
- Discrete, explicit simulations versus continuous, aggregated models (Organizers: R. Arditi, C. Lobry, Y. Tyutyunov).
- Multi-scale models, slow-fast differential equations, averaging in ecology (Organizers: M. Desroches, O. Faugeras, C. Lobry, T. Sari).
- Microbial ecology and mathematical modelling (Organizers : R. Arditi, J.J. Godon, J. Harmand, C. Lobry)

The third workshop was organized in collaboration with O. Faugeras (EPI Neuromathcomp, Sophia-Antipolis) and M. Desroches (EPI MYCENAE, Rocquencourt) and tried to find connections between neurosciences and theoretical ecology through mathematical models.

Web-site: http://mathcompecol.epfl.ch/

7.3.4.2. TREASURE

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), University of Patras, Process Control Laboratory (Greece), University of Tlemcen, Automatic control (Algeria), University 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

Abstract: The TREASURE network aims at integrating knowledge on the modelling, the control and the optimization of biological systems for the treatment and reuse of waste-waters 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

7.3.4.3. TASSILI

Program: Hubert Curien Program

Title: Procédés membranaires pour le traitement anaérobie des eaux usées - Modélisation, commande et optimisation

Inria principal investigator: MODEMIC (J. Harmand),

Partners: LBE-INRA (Narbonne), Univ. Tlemcen (Algeria)

Duration: 3 years

Abstract: This project aims at promoting collaborations with our historical Algerian partners of the department of automatic control of the University of Tlemcen. The objectives of the project are to develop research on the modeling and the control of anaerobic systems through the co-advisoring of Zeyneb Khedim (PhD 'co-tutelle' between UM2 and Univ. Tlemcen).

7.4. International Research Visitors

7.4.1. Visits of International Scientists

Imme Van Den Berg

Subject: Construction, analysis and simulation of population dynamics models

Date: until Feb. 2014

Institution: Univ. of Evorra (Portugal)

7.4.1.1. Internships

Moshen Chebbi

Subject: Stochastic modeling for membrane bioreactors

Date: from Sep 2014 until Nov 2014

Institution: ENIT, Tunis (Tunisia)

Alejandro Rojas-Palma

Subject: Study of some problems related to modelling and optimization of bioprocesses

Date: from Oct 2014 until dec 2014

Institution: Univ. of Chile

Victor Riquelme

Subject: Optimal control for the preservation of exploited water resources

Date: from Nov 2014 until Jan 2015

Institution: Univ. of Chile

7.4.2. Visits to International Teams

7.4.2.1. Research stays abroad

C. Lobry has spent one semester (July-December 2014) at CIB, EPFL (Lausanne, Switzerland) for the co-organization of the Bernoulli workshop on the role of mathematics and computer science in ecological theory (see 7.3.4.1).

B. Cloez has spent one month (November-December) in Switzerland at Univ. Neuchâtel and at CIB-EPFL, Lausanne.

MYCENAE Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

PSL☆ project NeuroMathematics (of Sensory Switch)- NeuroMath(SensoS)

7.2. National Initiatives

7.2.1. ANR

Jonathan Touboul is member of the ANR Kibord (KInetic models in Biology Or Related Domains) obtained in 2014.

7.2.2. National Networks

- GdR REPRO (member of the direction board, F. Clément)
- DLeRBio network: Dynamiques Lentes-Rapides avec applications Biologiques (animation, M. Desroches)
- MIA REM network: Réduction de modèles (PI Béatrice Laroche, INRA Jouy)

7.2.3. National Collaborations

- Center for Interdisciplinary Research in Biology, Collège de France (Alain Prochiantz)
- Jacques-Louis Lions Laboratory, Pierre & Marie Curie University (Jean-Pierre Françoise, Marie Postel)
- UMR Physiologie de la Reproduction et des Comportements, INRA Tours (Bios and Bingo teams)
- Group for Neural Theory, École Normale Supérieure, Paris (Boris Gutkin)
- Centre de Recherche en Mathématiques de la Décision, Paris Dauphine University (Stéphane Mischler)
- Computational Biology and Biomathematics, Jacques Monod Institute, Paris Diderot University (Khashayar Pakdaman)
- LAGA (Laboratoire Analyse, Géométrie et Applications), Paris-Nord University (Gilles Wainrib)
- Unité de Neurosciences, Information & Complexité (UNIC), CNRS Gif-sur-Yvette (Alain Destexhe)

7.3. International Initiatives

7.3.1. Inria International Partners

7.3.1.1. Informal International Partners

- **USA**: Florida State University (Richard Bertram, Patrick Fletcher, Joël Tabak), University of Pittsburgh (Bard Ermentrout, Jonathan Rubin), Princeton University (William Bialek, Thibault Taillefumier)
- **UK**: University of Bristol (Alan R. Champneys), University of Nottingham (Daniele Avitabile), Plymouth University (Serafim Rodrigues)
- **Spain**: University of the Balearic Islands (Antonio .E. Teruel, Rafel Prohens), Polytechnic University of Catalunya (Toni Guillamon), University of Sevilla (Enrique Ponce)
- **Denmark**: Technical University of Denmark (Morten Brøns and Frank Schilder)

7.4. International Research Visitors

7.4.1. Visits of International Scientists

- William Bialek (Princeton University), May 2014
  seminar More than the sum of their parts: Collective behavior in flocks of birds and networks of neurons, Grands séminaires du Collège de France
- Bard Ermentrout (University of Pittsburgh), June 2014
  seminar Keeping the beat : Homeostatic frequency control in coupled oscillators held in EITN (European Institute for Theoretical Neuroscience)
- Jacques Cowan (University of Chicago, USA), October 2014 (two weeks)
  Mathematics of the Brain Colloquium
- Alexey Kuznetsov (Indiana University-Purdue, University Indianapolis, USA, July 2014 (one week
  seminar A highly-reduced model of the dopaminergic neuron: mechanisms of oscillations
- Martin Wechselberger (University of Sydney, Australia), November 2014 (one week)
  seminar Neuronal Excitability and Canards

7.4.2. Visits to International Teams

7.4.2.1. Research stays abroad

- M. Desroches, one-month research stay in the Department of Mathematics of the University of the Balearic Islands (UIB, Palma, Spain), funded by a scholarship from the UIB, in the framework of a collaboration with Antonio E. Teruel and Rafel Prohens (June 2014).
- J. Touboul, twice one-month research stay in Princeton University, partially funded by the NeuroInfo PEPS PTI project, in the framework of a collaboration with the group of William Balek (March 2014 and December 2014).

NUMED Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

Two regional grants for mobility to develop collaborations with A. Samson (Grenoble) and Didier Bresch (Chambéry) respectively.

7.2. European Initiatives

7.2.1. FP7 & H2020 Projects

7.2.1.1. DDMoRE

Type: FP7

Duration: February 2011 - January 2016

Inria contact: Marc Lavielle

URL : http://www.ddmore.eu/

7.2.2. Collaborations with Major European Organizations

ERC Grant for Vincent Calvez.

7.3. International Research Visitors

7.3.1. Explorer programme

Emeric Bouin will spent three months as a post doc at Stanford university.

7.3.2. Research stays abroad

E. Bouin and V. Calvez worked two weeks in Austarlia. E. Grenier spent one week in Princeton. P. Vigneaux goes for two months in Sevilla.

REO Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

8.1.1.1. 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 Ángel Fernández Varela, is to study mathematically and numerically new numerical methods for incompressible fluid-sructure interaction.

8.1.1.2. ANR Project "CARDIOXCOMP"

Participants: Muriel Boulakia, Damiano Lombardi, Jean-Frédéric Gerbeau [Principal Investigator], Fabien Raphel, Eliott Tixier.

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.

8.1.1.3. 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.

Other partners: DHU Hepatinov - Hôpital Paul Brousse, Inria Mamba, Fluoptics, IfADo, MID.

8.1.1.4. Participation to other ANR projects

- Céline Grandmont is a member of the ANR TecSan Oxhelease
- Marina Vidrascu is a member of the ANR ARAMIS

8.1.2. Inria initiatives

8.1.2.1. ADT Project "MENAMES "

Participants: Miguel Ángel Fernández Varela [Principal Investigator], Axel Fourmont, Marina Vidrascu.

Period: 2014-2016
The aim of this project, coordinated by Miguel Ángel Fernández Varela, is to implement in the FELiScE library several algorithms included in the shelddon library, in particular shell elements and domain decomposition methods.

8.2. European Initiatives

8.2.1. FP7 & H2020 Projects

8.2.1.1. REVAMMAD

Participants: Matteo Aletti, Jean-Frédéric Gerbeau [correspondant], Damiano Lombardi.

Type: FP7-PEOPLE

Instrument: Marie Curie Initial Training Network

Duration: April 2013 - March 2017

Coordinator: Andrew Hunter, University of Lincoln (UK)

Partner: See the http://revammad.blogs.lincoln.ac.uk/partners/ web site

Inria contact: J-F Gerbeau

Abstract: http://revammad.blogs.lincoln.ac.uk 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.

8.3. International Initiatives

8.3.1. Inria International Labs

Participants: Céline Grandmont, Jessica Oakes, Irène Vignon-Clementel [correspondant].

Period: 2014-2015

Jessica Oakes was awarded an Inria@SiliconValley Grant for a post-doc at UC Berkeley to work on aerosol deposition in the lung.

8.3.2. Trans-Atlantic Network of Excellence for Cardiovascular Research

Participants: Grégory Arbia, Jean-Frédéric Gerbeau, Sanjay Pant, 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.

Other partners: see http://modelingventricle.clemson.edu/home.

8.3.3. 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 Mamba).

Other partners: see http://www.lungsys.de.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Stephanie Lindsey, PhD student at Cornell University (USA), Aug 2013 - February 2014 & 2 weeks in May 2014
- Weiguang Yang, Engineering research associate, Departments of Pediatrics and Cardiology, Stanford University (USA), May 20th-June 18th 2014
- Andrew Blaber, Carole Leguy, Joke Keijsers, Kouhyar Tavakolian, Simon Fraser University (Vancouver, Canada), May 26 - May 30, 2014

SISYPHE Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR project SODDA: Soft Defects Diagnosis in wired networks

Participants: Thomas Lepetit, Mohamed Oumri, Michel Sorine.

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 and 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 I4S (Qinghua Zhang), POEMS and Sisyphe.

7.2. International Research Visitors

7.2.1. Visits to International Teams

7.2.1.1. Sabbatical programme

Bliman Pierre-Alexandre

Date: May 2014 - Apr 2015

Institution: Fundação Getulio Vargas, Brazil EMAp (Brazil)