Activity Report 2012

Section Partnerships and Cooperations

<h1 style="color:red; text-align:center">ABS Project-Team</h1>

6. Partnerships and Cooperations

6.1. National Initiatives

6.1.1. *Projets Exploratoires Pluridisciplinaires from CNRS/Inria/INSERM*

Reconstruction by Data Integration (RDI) is an emerging paradigm to reconstruct large protein assemblies, as discussed in section 4.1.3 .

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

6.2. European Initiatives

6.2.1. *FP7 Projet*

6.2.1.1. CG-Learning

Title: Computational Geometric Learning (CGL)

Type: COOPERATION (ICT)

Defi: FET Open

Instrument: Specific Targeted Research Project (STREP)

Duration: November 2010 - October 2013

Coordinator: Friedrich-Schiller-Universität Jena (Germany)

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

See also: http://cglearning.eu/http://cglearning.eu/

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

6.3. International Research Visitors

6.3.1. *Internships*

- From May to July 2012, summer internship from Pratik Kumar (Indian Institute of Technology of Bombay). Topic: Modeling density maps in cryo electron microscopy.

AMIB Project-Team

6. Partnerships and Cooperations

6.1. Regional Initiatives

J. M. Steyaertwas the coordinator of RNA-omics Digiteo project, P. Clote (Boston College) being a Digiteo chair until June 2012.

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

6.2. National Initiatives

6.2.1. ANR

A. Denise is coordinator of the ANR project AMIS ARN 2009-2012 (ANR-09-BLAN-0160) and is involved in the NSD-NGD ANR project 2010-2014. Y. Ponty is involved in the MAGNUM ANR project (BLAN program, 12/2010–12/2014).

6.3. International Initiatives

6.3.1. Inria Associate Teams

6.3.1.1. ITSNAP

Title: Intelligent Techniques for Structure of Nucleic Acids and Proteins

Inria principal investigator: Julie Bernauer

International Partner (Institution - Laboratory - Researcher):

SLAC National Accelerator Laboratory (United States) - Stanford Synchrotron Radiation Laboratory - Henry van den Bedem

Stanford University (United States) - Computational Structural Biology, School of Medicine, Structural Biology - Michael Levitt

Duration: 2012 - 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. Participation In International Programs

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

Adrien Rougny, an internship student supervised by C. Froidevaux in AMIB, has successfully applied for the 2nd call of 2012 "NII International Internship Program". In February 2013, he will start an internship at NII for an Internship in Pr. Katsumi Inoue's group on the topic "Inference and Learning for Systems Biology and Network Dynamics".

M. Régnier and D. Sherman (MAGNOME-INRIA) participate to a joint project CARNAGE of France-Russia program.

6.4. International Research Visitors

6.4.1. Visits of International Scientists

R. Giegerich

Institution: Bielefeld University (Germany)

Subject: Efficient algorithms for RNA secondary structure alignment.

Funding: DGAR (Ecole Polytechnique)

R. Giegerich visited the AMIB project-team for a month. He taught dynamic-programming to the students of the BIBS master. He initiated a collaboration on sparsification, an algorithmic technique that speeds up dynamic programming algorithm. A comprehensive review on RNA structure alignment algorithms, to appear in a forthcoming book, was also written during his stay.

J. Waldispühl

Institution: McGill University (Canada)

Subject: RNA design and tertiary structure prediction.

Funding: DIGITEO (LRI)

J. Waldispühl visited AMIB for a month. He finalized a collaboration on RNA design (Y. Ponty, leading to [16]), established a new collaborative research (with A. Denise and Y. Ponty, on tertiary motifs), laid the foundations of a future X-UPSud exchange program, initiated a workshop on molecular interactions (with J. Bernauer), and started a PhD co-supervision (A. Soulé, co-supervised with J.-M. Steyaert and Y. Ponty).

X. Huang

Subject: Millisecond dynamics at atomic resolution by Markov State Models

Institution: Hong Kong University of Science and Technology (Hong-Kong)

A. Sim

Subject: Modeling RNA by hierarchical natural moves

Institution: Stanford University (USA) / A*STAR (Singapore)

L. Pereyaslavets

Subject: Critical assessment of non bonded part of force fields

Institution: Stanford University (USA)

Y. Okamoto

Subject: Protein folding, unfolding, and ligand docking by computer simulations

Institution: Nagoya University (Japan)

6.4.1.1. Internships

A. Martirosyan (March-Jul 2012)

Subject: A Dynamical Model for the Transmembrane Potential Regulation by pH

Institution:Cergy University (Pontoise)

Funding: INRIA

Supervision:L. Paulevé and M. Régnier

B. Brancotte (March-July 2012)

Subject: Designing a framework to compare biological data ranking methods

Institution: Paris-Sud University (France)

Funding: INRIA

Supervision: S. Cohen-Boulakia and A. Denise

Gh.Fievet (March-Sept 2012)

Subject: Improving `MPAS` software

Institution: Paris-Sud University (France)

Funding: Ecole Polytechnique

Supervision:J.M. Steyaert

J. Weaver (Jun-Aug 2012)

Subject: Efficient Motif Discovery and Evaluation

Institution: Massachusetts Institute of Technology (United States)

Funding: MIT France program

Supervision: Y. Ponty and M. Régnier

A. Menard (Jun-Aug 2012)

Subject: Extending `JalView`'s RNA interconnection with `Varna`

Institution: Université Paris-Sud

Supervision: Y. Ponty and J. Procter (Univ. Dundee, Scotland)

A. Soulé (Jun-Aug 2012)

Subject: Prediction of RNA-RNA interactions in yeast

Institution: Ecole Polytechnique

Supervision: Y. Ponty and J.-M. Steyaert

V. Arendt (Jun-Aug 2012)

Subject: Integrating RNA web services into `JalView` using `Jabaws`

Institution: Duke University (United States)

Funding: Google Summer of Code program

Supervision: Y. Ponty and J. Procter (Univ. Dundee, Scotland)

T. Coulmy & N. Duhamel (Jun-Jul 2012)

Subject: Average-case property analysis of workflows based on hypergraphs

Institution: Université Paris-Sud

Supervision: S. Cohen-Boulakia and Y. Ponty

F.K. Sheong (May-Aug 2012)

Subject: RNA structural design by docking and machine learning

Institution: The Hong Kong University of Science and Technology (Hong Kong, (China))

L. Uroshlev (Oct-Nov 2012)

Subject: Reference state for RNA KB potentials

Institution: IOGEN (Moscou, (Russia))

A. Bari (Oct 2012)

Subject: stress-inducible miRNAs

Institution:El Farabi University (Almaty, (Kazakhstan))

BAMBOO Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. InférenceGraphesRégulation

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

7.2. National Initiatives

7.2.1. ABS4NGS

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

7.2.2. Adapthantroph

- Title: Adaptation des insectes aux anthroposystèmes
- Coordinator: M. Harry
- BAMBOO participant(s): C. Vieira
- Type: ANR Génoplante (2009-2012)
- Web page: Not available

7.2.3. Exomic

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

7.2.4. ImmunSymbArt

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

7.2.5. Metagenomics of Bemisia tabaci

- Title: Metagenomics of *Bemisia tabaci* symbiotic communities

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

7.2.6. MIRI

- Title: Mathematical Investigation of "Relations Intimes"
- Coordinator: M.-F. Sagot
- BAMBOO participant(s): V. Acuña, C. Baudet, C. Gautier, V. Lacroix, P. Milreu, C. Klein, I. Nor, M.-F. Sagot, P. Simões
- Type: ANR Blanc (2009-2012)
- Web page: http://pbil.univ-lyon1.fr/members/sagot/htdocs/team/projects/miri/miri.html

7.2.7. SpeciAphid

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

7.3. European Initiatives

7.3.1. FP7 Projects

7.3.1.1. Microme

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

7.3.1.2. SISYPHE

- Title: Species Identity and SYmbiosis Formally and Experimentally explored
- Coordinator: M.-F. Sagot
- BAMBOO participant(s): Whole BAMBOO team
- Type: ERC Advanced Grant (2010-2015)
- Web page: http://pbil.univ-lyon1.fr/members/sagot/htdocs/team/projects/sisyphe/sisyphe.html

7.3.1.3. 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

7.3.1.4. 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

7.3.2. Collaborations with Major European Organizations

Partner 1: Pierluigi Crescenzi, Univ. Florence, Italy

Algorithmic (graphs, trees, sequences), complexity

Partner 2: Ana Teresa Freitas and Susana Vinga, INESC-ID, IST Lisbon, Portugal

NGS, metabolism, small RNAs, motifs

Partner 3: Alberto Marchetti-Spaccamela, Univ. Rome La Sapienza, Italy

Algorithmic (graphs, trees), complexity

Partner 4: Nadia Pisanti and Roberto Grossi, Univ. Pisa, Italy

Algorithmic (graphs, trees, sequences)

Partner 5: Leen Stougie, Free Univ. Amsterdam and CWI, the Netherlands

Algorithmic (graphs, trees), complexity

7.4. International Initiatives

7.4.1. DISCO

- Title: Laboratoire International de Recherche en BIoinformatique
- Coordinators: E. Zucca (Italy)
- BAMBOO participant(s): Pierluigi Crescenzi (external member BAMBOO)
- Type: Ministero dell'Istruzione, dell'Università e della Ricerca
- Web page: http://bart.disi.unige.it/DISCO/

7.4.2. LIA project with Brazil: LIRIO

- Title: Laboratoire International de Recherche en BIoinformatique
- Coordinators: M.-F. Sagot (France), A. T. Vasconcelos (LNCC, Brazil)
- BAMBOO participant(s): BAMBOO Team
- Type: LIA CNRS
- Web page: https://team.inria.fr/bamboo/en/cnrs-lia-laboratoire-international-associe-lirio/

7.4.3. Inria-Faperj (Brazil) project: RAMPA

- Title: Bioinformatics for the Reconstruction and Analysis of the Metabolism of PArasites
- Coordinators: M.-F. Sagot (France), A. T. Vasconcelos (LNCC, Brazil)
- BAMBOO participant(s): Whole BAMBOO Team
- Type: Faperj-Inria
- Web page: Not available

7.4.4. Project within CIRIC

- Title: Omics Integrative Sciences

- Coordinators: Alejandro Maass (Chile), Anne Siegel and M.-F. Sagot (France)
- BAMBOO participant(s): BAMBOO Team
- Type: Communication and Information Research and Innovation Center (CIRIC)
- Web page: Not available

7.4.5. Inria International Partners

- Acronym: AMICI
- Title: Algorithms and Mathematics for Investigating Communication and Interactions intra- and inter-organisms
- Coordinators: M.-F. Sagot (France), A. Marchetti-Spaccamela (Univ. Rome, Italy), L. Stougie (Free Univ. Amsterdam and CWI, the Netherlands), P. Crescenzi, Univ. Florence, Italy), N. Pisanti (Univ. Pise, Italy)
- BAMBOO participant(s): Whole BAMBOO Team
- Type: Inria International Partner
- Web page: http://amici.dsi.unifi.it/amici/

7.5. International Research Visitors

7.5.1. Visits of International Scientists

Andrea Marino, PhD student (Supervisor: Pierluigi Crescenzi), University of Florence, Italy, visit of 3 months and various visits of 1-2 weeks
Maria Cristina Motta, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil, visit of 10 days
Susana Vinga, Professor, INESC-ID, IST Lisbon, Portugal, visit of 1 week
Arnaldo Zaha, Universidade Federal de Rio Grande do Sul, Porto Alegre, Brazil, visit of 10 days

<p style="text-align: center; color: red;">**BEAGLE Team**</p>

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

- PAGDEG: Causes and consequences of protein aggregation in cellular degeneration, a three-year project (2009-20012), Call "PIRIBIO". Supervisor: A. Lindner (INSERM, Paris) ; Other participants: Y. Chen (ENS Paris), L. Moisan (Univ. Paris 5). Participants: Hugues Berry, Anne-Sophie Coquel

- Stochagene (2011-2014). Objective: identify the molecular basis of the stochasticity of gene expression in eukaryotic cells. Partners: CGPhyMC (Olivier Gandrillon, Lyon, Leader), Genethon (Andras Paldi, Evry). Participants: G Beslon, H Berry, Gael Kaneko

- Ancestrome: phylogenetic reconstruction of ancestral "-omes", a five-year project (2012-2016), call "Bioinformatics" of the "Investissements d'avenir". Supervisor: V. Daubin (CNRS, LBBE, Lyon) ; with Institut Pasteur, ENS Paris, ISEM (Univ Montpellier 2) Participant: E Tannier

7.1.2. CNRS

- H Berry participates to a PEPII (Projets exploratoires pluridisciplinaires inter-instituts) called NeoBG: towards a biologically realistic theory of reinforcement learning, 2011-2012, Supervisor : B. Delord (Univ. P & M Curie, Paris). With Ph. Faure and L. Venance (College de France, Paris)

- Carole Knibbe coordinated in 2011 and 2012 a PEPII (Projets exploratoires pluridisciplinaires inter-instituts) called "Analyser, simuler et expérimenter l'évolution des génomes bactériens". The aim of the project was to study the dynamics and the evolvability of bacterial genomes by combining "wet" evolution experiments, individual-based simulations, mathematical models and bioinfomatics of real genomes. The total budget was 50 k€. The involved teams were, beside Beagle, Dynamics and evolution of the bacterial genome / Laboratoire Adaptation et Pathogénie des Microorganismes (LAPM, CNRS UMR5163, Grenoble), Modélisation mathématique et calcul scientifique / Institut Camille Jordan (ICJ, CNRS UMR5208, Lyon), Algorithmique et ordonnancement pour plates-formes hétérogènes distribuées / Laboratoire de l'Informatique du Parallélisme (LIP, CNRS UMR5668, Lyon), and Bioinformatique et génomique évolutive / Laboratoire de Biométrie et Biologie Evolutive (LBBE, CNRS UMR5558, Lyon)

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

7.2. International Initiatives

7.2.1. Inria International Partners

- "Astrocytic regulation of neuronal network activity" 2012-2103, A Research Networks Program in Computational Neurosciences and Computational Cognitive Sciences of the High Council for Scientific and Technological Cooperation between France-Israel, with E Ben-Jacob and Y Hanein (Tel Aviv Univ, Israel). Supervisors: H. Berry (French side) and Y. Hanein (Israeli side).

7.3. International Research Visitors

7.3.1. Visits of International Scientists

- Nadia El-Mabrouk, professeure à l'université de Montreal, "chercheur invité" of Inria, October 1-12, 2012
- Jacques Rougemont (team leader) and Marion Leleu (researcher) of the Bioinformatics and Biostatistics Core Facility of EPFL (Ecole Polytechnique Fédérale de Lausanne). November 23, 2012.
- Thomas Höfer (Heidelberg) in May
- Kirsten HWJ ten Tusscher (Theoretical Biology/Bioinformatics, Utrecht University, Netherlands) in September

7.3.2. Visits to International Teams

- H. Soula is visiting professor in the Theunissen Lab of Auditory and Neuroscience during the academic year 2012-2013. Grant: CRCT CNU.
- Visit of C Rigotti to the team Bioinformatics and Biostatistics Core Facility of EPFL (Ecole Polytechnique Fédérale de Lausanne). March 8 and 9, 2012.

BONSAI Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

- At the end of 2010, we started a collaboration with the sequencing platform of Université Lille 2 and IRCL (M. Figeac) and the hematology lab of Lille hospital (N. Grardel, C. Roumier, C. Preudhomme), on the diagnosis of leukemia residual disease. This project has been awarded by a "Projet émergent region" grant for 2012 – 2013.

- Our research on *nonribosomal peptide synthesis* is based on a collaboration with the ProBioGEM laboratory (*Laboratoire des Procédés Biologiques Génie Enzymatique et Microbien*, Université Lille 1). This laboratory develops methods to produce and extract active peptides in agriculture or food. Two PhD thesis has been co-supervised by the two labs.

- We have a long term collaboration with GEPV Lab (Genetics and Evolution in Plants, UMR CNRS 8198, Université Lille 1). Topics includes rearrangements in mitochondrial genomes and evolution of plant miRNAs. One supervised PhD thesis has been defended in 2010, and a new thesis just started in October 2012.

- The team is in charge of the PPF *Bioinformatique*. This is an initiative of Université Lille 1 that coordinates public bioinformatics activities at the local level. It gathers seven labs coming from biology, biochemistry and computer science. Main topics are proteomics, microbiology, population genetics, etc.

7.2. National Initiatives

7.2.1. ANR

- ANR Mappi (2010-2013, call *Conception and Simulation*). This project involves four partners: LIAFA (Université Paris 7), Genscale (Inria Rennes), Genoscope (French NAtional Center for SEquencing) and BONSAI. The topic is *Nouvelles approches algorithmiques et bioinformatiques pour l'analyse des grandes masses de données issues des séquenceurs de nouvelle génération*.

- ANR France Génomique (2011-2014, PIA *Infrastructures Biologie Santé*). This national project involves 13 partners, including sequencing paltforms and bioinformatics platform. We take part to the workpackage on sRNA-seq data analysis.

7.2.2. PEPS

- PEPS Biology-Mathematics-Computer science: "Etude comparative de l'architecture du génome mitochondrial chez les Caryophyllacées et les Poacées". This project involves three partners: IBMP (Institut de Biologie Moléculaire des Plantes), GEPV (UMR CNRS 8198, Université Lille 1) and BONSAI.

7.2.3. ADT

- ADT biomanyocres (2010-2012): see section 5.8 .

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

7.3. International Initiatives

- S. Blanquart pursues his collaboration with the Sterner Group of the "Institut für Biophysik und Physikalische Biochemie" (Regensburg, Germany) on an ancestral sequences resurrection project. Researchers of the Sterner Groups succeeded in the resurrection and characterization of the LUCA's (Last Universal Common Ancestor) Histidine F enzyme, which have a TIM barrel fold. The paleo-enzyme works fine, just as do modern ones. It is the oldest resurrected yet proteins to our knowledge.

- In genomic rearrangement, we pursued our collaboration with the LaCIM at Université du Québec à Montréal, and DIRO at Université de Montréal. In the context of multiple genome comparison, we proposed a new framework for the multiple comparison of sets of transcripts transcribed from orthologous loci of several species [12].

7.4. International Research Visitors

7.4.1. Visits to International Teams

- A. Thomas, Univ. du Québec à Montréal (Canada), visit to Anne Bergeron (2 weeks),
- J.-S. Varré, Univ. du Québec à Montréal (Canada), visit to Anne Bergeron (1 week),
- A. Ouangraoua, Univ. du Québec à Montréal (Canada), visit to Anne Bergeron (4 months),
- M. Giraud, Univ. of Thessaloniki (Greece), visit to E. Cambouroupoulos (1 month).

<p style="text-align:center">**DYLISS Team**</p>

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. Partnership with computer science laboratories in Nantes

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

Methodologies are developed in close collaboration with university of Nantes (LINA) and Ecole centrale Nantes (Irccyn). This is acted through the Biotempo and Idealg ANR projects and co-development of common software toolboxes within the Renabi-GO platform process. Two Ph-D thesis are also co-supervised within these collaborations.

7.1.2. Partnership in Marine Biology

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

A strong application domain of the Dyliss project is marine Biology. This application domain is co-developed 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 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 modelling of the initation of sea-urchin translation (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 P.-F. Pluchon) and the dentification of key actors implied in competition for light in the ocean (PELICAN ANR project).

7.1.3. Partnership with Inra and Health

Participants: Jacques Nicolas, Catherine Belleannée, François Coste, Michel Le Borgne, Anne Siegel, Oumarou Abdou-Arbi, Geoffroy Andrieux, Pierre Blavy, Valentin Wucher.

We have a strong and long term collaboration with biologists of INRA in Rennes : IGEEP and SENAH units. This partnership is acted by the co-supervision of one post-doctorant and two PhD students. It is also reinforced by collaboration within ANR contracts (Lepidolf, MirNadapt, FatInteger).

We also have a strong and long term collaboration with the IRSET laboratory at Univ. Rennes 1, acted by a co-supervised Ph-D thesis. This partnership is reinforced with the ANR contract Biotempo and has been also supported in the framework of the previous CPER by a project, BasicLab, on a lab on chip for cell assays.

7.2. National Initiatives

7.2.1. Long-term contracts

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

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

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

7.2.1.2. ANR Idealg

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

IDEALG is one of the five laureates from the national call 2010 for Biotechnology and Bioresource and will run until 2020. It gathers 18 different partners from the academic sector (CNRS, IFREMER, UEB, UBO, UBS, ENSCR, University of Nantes, INRA, AgroCampus), the industrial sector (C-WEED, Bezhin Rosko, Aleor, France Haliotis, DuPont) as well as a technical centre 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.

7.2.2. Methodology: ANR Biotempo

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

The BioTempo projects aims at developing some original methods for studying biological systems. The goal is to introduce partial quantitative information either on time or on component observations to gain in the analysis and interpretation of biological data. Three biological applications are considered regulation systems used by biomining bacteria, TGF$beta$ signaling and initiation of sea-urchin translation. It is funded by ANR Blanc (SIMI2) and coordinated by A. Siegel from 2011 to 2014. [details]

7.2.3. Proof-of-concept on dedicated applications

7.2.3.1. ANR Fatinteger

Participants: Anne Siegel, Jacques Nicolas, Catherine Belleannée, Pierre Blavy.

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

7.2.3.2. ANR Lepidolf

Participants: François Coste, Jacques Nicolas.

The LEPIDOLF project aims at better understanding olfactory mechanisms in insects. The goal is to establish the antennal transcriptome of the cotton leafworm Spodoptera littoralis, a noctuid representative of crop pest insects. It is funded by ANR call Blanc and coordinated by E. Jacquin-Joly from UMR PISC (INRA Versailles) from 2009 to 2012. Our contribution is to use grammatical inference to build characteristic signatures of the Olfactory Receptor family, which will be used to scan directly 454-sequencing reads and available partial cDNAs of genes expressed in the antenna of Lepidoptera or deduced proteins.

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

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

7.2.3.4. ANR Pelican
Participant: François Coste.

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

7.2.4. Programs funded by research institutions

7.2.4.1. Inria Bioscience Ressource
Participants: Claudia Hériveau, Jacques Nicolas.

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

7.2.4.2. Aquasyst
Participants: Damien Eveillard, Anne Siegel.

PEPS contract 2011-2012 whose goal is to combine Environmental genomics and Systems biology for the understanding of aquifere denitrification.

7.3. European Initiatives

7.3.1. Collaborations with Major European Organizations

Partner: EBI (Great-Britain)

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

Partner: Potsdam university (Germany)

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: SIEGEL Anne

International Partner (Institution - Laboratory - Researcher):

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

Duration: 2011 - 2013

See also: http://www.irisa.fr/symbiose/people/asiegel/EA/

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

7.4.2. Participation In International Programs

7.4.2.1. Argentina - MinCYT-Inria 2011-12

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

Title: Modélisation linguistique de séquences génomiques par apprentissage de grammaires

Financial support: MinCYT-Inria program 2011-12

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

7.4.2.2. International joint supervision of PhD agreement

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

Inria principal investigator: Anne Siegel

International Partners (Institution - Laboratory - Researcher):

University of Chile (Chile)

Duration: Jul 2011 - Jul 2014

Title: Analyse automatisée et générique de réseaux métaboliques en nutrition

Inria principal investigator: Anne Siegel

International Partner (Institution - Laboratory - Researcher):

University of Ouagadougou (Burkina Faso)

Duration: October 2010 - September 2013

7.4.2.3. Germany. Egide Procope Program 2011-12

Program: PHC

Title: Reasoning in systems biology with answer set programming.

Inria principal investigator: Jacques Nicolas

International Partner :

University of Potsdam (Germany)

Institut fur Informatik Wissensverarbeitung und Informationssysteme

T. Schaub

Duration: Jan 2011 - Dec 2012

The cooperation adresses various aspects of the development of the Answer Set Programming approach in bioinformatics.Based on formal methods for the Analysis of big metabolic networks we developed a new approach with Answer Set Programming This approach can be used to check whether a network contains the reaction pathways that explain the bio-synthetic behavior of the organism. Further we developed an approach for the learning of logical models of protein signaling networks.

7.4.2.4. Amadeus (Austria)

Program: PHC

Title: From fractals to numeration

Inria principal investigator: Anne SIEGEL

International Partner (Institution - Laboratory - Researcher):

University of Leoben (Austria)

Duration: Jan 2011 - Dec 2012

7.5. International Research Visitors

7.5.1. Visits of International Scientists

- **Germany**. Department of Computer Science, Potsdam. 5 days [T. Schaub, M. Gebser, M. Ostrowski]
- **Chile**. Centro de Modelimiento Matematico, Santiago. 10 days [A. Maass]

7.5.1.1. Internships

- Internship April to July, 2012. Co-supervised by Anne Siegel and Sylvain Prigent. Student : Floriane Ethys de Corny. Subject: Improvement of metabolic networks. Application to Ectocarpus siliculous.

7.5.2. Visits to International Teams

- **Austria**. Department of Mathematics, Leoben & Vienna. *Dynamical systems*. 5 days [A. Siegel]
- **Burkina-Faso**. Department of Computer Science, Oagadougou. *Multi-objective methods for the static analysis of metabolic network*. 2 months [O. Abdou-Arbi]
- **Chile**. Centro de Modelimiento Matematico, Santiago. *Metabolic modeling of bacteria*. 14 days [D. Eveillard]
- **Chile**. Centro de Modelimiento Matematico, Santiago. *Data integration*. 7 days [A. Siegel]
- **Chile**. Centro de Modelimiento Matematico, Santiago. *Applications of ASP*. 21 days [S. Thiele]
- **Chile**. Centro de Modelimiento Matematico, Santiago. *Applications of ASP*. 10 days [S. Videla]
- **Germany**. Department of Computer Science, Potsdam. *Constraint-based approaches*. 5 days [J. Nicolas]
- **Germany**. Department of Computer Science, Potsdam. *Application of ASP to biology*. 5 days [A. Siegel]
- **Germany**. Department of Computer Science, Potsdam. *Reconstruction of metabolic networks*. 10 days [S. Thiele]
- **Germany**. Department of Computer Science, Potsdam. *Learning logical rules for protein signaling networks*. 2 months [S. Videla]
- **Niger**. University of Maradi. *Multi-objective methods for the static analysis of metabolic network*. 1 month [O. Abdou-Arbi]
- **UK** EMBL-European Bioinformatics Institute. *Learning logical rules for protein signaling networks*. 3 days [S. Videla]

GENSCALE Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Program from Région Bretagne : MIRAGE

Participants: Liviu Ciortuz, Claire Lemaitre, Pierre Peterlongo.

The MIRAGE project is funded by Région Bretagne in the framework of the SAD call (Stratégie Attractivité Durable) which aims at attracting international post-doctorant for one year. The MIRAGE project aims at developing new methods to detect complex variation (structural variations) in non-assembled NGS data. It is funded from Sept. 2012 until August 2013 and coordinated by C. Lemaitre.

8.1.2. Partnership with INRA

Participants: Thomas Derrien, Anaïs Gouin, Fabrice Legeai, François Moreews, Raluca Uricaru.

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

8.2. National Initiatives

8.2.1. ANR

8.2.1.1. BIOWIC

Participants: Rumen Andonov, Dominique Lavenier, François Moreews.

The BioWIC project aims to speed up both the design and the execution of bioinformatics workflows. It is funded by ANR call ARPEGE and coordinated by D. Lavenier from Jan. 2009 to June 2012. http://biowic. inria.fr/

8.2.1.2. MAPPI

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

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

8.2.1.3. FATINTEGER

Participants: Dominique Lavenier, François Moreews.

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

8.2.1.4. SPECIAPHID

Participants: Thomas Derrien, Anaïs Gouin, Fabrice Legeai, Claire Lemaitre.

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

8.2.1.5. ADA-SPODO

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

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

8.2.1.6. RAPSODYN

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

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

8.2.1.7. LEPIDOLF

Participants: Dominique Lavenier, Fabrice Legeai.

The LEPIDOLF project aims at better understanding olfactory mechanisms in insects. The goal is to establish the antennal transcriptome of the cotton leafworm Spodoptera littoralis, a noctuid representative of crop pest insects. It is funded by ANR call Blanc and coordinated by E. Jacquin-Joly from UMR PISC (INRA) from 2009 to 2012. As part of this project, a post-doctoral student, Aurore Gallot, visited Genscale for 5 months.

8.2.2. Programs from research institutions

8.2.2.1. Mapsembler

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

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

8.2.2.2. Mastodons

Participants: Dominique Lavenier, Claire Lemaitre, Pierre Peterlongo.

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

8.2.2.3. BioManyCores

Participants: Guillaume Chapuis, Charles Deltel, Dominique Lavenier.

The BioManyCores project aims to develop a library of bioinformatics softwares implemented on manycore structures such as GPU. It is funded by Inria ADT call and supervised by J.S. Varré in Sequoia Team in Lille. http://www.biomanycores.org/

8.2.2.4. ParaQtlMap

Participants: Guillaume Chapuis, Charles Deltel, Dominique Lavenier.

The ParaQtlMap project is a join initiative from Genscale team and Genetique Animale. to design high performance software for detecting quantitative trait locus. It is funded by Inria/INRA call and coordinated by D. Lavenier (Genscale) and P. Leroy (GA INRA) from oct. 2010 to sept. 2012. https://qgp.jouy.inra.fr/index.php?option=com_content&task=view&id=17&Itemid=28

8.2.2.5. Barcoding de nouvelle génération

Participants: Dominique Lavenier, Claire Lemaitre, Pierre Peterlongo.

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

8.2.2.6. Poly-BNF

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

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

8.2.3. Cooperations

8.2.3.1. Inria Bamboo Team

Participants: Claire Lemaitre, Pierre Peterlongo.

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

8.2.3.2. LIGM, Paris

Participant: Pierre Peterlongo.

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

8.2.3.3. LIX

Participant: Antonio Mucherino.

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

8.3. European Initiatives

8.3.1. Collaborations with Major European Organizations

Partner: CWI, University of Amsterdam, (Netherland)

Subject of cooperation: Optimization algorithms for protein structures alignments.

8.4. International Initiatives

8.4.1. Participation In International Programs

8.4.1.1. CONICYT (Chile)

Program: Coopération bilatérale CNRS

Title: Wine fermentation analysis by biclustering

Inria principal investigator: Antonio MUCHERINO

International Partner (Institution - Laboratory - Researcher):

Technical University Federico Santa Maria (Chile)

Duration: Jan 2012 - Dec 2012

This project aims at using data mining techniques for predicting problematic wine fermentations from the first stages of the fermentation process.

8.4.2. Collaborations

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

Subject: distance geometry, bioinformatics.

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

Subject: distance geometry, bioinformatics.

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

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

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Carlile Lavor, from IMECC-UNICAMP, Campinas-SP, Brazil, visited Genscale 3 times (2 times, for 1 week, funded by his own projects and 1 time, for 1 month, funded by "mois ISTIC").

- Alejandra Urtubia, from Universidad Tecnica Federico Santa Maria, Valparaiso, Chile, visited genscale for 2 weeks. This visit was funded by CNRS-CONICYT project on wine fermentation (A. Mucherino).

- Hristo Djidjev from Los Alamos, USA, visited Genscale for a month in the framework of University of Rennes 1 visiting positions "professeur invité".

- Van-Hoa Nguyen from University of Angiang, Viet Nam, visited GenScale for 3 months (nov. 2012 - jan. 2013). The visit was funded by the French Mastodons program from CNRS to research focusing on bioinformatics big data problem.

- Rafael Santos, from UNICAM, Bresil, visited GensCale for 3 months (oct. 2012 - dec. 2012). The visit was funded by CNPq (collaboration with A. Mucherino on protein structure).

- Virginia Silva da Costa, from the Federal University of Rio, Bresil, visited Genscale for 4 months (mar. 2012 - june 2012), funded by CAPES.

- Mariade Cola, from the University of Rome, Italia, visited Genscale for 3 months (apr. 2012 - june 2012), funded by IASI-CNR.

- Sharat Bogaraju, from IIT Delhi, India, visited GenScale for 6 months (dec. 2011 - may 2012). The visit was funded by Rennes Metropole (International exchange of PhD Students). Collaboration with D. Lavenier on parallel bioinformatics algorithms .

8.5.2. Visits to International Teams

- Antonio Mucherino visited IMECC-UNICAMP, Campinas-SP, Brazil, for 2 months, under the program "chaires française à São Paulo"

- Claire Lemaitre and Pierre Peterlongo visited for 1 week the "Laboratory of Bioinformatics and Mathematics of the Genome" hosted at CMM at University of Chile. The visit was funded by CIRIC-omics research line of the Inria center in Chile.

- Nicolas Maillet (PhD) wisited during three months the LNCC (Laboratório Nacional de Computação Científica) in Petropolis (state of Rio de Janeiro, Brazil) from March to June 2012.

- Mathilde Le Boudic-Jamin (PhD) visited the CWI in Amsterdam, Neetherlands (June 2012, one month) and collaborated with Gunnar KLAU and Inken WOHLERS on the family identification problem.

<p style="text-align:center">**IBIS Project-Team**</p>

7. Partnerships and Cooperations

7.1. Regional initiatives

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

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

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

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

7.2. National initiatives

Project name	ColAge – Lifespan control in bacteria: Natural and engineering solutions
Coordinator IBIS participants Type Web page	H. Berry G. Baptist, E. Cinquemani, J. Geiselmann, H. de Jong, J. Izard, S. Lacour, C. Pinel, D. Ropers Action d'Envergure Inria-INSERM (2008-2012) http://colage.saclay.inria.fr

Project name	GeMCo – Model reduction, experimental validation, and control for the gene expression machinery in *E. coli*
Coordinator	M. Chaves
IBIS participants	G. Baptist, E. Cinquemani, J. Geiselmann, E. Grac, H. de Jong, J. Izard, S. Lacour, C. Pinel, D. Ropers
Type	ANR Blanc (2010-2013)
Web page	http://www-sop.inria.fr/members/Madalena.Chaves/ANR-GeMCo/main.html

Project name	RESET – Arrest and restart of the gene expression machinery in bacteria: from mathematical models to biotechnological applications
Coordinator	H. de Jong
IBIS participants	G. Baptist, E. Cinquemani, J. Geiselmann, H. de Jong, J. Izard, S. Lacour, Y. Markowicz, C. Pinel, D. Ropers
Type	Bioinformatics call, Investissements d'Avenir program (2012-2016)

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

7.3. International projects

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

The goal of ICGC (International Cancer Genome Consortium) is to obtain a comprehensive description of genomic, transcriptomic and epigenomic changes in 50 different cancer types. In France, INCa (French National Cancer Institute) contributes to this project and focuses on two types of cancer. The main idea is to sequence the human genome of normal and tumoral cells of a large set of patients and to compare these genomic sequences to identify the mutations which may explain the development of the cancers. Bioinformatics is clearly involved in the management, the analysis and the visualization of the huge sets of data and results. Bioinformatics of the French contribution is carried out at Lyon, in the context of the Synergie Lyon Cancer Foundation. François Rechenmann has joined this bioinformatics team and contributes to the organization of the data management and analysis workflow, under the leadership of prof. Gilles Thomas [12], [10].

7.4. International collaborations

IBIS has strong collaborations with the group of Giancarlo Ferrari-Trecate at the Computer Engineering & Systems Science Department of the University of Pavia (Italy) and the group of John Lygeros at the Automatic

Control Lab at ETH Zürich (Switzerland). This collaboration started with the FP6 project Hygeia, in which the above groups and IBIS (then HELIX) participated. Over the years, it has resulted in a dozen of co-authored papers and the co-supervision of a PhD thesis by Hidde de Jong and Giancarlo Ferrari-Trecate. Eugenio Cinquemani was a post-doctoral fellow at ETH in the framework of the Hygeia project, and joined the IBIS group as a research scientist in the fall of 2009.

7.5. International research visitors

Internship	Elif Köksal (Bogazici University, Turkey))
Supervisor	E. Cinquemani
Subject	Modeling, analysis, and identification of metabolic networks

Internship	Nicola Simeone (University of Pavia, Italy))
Supervisor	E. Cinquemani
Subject	Stochastic modeling and identification of bacterial regulatory networks

<p align="center" style="color:red">MAGNOME Project-Team</p>

8. Partnerships and Cooperations

8.1. Regional Initiatives

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

Participants: David James Sherman [correspondant], Elisabeth Bon, Pascal Durrens, Aurélie Goulielmakis, Nicolás Loira, Tiphaine Martin.

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

8.2. National Initiatives

8.2.1. ANR MYKIMUN

Participants: Pascal Durrens [correspondant], Witold Dyrka, David James Sherman.

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). MAGNOMEdevelops machine learning techniques for classifying and identifying STAND proteins in fungal genomes, as well as statistical analysis of their genomic neighborhoods.

8.2.2. ANR DIVOENI, 2008-2012

Participants: Elisabeth Bon [correspondant], Aurélie Goulielmakis.

LaBRI, through Elisabeth Bon, is a partner in DIVOENI, a four-year ANR project concerning intraspecies biodiversity of the oenological bacteria *Oenococcus oeni*. Coordinated by Prof. Aline Lonvaud (Univ. Bordeaux Segalen) from the Institute of Vine and Wine Sciences of Bordeaux – Aquitaine, this scientific programme was developed:

1. To evaluate the genetic diversity of a vast collection of strains, to set up phylogenetic groups, then to investigate relationships between the ecological niches (cider, wine, champagne) and the essential phenotypical traits. Hypotheses on the evolution in the species and on the genetic stability of strains will be drawn.
2. To propose methods based on molecular markers to make a better use of the diversity of the species.
3. To measure the impact of the repeated use of selected strains on the diversity in the ecosystem and to draw the conclusions for its preservation.

Elisabeth is in charge of the computational infrastructure dedicated to genomics and post-genomics data storage, handling and analysis. She coordinates collaboration with the CBiB-Centre de Bioinformatique de Bordeaux (Aurélien Barré).

8.3. European Initiatives

8.3.1. FP7 Projects

8.3.1.1. Affinity Proteomics

Participants: David James Sherman [correspondant], Natalia Golenetskaya.

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

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

8.3.2. Collaborations with Major European Organizations

Prof. Mike Taussig: Babraham Institute & Cambridge University

Knowledge engineering for Affinity Proteomics

Henning Hermjakob: European Bioinformatics Institute

Standards and databases for molecular interactions

8.4. International Initiatives

8.4.1. Inria Associate Teams

8.4.1.1. CARNAGE

Program: Inria-Russia

Title: CARNAGE: Combinatorics of Assembly and RNA in GEnomes

Inria principal investigator: Mireille Régnier

International Partner (Institution - Laboratory - Researcher):

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

Duration: 2012–13

See also: http://en.inria.fr/domaines-epi/computational-sciences-for-biology-medicine-and-the-environment

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.

8.4.2. Participation In International Programs

8.4.2.1. Génolevures and Dikaryome Consortia
Participants: David James Sherman [correspondant], Pascal Durrens, Florian Lajus, Tiphaine Martin, Anna Zhukova.

Since 2000 our team is a member of the Génolevures Consortium (GDR CNRS), a large-scale comparative genomics project that aims to address fundamental questions of molecular evolution through the sequencing and the comparison of 14 species of hemiascomycetous yeasts. The Consortium is comprised of 16 partners, in France, Belgium, Spain, the Netherlands (see http://genolevures.org/). Within the Consortium, our team is responsible for bioinformatics, for research in new methods of analysis. Pascal Durrens and Tiphaine Martin of the CNRS are responsible for the development of resources for exploiting comparative genomic data. Pascal Durrens is the editorial manager of the Génolevures on-line resource.

The Dikaryome Consortium is a scientific collaboration between several international partners and the National Center for Sequencing (CEA–Génoscope, Évry) on the sequencing, annotation, and comparative analysis of fungal genomes.

These perennial collaborations continue in two ways. First, a number of new projects are underway, concerning several new genomes currently being sequenced, and new questions about the mechanisms of gene formation. Second, through the development and improvement of the Génolevures On Line database, in whose maintenance our team has a longstanding committment and the improvement of tools like the YAGA software.

8.5. International Research Visitors

8.5.1. *Visits of International Scientists*

Rodrigo Assar Cuevas was invited for a month in Fall 2012 to work with David James Sherman on Quantized State Systems applied to BioRica hierarchical models.

8.5.2. *Visits to International Teams*

Anna Zhukova was invited to the Babraham Institute (Babraham, UK) for two week in December, 2012 to work on knowledge engineering for biological networks and visualization.

Pascal Durrens and David James Sherman are invited to the Vavilov Institute for General Genetics in Moscow in December, 2012 to work on regulon identification and analysis in hemisascomycete yeasts.

MORPHEME Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. LABEX SIGNALIFE

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

7.1.2. ARC DADA

Participants: Xavier Descombes [PI], Florence Besse, Huei Fang Yang, Alejandro Mottini.

The DADA project (Description et Analyse Dynamique de la Croissance Axonale) is a common projet with the SERPICO team from Inria Bretagne (Charles Kervrann). The goal is to develop new computational techniques to track axons during their growth. We consider 4D data obtained on a bi-photons microscope. In a longer term, we expect to model the morphological develepement of axons in different populations to characterize some disorders such as the fragile-X symdrom. (DADA).

7.1.3. ANR DIAMOND

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

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

(DIAMOND)

7.1.4. ANR MOTIMO

Participants: Laure Blanc-Féraud, Xavier Descombes, Eric Debreuve, Huei Fang Yang, Clarens Caraccio.

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

7.1.5. 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.

7.1.6. Inria Large-scale initiative Morphogenetics

Participants: Grégoire Malandain, Xavier Descombes.

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.

7.1.7. PEPII 1

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

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

7.1.8. PEPII 2

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

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

7.1.9. Informal collaboration

Participant: Eric Debreuve.

- Partners: Barbara André, Mauna Kea Technologies, Paris, France
- Subject: Automatic classification of endomicroscopic videos

7.2. International Research Visitors

7.2.1. Visits of International Scientists

- Roberto Cavicchioli, PhD student, University de Modena and Reggio Emilia. Visting period 01/04/2012 - 30/06/2012; MAEE Research grant.
- Alexandre Dufour, Pasteur Institute, Unité d'Analyse d'Images Quantitative CNRS URA 2582 "Interactions et dynamique cellulaires". 3 december 2012, seminar at I3S.
- Caroline Fonta, CerCo, Toulouse, 7 december 2012, seminar at iBV.
- Charles Deledalle, Ceremade, Paris Dauphine, 3 august 2012, seminar at I3S.

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. *Computing and storage facilities*

Participants: Tristan Lecorgne, Charles Kervrann.

The aim is to design a computing architecture to process bioimaging data sets and to deal with the data flow from the different imaging microscopy platforms. The software packages will manage the needs of end users in Rennes, where interactivity with the imaging devices and information systems are desirable.

Funding: Rennes-Metropole - "Allocation Installation Scientifique"

8.2. National Initiatives

8.2.1. *Quaero project*

Participants: Charles Kervrann, Patrick Bouthemy, Denis Fortun, Solène Ozeré.

Quaero is a European collaborative research and development program with the goal of developing multimedia and multi-lingual indexing and management tools for professional and public applications. SERPICO team participates in the Work Package 9 on Video Processing (WP9) of QUAERO Core Technology Cluster Project (CTC). Within WP9, former Vista project-team leaded three tasks: "Motion Recognition", "Object Tracking" and "Event Recognition". Since October 2010, SERPICO has conducted activities in object tracking and indexing for video-microscopy analysis (Denis Fortun PhD grant (6.3 and 6.4) and Solène Ozeré Internship (6.1)).

 Funding: Quaero (no. Inria Alloc 3184), duration: 30 months
 Partners: 24 academic and industrial partners leaded by Technicolor

8.2.2. *ANR GreenSwimmers project*

Participant: Charles Kervrann.

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

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

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

8.2.3. *LI-FLIM project*

Participants: Charles Kervrann, Philippe Roudot.

The goal is to develop lifetime estimation methods of moving vesicles in FLIM microscopy. Grant to support collaboration between SERPICO team and UMR 144 CNRS PICT-IBiSA Institut Curie (P. Roudot's PhD (6.5))

Funding: GdR 2588 "Microscopie Fonctionnelle du Vivant" - Mobility grant
Partner: UMR 144 CNRS PICT IBiSA Institut Curie

8.2.4. DADA project

Participant: Charles Kervrann.

The accurate control of the growing and guidance of neuronal extensions to their target is a very important step for the maturation of the nervous system. The goal of this project (http://www-sop.inria.fr/members/Xavier.Descombes/DADA/home.html) is to develop new computational techniques to analyze image sequences of 3D volumes containing a population of growing axons (see Fig. 3) .

Funding: Inria ARC (2011-2012)
Partners: Inria Morpheme team and IBDC, laboratory from University of Nice Sophia Antipolis

8.2.5. France-BioImaging project

Participants: Charles Kervrann, Tristan Lecorgne.

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.

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

8.3. European Initiatives

8.3.1. Collaborations with Major European Organizations

ESFRI Euro-BioImaging initiative: SERPICO participates to the ESFRI Euro-BioImaging project, one of the four new biomedical science projects in the roadmap of the European Strategic Forum on Research Infrastructures (ESFRI). The mission of Euro-BioImaging is to provide access, service and training to state-of-the-art imaging technologies and foster the cooperation and networking at the national and European level including multidisciplinary scientists, industry regional, national and European authorities. (3-year Preparatory Phase / start: December 2010). SERPICO also participates to 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 8.2.5 .

8.4. International Research Visitors

8.4.1. Visits to International Teams

- Collaboration with University of Saarland (Germany), Prof. J. Weickert, on optical flow computing (D. Fortun's visit in 2012, 3 months, Rennes-Metropole grant).

- Collaboration with Harvard Medical School (Boston, MA), Prof. G. Danuser, on object tracking in video-microscopy (P. Roudot's visit in 2012-2013, 3 months, Inria & CNRS grant).

8.4.2. Others

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

<p style="text-align: center; color: red;">**ASCLEPIOS Project-Team**</p>

7. Partnerships and Cooperations

7.1. European Initiatives

7.1.1. FP7 Projects

7.1.1.1. VPH NOE

Participants: Benoît Bleuzé [correspondant], Olivier Clatz, Maxime Sermesant, Nicholas Ayache.

medinria registration toolbox VPH NOE standards

Title: VPH NoE

Type: COOPERATION (ICT)

Defi: Virtual Physiological Man

Instrument: Network of Excellence (NoE)

Duration: June 2008 - November 2012

Coordinator: University College London, UK

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

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

Abstract: The Virtual Physiological Human Network of Excellence (VPH NoE) is a EU seventh Framework funded project, working to connect and support researchers in the VPH field within Europe and beyond. Inria is one of the core members, and is more dedicated, through Asclepios, to the data fusion part of the VPH toolkit. More precisely, a registration toolbox has been delivered which aims at including registration algorithms from the team and elsewhere into the new version of MedInria (2.x).

7.1.1.2. EUHEART

Title: euHeart

Type: COOPERATION (ICT)

Defi: Virtual Physiological Man

Instrument: Integrated Project (IP)

Duration: June 2008 - May 2012

Coordinator: Philips Technologie GmbH Forschungslaboratorien (Germany)

Others partners: Philips Technologie GmbH (DE), The University of Oxford (UK), Universitat Pompeu Fabra (SP), The University of Sheffield (UK), Inria, French National Research Institute in Informatics and Mathematics (FR), King's College London (UK), Academisch Medisch Centrum bij de Universiteit van Amsterdam (NL), Universität Karlsruhe (TH) (DE), Institut National de la Santé et de la Recherche Médicale, INSERM (FR), Philips Medical Systems Nederland BV (NL), Berlin Heart GmbH (DE), HemoLab BV (NL), Universitätsklinikum Heidelberg (DE), Volcano Europe SA / NV (BE), Hospital Clínico San Carlos de Madrid (SP), Philips Ibérica S.A. (SP)

See also: http://www.euheart.eu/

Abstract: The euHeart project (Ref 224495), is a 4-year integrated European project which aims at developing personalized, and clinically validated multi-physics, multi-level models of the heart and great vessels. Those models need to be tightly integrated with signal and image processing tools in order to assist clinical decision making and to help reducing morbidity and mortality rates associated with cardiovascular diseases. Asclepios is leading a workpackage on radiofrequency ablation for which electromechanical models of the heart are used to improve the planning of radiofrequency ablation lines for patient suffering from atrial fibrillation and ventricular tachycardia. The research performed in this project is partially described in section 5.4.3 and 5.4.4 .

7.1.1.3. MedYMA

Title: Biophysical Modeling & Analysis of Dynamic Medical Images

Type: IDEAS ()

Instrument: ERC Advanced Grant (Advanced)

Duration: April 2012 - March 2017

Coordinator: Inria (France)

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

Abstract: During the past decades, exceptional progress was made with in vivo medical imaging technologies to capture the anatomical, structural and physiological properties of tissues and organs in a patient, with an ever increasing spatial and temporal resolution. The physician is now faced with a formidable overflow of information, especially when a time dimension is added to the already hard to integrate 3-D spatial, multimodal and multiscale dimensions of modern medical images. This increasingly hampers the early detection and understanding of subtle image changes which can have a vital impact on the patient's health. To change this situation, this proposal introduces a new generation of computational models for the simulation and analysis of dynamic medical images. Thanks to their generative nature, they will allow the construction of databases of synthetic, realistic medical image sequences simulating various evolving diseases, producing an invaluable new resource for training and benchmarking. Leveraging on their principled biophysical and statistical foundations, these new models will bring a 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 the 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. Collaborations in European Programs, except FP7

7.1.2.1. Care4Me

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

Program: ITEA2

Project acronym: Care4Me

Project title: Cooperative Advanced REsearch for Medical Efficiency

Duration: Sept. 2009 - Sept. 2013

Coordinator: Philips, NL.

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

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

7.2. International Initiatives

7.2.1. *Inria Associate Teams*

Title: Analysis of structural MR and DTI in neonates

Inria principal investigator: Pierre Fillard [Parietal]

Asclepios investigator: Xavier Pennec

International Partner (Institution - Laboratory - Researcher):

University of Pennsylvania (United States) - Penn Image Computing and Science Laboratory - Caroline Brun

International Partner (Institution - Laboratory - Researcher):

Institution: University of Southern California (United States)

Laboratory: Image Lab at Children Hospital at Los Angeles

Researcher: Natasha Leporé

Duration: 2011 - 2013

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

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

7.2.1.1. *COMPUTUMOR*

Title: Computational Brain Tumor

Inria principal investigator: Olivier Clatz

International Partner:

    Institution: Massachusetts Institute of Technology (United States)

    Laboratory: Computer Science and Artificial Intelligence Laboratory (CSAIL)

International Partner:

    Institution: German Cancer Research Center (United States)

    Laboratory: DKFZ Heidelberg diffusion group

Duration: 2007 - 2012

See also: http://www-sop.inria.fr/asclepios/projects/boston/

The CompuTumor associated team has been funded early 2007 and renewed in 2009. The CompuTumor project is dedicated to the study of brain tumor models and their coupling with medical images to better assist diagnosis and therapy. The project strongly enhance the current collaborations between Inria and a group of world leading teams with complementary technical and clinical expertise on these topics in Boston and Nice. More specifically, the project aims at (a) proposing new medical image processing method that could be used to better analize tumor images, (b) developping new brain tumor models in order to personalise these models with patient data. Microsoft Research has been also recently involved in the collaboration on lesion segmentation. Our most recent activity is described in sections 5.1.1 and 5.4.1 and also on the website of the associated team : http://www-sop.inria.fr/asclepios/projects/boston/.

7.2.2. Inria International Partners

7.2.2.1. Collaboration with international hospitals

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

Maxime Sermesant is a part-time lecturer in the Interdisciplinary Medical Imaging Group, Division of Imaging Sciences, St Thomas' Hospital, King's College London lead by Pr Reza Razavi. The XMR facility within this hospital is a unique possibility to validate and exploit the cardiovascular modelling work.

7.2.2.1.2. Children Hospital, Boston

A collaboration with Dr Simon Warfield, director of the Computational Radiology Laboratory has been active for several years, especially on the issue of atlas-based image segmentation and registration.

7.2.2.1.3. Other International Hospitals

Collaborations with several other European hospitals have been established through the European projects Passport and euHeart.

7.3. International Research Visitors

7.3.1. Visits of International Scientists

- **Marc Niethammer** (Assoc. Prof. at the Biomedical Research Imaging Center (BRIC), Univ. North Carolina Chapel Hill). Hosted by the Inria-Microsoft common research lab. *Control methods in diffeomorphic non linear registration for longitudinal image analysis*. September to November.

<h1 style="text-align: center; color: red;">ATHENA Project-Team</h1>

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

7.1.2. ANR ViMAGINE

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

Duration: *July 2008 to July 2013*

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

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

7.1.3. ANR CO-ADAPT

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

Duration: *December 2009 to December 2013*

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

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

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

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

7.1.4. ANR NucleiPark

Participants: Rachid Deriche, Aurobrata Ghosh, Anne-Charlotte Philippe, Emmanuel Caruyer, Jian Cheng.

Duration: *September 2009 to June 2013*

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

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

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

7.1.5. ANR MULTIMODEL

Participants: Théodore Papadopoulo, Maureen Clerc, Sebastian Hitziger.

Duration: *December 2010 to March 2014*

The general objectives of the MULTIMODEL project are twofold:

- Develop computational models at the level of neuronal systems that will help interpreting neuroimaging data in terms of excitation-, inhibition- and synchronization-related processes.

- 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, during this 3-year project, the following questions will be 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 will operate at the level of population of cell, i.e. at a scale compatible with the resolution of neuroimaging tools (at the level of the mm). A novel model structure will be investigated. It will include astrocytes at this "mesoscopic" level and will operate in networks of connected regions. Moreover, models in physiological and pathological conditions will be compared, which will be a step towards a better understanding of mechanisms underlying epileptic condition.

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).

7.1.6. 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.

7.1.7. 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 th egoal 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, deployement and perenity. The goal of this ADT is to solve these problems, to improve and to extend OpenViBe One main goal is to improve the usability and the attractivity of the software and to retain a large community of users so as to ensure its sustainability. This ADT will allow to support the research made in four Inria teams (ATHENA, HYBRID, NEUROSYS and POTIOC) on hot topics such as adaptive or hybrid BCIs.

7.2. International Initiatives

7.2.1. Inria Associate Teams

7.2.1.1. BRAINCONNECTIVITIES

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

Inria principal investigator: Théodore Papadopoulo

International Partners (Institution - Laboratory - Researcher):

University of Québec, School of Higher Technology (Canada) - PhysNum Group, Centre de recherches mathématiques, Montréal - Jean-Marc Lina

University of Sherbrooke (Canada) - Departement d'Informatique - Maxime Descoteaux

Duration: 2012 - 2014

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

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

7.2.2. *Participation In International Programs*

7.2.2.1. *STIC-Algérie*

Title: Computational Diffusion MRI.

Inria principal investigator: Rachid Deriche

International Partners: Université des Sciences et des Technologies Houari Boumedienne (F. Boumghar, USTHB - Algiers) - Université de Boumerdes (D. Cherifi).

7.3. International Research Visitors

7.3.1. *Visits of International Scientists*

In the framework of the BrainConnectivities associate team:
- Pr. Linda Boumghar from USTHB (Université des Sciences et Technologies Hourai Boumedienne, Algiers) visited Athena from Jan. 30 to February 4th, 2012.
- Maxime Descoteaux and Michael Paquette (USherbrooke) visited Athena on Sept. 24th for a week.
- Gabriel Girard (USherbrooke) visited Inria from Sept. 24th to Oct. 26th.
- Jean-Christophe Houde and Maxime Chamberland (USherbrooke) visited Athena October 8-9th.
- Jean-Marc Lina and Younes Zerouali (CRM) visited Athena from Nov. 26 to Dec. 2 with the goal of starting integrating cortical patch information developed at Athena into the source localisation method developed at CRM.

In the framework of the STIC-Algérie program:
- Pr. Linda Boumghar from USTHB (Université des Sciences et Technologies Hourai Boumedienne, Algiers) visited Athena from Jan. 30 to February 4th, 2012.
- Thinhinane Megherbi and Sihem Zeggout from USTHB (Université des Sciences et Technologies Houari Boumedienne, Algiers) visited Athena from May 17 to June 21th, 2012.

7.3.2. *Internships*

Tristan Milne (from May 2012 until Aug 2012)

Subject: Constrained Diffusion Kurtosis Imaging Using Ternary Quartics and MLE

Institution: Queen's University, Kingston, Ontario (Canada)

<p style="text-align:center; color:red;">**CORTEX Project-Team**</p>

7. Partnerships and Cooperations

7.1. Regional initiatives

7.1.1. *Action Situated Informatics of the CPER*

Participants: Laurent Bougrain, Octave Boussaton, Thierry Viéville.

In the framework of the Contrat de Projet État Région, we are contributing to the axis IS (Informatique Située) through the project CoBras whose goal is to study reinforcement learning to better control a robotic arm in a Brain-Machine interface. We bought a JACO robotic arm for wheelchair by Kinova.

7.2. National initiatives

7.2.1. *DGE Ministry grant COMAC "Optimized multitechnique control of aeronautic composite structures"*

Participants: Laurent Bougrain, Octave Boussaton, Marie Tonnelier.

The goal of this three-years project is to develop a powerful system of control on site, in production and in exploitation, of aeronautical pieces made of composite. It takes up the challenge of the precise, fast and local inspection on composite pieces of aeronautical structures new or in service by using techniques of non-destructive control more effective and faster to increase the lifespans of the structures of planes. This project requires a decision-making system including fast methods of diagnostic based on several optical technics as non-destructive control.

7.2.2. *ANR project KEOPS*

Participants: Frédéric Alexandre, Laurent Bougrain, Thierry Viéville.

This «ANR Internal White Project» involving NEUROMATHCOMP and CORTEX Inria EPI in France with the U. of Valparaiso, U. Tecnica Frederico Santa-Maria, and U. De Chili is a 3 years, 248 person-months, sensory biology, mathematical modeling, computational neuroscience and computer vision, project addressing the integration of non-standard behaviors from retinal neural sensors, dynamically rich, sparse and robust observed in natural conditions, into neural coding models and their translation into real, highly non-linear, bio-engineering artificial solutions. An interdisciplinary platform for translation from neuroscience into bio-engineering will seek convergence from experimental and analytical models, with a fine articulation between biologically inspired computation and nervous systems neural signal processing (coding / decoding) [23].

7.2.3. *ANR project PHEROTAXIS*

Participants: Dominique Martinez, Thomas Voegtlin.

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

7.2.4. Project CNRS PEPII: A large-scale, robotically embodied decision making model

Participants: Frédéric Alexandre, Nicolas Rougier, Thierry Viéville.

This project is a collaboration between the "Institut des Maladies neuro-dégénératives" (UMR 5293, team "Approche systémique de la Boucle Extrapyramidale"), Supélec ("Information, Multimodalité, Signal") and the Cortex team. This project aims at studying the decision making process viewed as a high-level brain function, actioned by a distributed network of cortical and sub-cortical structures, interconnected in positive and negative feedback loops.

7.2.5. Project CNRS PEPII IMAVO

Participants: Nicolas Rougier, Yann Boniface.

This project is a collaboration between the "Institut des Neurosciences Cognitives et Intégratives d'Aquitaine" (UMR 5287), the "Institut des Systèmes Intelligents et de Robotique" (Systèmes Intégrés Mobiles et Autonomes) and the LORIA (Maia and Cortex groups). This project aims at investigating model-free and model-based approaches in the decision process in order to propose a computational model of the decision process in simple tasks.

7.3. European Initiatives

7.3.1. FP7 Projects

7.3.1.1. MathAna

Title: Mathematical Analysis of Anaesthesia

Type: IDEAS

Instrument: ERC Starting Grant (Starting)

Duration: January 2011 - December 2015

Coordinator: Inria (France)

Abstract: General anaesthesia is an important method in today's hospital practice and especially in surgery. To supervise the depth of anaesthesia during surgery, the anaesthesist applies electroencephalography (EEG) and monitors the brain activity of the subject on the scalp. The applied monitoring machine calculates the change of the power spectrum of the brain signals to indicate the anaesthetic depth. This procedure is based on the finding that the concentration increase of the anaesthetic drug changes the EEG-power spectrum in a significant way. Although this procedure is applied world-wide, the underlying neural mechanism of the spectrum change is still unknown. The project aims to elucidate the underlying neural mechanism by a detailed investigating a mathematical model of neural populations. The investigation is based on analytical calculations in a neural population model of the cortex involving intrinsic neural properties of brain areas and feedback loops to other areas, such as the loop between the cortex and the thalamus. Currently, there are two proposed mechanisms for the charactersic change of the power spectrum: a highly nonlinear jump in the activation (so-called phase transition) and a linear behaviour.

The project mainly focusses on the nonlinear jump to finally rule it out or support it. A subsequent comparison to previous experimenta results aims to fit the physiological parameters. Since the cortex population is embedded into a network of other cortical areas and the thalamus, the corresponding analytical investigations takes into account external stochastic (from other brain areas) and time-periodic (thalamic) forces. To this end it is necessary to develop several novel nonlinear analysis technique of neural populations to derive the power spectrum close to the phase transition and conditions for physiological parameters.

7.4. International Initiatives

7.4.1. Inria Associate Teams

7.4.1.1. Cortina, associate team with Chile

Participants: Frédéric Alexandre, Thierry Viéville, Laurent Bougrain.

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

7.5. International Research Visitors

7.5.1. Visits of International Scientists

7.5.1.1. Internships

Elaa TEFTEF (from Dec 2011 until Jun 2012)

> Subject: Formalisation de la transformation analogique / événementielle des mécanismes non-standards des cellules ganglionnaires de la rétine.

> Institution: Ecole Nationale d'Ingénieurs de Tunis (Tunisia)

TARUN JAIN (from May 2012 until Aug 2012)

> Subject: Optimization of reconstruction of brain signals by neural population models

> Institution: IIT Delhi (India)

7.5.1.2. Visiting professors/researchers

Peter BEIM GRABEN (from 01/10/2012 until 22/12/2012)

> Funding: Inria Mathana

> Subject: Detection of metastable states in brain signals

> Institution: Humboldt University Berlin, Germany

Chahinez Meriem BENTAOUZA (from 17/11/2012 until 08/12/2012)

> Funding: University of Mostaganem

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

> Institution: University of Mostaganem, Algeria

Samira CHOURAQUI (from 01/04/2012 until 30/04/2012)

> Funding: University of Oran

> Subject: Modélisation des systèmes non linéaires par des réseaux de neurones

> Institution: University of Oran, Algeria

Fatiha HENDEL (from 12/01/2012 until 28/01/2012)

> Funding: University of Oran

> Subject: Apprentissage et classification automatique

> Institution: University of Oran, Algeria

Rodrigo SALAS FUENTES (from 20/04/2012 until 19/07/2012)

> Funding: Inria Cortina

> Subject: Event-based neural network weight adjustment

> Institution: Académico del Departamento de Ingeniería Biomédica, Facultad de Ciencias, Universidad de Valparaíso, Chile

DEMAR Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. SANOFI (Montpellier financial support)

Participants: Christian Geny (CHU Montpellier), Christine Azevedo-Coste, René Zapata (LIRMM), Lionel Lapierre (LIRMM).

Project SANOFI on developing a robot carrying a video camera for gait analysis of patients with neurological disorders.

8.1.2. CGS Merri (Languedoc-Roussillon - Montpellier)

Participants: Christian Geny (CHU Montpellier), Christine Azevedo-Coste, Simone Dalla Bella (UM1 M2H).

Developement and evaluation of controlled assistive device for freezing of gait in Parkinson Disease, 30keuros.

8.2. National Initiatives

8.2.1. DEMAR / MXM Innovation Lab "SoftStim" project

Participants: David Guiraud, David Andreu.

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

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

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

8.2.2. Cosinus ANR - SoHuSim

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

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

8.2.3. ADT SENSAS - SENSBIO

Participants: Christine Azevedo-Coste, David Andreu.

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

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

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

8.2.4. *Programme de recherche en qualité hospitaliere (PREQHOS)*

Participants: Leader: Jean-Christophe LUCET (GH Bichat - Claude Bernard), Christine Azevedo-Coste, Eric Fleury (Inria), Bruno Grandsebastien (CHRU Lille).

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

8.2.5. *INTENSE project*

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

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

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

8.3. European Initiatives

8.3.1. *FP7 European project TIME*

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

(2008-2012). 375keuros, "*Transverse, Intrafascicular Multichannel Electrode system for induction of sensation and treatment of phantom limb pain in amputees*". Partners : AAU (Aalborg, Denmark), MXM (Vallauris, France), SSSA (Pisa, Italy), IMTEK (Freiburg, Germany), UAB (Barcelona, Spain), UCBM (Roma, Italy), IUPUI (Indianapolis, USA).

8.4. International Initiatives

8.4.1. *Inria Associate Teams*

8.4.1.1. *WALK*

Title: Artificial Walking

Inria principal investigator: Philippe Fraisse

International Partner (Institution - Laboratory - Researcher):

Stanford University (United States) - Artifical Intelligence Lab

Duration: 2010 - 2012

See also: http://www.lirmm.fr/~fraisse/@WALK/

The motivation approach is the complementary research works of these teams. Indeed, a collaborative project should give an additional value to their research results. On one hand, the DEMAR Project Team has experience in Functional Electrical Stimulation to restore or modulate movements on spinal cord injured patients and post stroke patients. In both pathologies researches on assisted gait using FES (for paraplegics with a walker and hemiplegics) are carried out in the team. On the other hand, the Robotics research group (Stanford) carries out manipulation tasks with a humanoid robot under equilibrium constraints. Within the framework of the previous collaboration, the crossed visits and seminars last year led us to work on two different directions: - FES muscle modeling in Opensim framework - Control mechanisms underlying age-related changes in motor control strategies during Sit-To-Stand.

8.4.2. Inria International Partners

- Collaborative Research agreement on Academic Co-operation (contrat sans financement) "Neuro-muscular function analysis and identification for Rehabilitation" Partner: University of Tokyo (Prof. Yoshihiko Nakamura) Duration: 2011 - 2014

8.4.3. Participation In International Programs

8.4.3.1. STIC AmSud

Title: CARAT (Computer Aided Rehabilitation Algorithms and Tools)

Inria principal investigator: Mitsuhiro Hayashibe

International Partner (Institution - Researcher):

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

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

Duration: 2012 - 2013

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

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Prof. Keisuke Morishima (Professor, Osaka University) visited and presented his work on "Emergent Functionality of Cellular Buildup Wet Robotics" (15th, June 2012).
- Prof. Antônio P.L. Bó (Professor, Universidade de Brasília) visited and presented his work on "Human Centered robotics at UnB" (18th, July 2012).
- Prof. Thomas Stieglitz (Professor, Laboratory for Biomedical Microtechnology, Department of Microsystems Engineering - IMTEK, University of Freiburg) visited and presented his work on "Microtechnologies for Neural Implants" (17th, October 2012).
- Prof. Jessica Rose (Associate Professor, Department of Orthopedic Surgery, Stanford University and Director, Motion and Gait Analysis Lab, Lucile Packard Children's Hospital) visited and presented her work on "Gait Analysis in Cerebral Palsy: Applications for Artificial Walking Technologies" (17th, October 2012).
- Prof. Dejan B. Popović (Professor, University of Belgrade, Serbia and Aalborg University, Denmark) visited and presented his work on "Neuroprosthesis: A tool for neurorehabiliation or functional compensation?" (25th, October 2012).

8.5.2. Visits to International Teams

- Mitsuhiro Hayashibe gave invited talk at the Institute of Perception, Action and Behaviour (IPAB), University of Edinburgh, "Identification and Control of the Human Neuromuscular Dynamics toward Advanced Neuroprosthetics", February 2nd 2012.
- Mitsuhiro Hayashibe was Visiting Researcher at Nakamura lab, University of Tokyo and Tokyo University of Agriculture and Technology for JSPS-Inria Ayame project and worked on "Muscle Strength and Mass Distribution Identification Toward Subject-Specific Musculoskeletal Modeling" (March 2012).

- Mitsuhiro Hayashibe gave invited talk at workshop on EMG Technology and Application, Shanghai Jiao Tong University, May 7th 2012.

- Mitsuhiro Hayashibe visited the Laboratory of Automation and Robotics (LARA), Universidade de Brasília for STIC Amsud - CARAT project and made a seminer on "Modeling and identification for Neuroprosthetic systems and some related works for CARAT program" (20th May 2012 -4th June 2012).

- Mitsuhiro Hayashibe was Visiting Researcher at RIKEN BSI-TOYOYA research institute and worked on "Tacit Motor learning for rehabilitation" (Aug.-Sep. 2012).

GALEN Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- 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 data

  Duration: 1/2012-12/2015

  Coordinator: ECP-FR

- Program: DIGITEO OMTE

  Project acronym: CURATEUR

  Project title: Real-time Multi-sensor (2D/3D) Elastic Image Fusion towards Computer-assisted Tumor Removal Surgery

  Duration: 1/2012-6/2014

  Coordinator: ECP-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: 10/2010-9/2013

  Coordinator: ECP - FR

8.2.2. Competitivity Clusters

- Program: MEDICEN

  Project acronym: ADOC

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

  Duration: 11/2011-10/2014

  Coordinator: LLTECH - FR

8.3. European Initiatives

8.3.1. FP7 Projects

- Project acronym: MOBOT

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

    Duration: 36 months

    Coordinator: TUM - DE

- Project acronym: RECONFIG

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

    Duration: 36 months

    Coordinator: KTH - SE

8.3.2. Collaborations in European Programs, except FP7

- Program: European Research Council

    Project acronym: DIOCLES

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

    Duration: 9/2011-8/2016

    Coordinator: ECP - FR

8.3.3. Collaborations with Major European Organizations

Technical University of Munich, Chair for Computer Aided Medical Procedures & Augmented Reality - Computer Science Department (DE): Mono and Multi-modal image fusion using discrete optimization and efficient linear programming.

Università della Svizzera Italiana, Institute of Computational Science (CH), Construction of deformation-invariant surface descriptors [39] and meta-descriptors for surfaces [17].

8.4. International Initiatives

8.4.1. Inria Associate Teams

8.4.1.1. SPLENDID

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

Inria principal investigator: Pawan Kumar

International Partner (Institution - Laboratory - Researcher):

Stanford University (United States) - Artificial Intelligence Lab

Duration: 2012 - 2014

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

8.4.2. Inria International Partners

- **Department of Diagnostic Radiology, University of Pennsylvania:** The GALEN and the Section of Biomedical Image Analysis - SBIA group (Pr. Christos Davatzikos) have an established collaboration during the past three years in the area of deformable image fusion. In this context, PhD candidates of the GALEN group spend time visiting the SBIA group, while Pr. Paragios participates at a Nantional Institute Health grant led by SBIA. Such a collaboration led to a number of outstanding rank journal and conference publications.

- **Department of Computer Science, StonyBrook, State University of New York:** The GALEN and the Image Analysis Lab - CBL (Pr. Dimitris Samaras) have an established collaboration during the past years in the area of graph-based methods in medical imaging and computer vision. Pr. Samaras holds a research professor position (DIGITEO chair) at Ecole Centrale de Paris. Such a collaboration led to a number of outstanding rank conference publications during the last years.

- **Chang Gung Memorial Hospital – Linkou, Taiwan:** In the context of France-Taiwan program sponsored from the French Science Foundation, GALEN (in collaboration with the department of radiology of Henri Mondor University Hospital), a project (ADAMANTIUS) was initiated with the Chang Gung Memorial Hospital – Linkou that is the largest private hospital in Taiwan. The aim of the project is to study the 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.

8.5. International Research Visitors

8.5.1. Internships

- Aseem BEHL (from Nov 2012 to Dec 2012)

  Subject: Optimizing Average Precision using Weakly Supervised Data. The average-precision support vector machine (AP-SVM) optimizes an upper bound on the average-precision (AP) loss, which is often used as a measure of accuracy for binary classification. However, it does not handle partially annotated datasets. To address this shortcoming of AP-SVM, we proposed a novel latent AP-SVM formulation, which allows us to learn an accurate set of classifier parameters by minimizing a carefully designed difference-of-convex upper bound on the AP loss.

  Institution: International Institute of Information Technology (IIIT), Hyderabad (India).

  Enzo FERRANTE (from June 2012 until October 2012)

  Subject: Plane+Deformation 2D-3D multimodal data fusion. The goal of the internship was to study the use of discrete optimization methods in the context of 2D to 3D registration in biomedical image analysis. In particular the aim was to define a metric free graphical model formulation that is able to determine for a given 2D image the corresponding 3D volume plane along with the in plane deformation. The case of computer assisted surgery was considered as a test case between 2D interventional images and 3D pre-operative high resolution annotated data.

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

- Danny GOODMAN (Aug 2012)

  Subject: Discriminative Parameter Estimation for Random Walks Segmentation. While random walks (RW) provide an efficient formulation for segmentation, there use is restricted by the lack of an accurate learning framework that estimates its parameters. The main difficulty is that a user can only provide a hard segmentation of a training sample, instead of the optimal probabilistic segmentation. We overcome this deficiency by treating the optimal probabilistic segmentation as latent variables, which allows us to employ the latent SVM formulation for parameter estimation.

  Institution: Stanford University (USA).

Ishan MISRA (from May 2012 until Aug 2012)

> Subject: Shape-from Shading analysis for Object Categories. The goal of the internship was to see whether shape-from-shading techniques can be used to recover the 3D geometry within an object category. Mr. Misra experimented with techniques for shape-from-shading under unknown illumination as well as surface recovery from a single image. Mr. Misra has delivered the source code for his software to our team, and we intend to use it in our on-going research.

> Institution: IIIT HYDERABAD (India)

Bharat SINGH (from May 2012 until September 2012)

> Subject: Sub-space real-time Deformable Registration. The aim of this internship was to investigate the use of sub-space image representations towards defining an appropriate metric in the context of mono-modal and multi-modal fusion. Furthermore, it was studied their integration in a graph-theoretic framework for deformable fusion that can benefit from its implementation on modern parallel architectures like graphics processing units.

> Institution: IIT MADRAS (India)

Eduard TRULLS (from January 2012 until April 2012)

> Subject: Segmentation-Aware Image Descriptors. The goal of the internship was to construct appearance descriptors that can exploit segmentation information in order to achieve invariance to background changes. Mr. Trulls implemented a dense descriptor that uses soft segmentation masks, and demonstrated that this results in substantially more invariant descriptors; he evaluated these descriptors on image registration (optical flow) and wide-baseline matching (stereo) where state-of-the-art results were obtained. This work has been submitted for publication and is under evaluation.

> Institution: Universidad Polytecnica de Catalunia (UPC) (Spain)

8.5.2. Visits to International Teams

Matthew BLASCHKO & Iasonas KOKKINOS (from June 2012 until August 2012)

> Subject: Center for Language and Speech Processing: Towards a Detailed Understanding of Objects and Scenes in Natural Images Workshop. The objective of this workshop was to develop novel methods to reliably extract from images a diverse set of attributes, and to use them to improve the accuracy, informativeness, and interpretability of object models. The goal is to combine advances in discrete-continuous optimisation, machine learning, and computer vision, to significantly advance our understanding of visual attributes and produce new state-of-the-art methods for their extraction.

> Institution:John Hopkins University (USA)

Pawan KUMAR (from April 2012 until May 2012)

> Subject: SPLENDID Associate Team

> Institution: Stanford University (United States)

MNEMOSYNE Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

7.1.1.1. ANR project KEOPS
Participants: Frédéric Alexandre, Thierry Viéville.

We are implicated in this «ANR Internal White Project» involving NEUROMATHCOMP and CORTEX Inria EPI in France with the U. of Valparaiso, U. Tecnica Frederico Santa-Maria, and U. Chile. The project addresses the integration of non-standard behaviors from retinal neural sensors, dynamically rich, sparse and robust observed in natural conditions, into neural coding models and their translation into real, highly non-linear, bio-engineering artificial solutions. An interdisciplinary platform for translation from neuroscience into bioengineering will seek convergence from experimental and analytical models, with a fine articulation between biologically inspired computation and nervous systems neural signal processing (coding / decoding) [9], [10].

7.2. International Initiatives

7.2.1. Inria Associate Teams

7.2.1.1. Cortina, associate team with Chile
Participants: Frédéric Alexandre, Thierry Viéville.

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

<p style="text-align:center; color:red">**NEUROMATHCOMP Project-Team**</p>

6. Partnerships and Cooperations

6.1. National Initiatives

6.1.1. ANR

6.1.1.1. KEOPS

See section "International Initiatives" below.

6.2. European Initiatives

6.2.1. FP7 Projects

6.2.1.1. BRAINSCALES

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

Type: COOPERATION (ICT)

Defi: Brain-inspired multiscale computation in neuromorphic hybrid systems

Instrument: Integrated Project (IP)

Duration: January 2011 - December 2014

Coordinator: Universitaet Ruprecht- Karls Heidelberg (Germany)

Others 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 Jülich GmbH, Jülich; EPFL LCN, Lausanne; EPFL-BBP, Lausanne; The University Of Manchester, Manchester; KTH, Stockholm; Universität Zürich, Zürich

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

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. FACETS-ITN

Title: FACETS-ITN

Instrument: Initial Training Network (ITN)

Duration: September 2009 - August 2013

Coordinator: Universität Heidelberg- Ruprecht-Karls (Germany)

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

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

6.2.1.3. MATHEMACS

Title: Mathematics of Multilevel Anticipatory Complex Systems

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

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

Instrument: Integrated Project (IP)

Duration: October 2012 - September 2015

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

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

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

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.

6.2.2. Collaborations in European Programs, except FP7

6.2.2.1. ERC NerVi

Program: ERC IDEAS

Project acronym: NerVi

Project title: From single neurons to visual perception

Duration: January 2009 - December 2013

Coordinator: Olivier Faugeras

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

6.3. International Initiatives

6.3.1. Inria Associate Teams

6.3.1.1. CORTINA

Title: Retina neural network coding

principal investigator: Frédéric Alexandre (Inria 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 - 2013

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

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

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

6.3.2. Participation In International Programs

6.3.2.1. 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 - 2013

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

- Panagiota Theodoni, 11-15 september 2012.
- Gasper Tkacik, IST Austria, Wien, 04-07 July 2012.

- Olivier Marre, Institut de la Vision, Paris, 04-07 July 2012.
- Thierry Mora, Laboratoire de Physique Statistique, ENS Ulm Paris, 04-07 July 2012.
- Martin Golubitsky, Mathematical Biology Institute (Columbus Ohio) 09-13 June 2012
- Reiner Lauterbach, Mathematics Departement, Hambourg 09-13 June 2012
- Arnd Scheel, Mathematics Department, U of Minnesota (Minneapolis) 09-13 June 2012.

6.4.1.1. Internships

- Viktor Shcherbakov, Master 2, March-July 2012.

<p style="text-align:center; color:red;">**PARIETAL Project-Team**</p>

7. Partnerships and Cooperations

7.1. Regional initiatives

7.1.1. Digiteo/DIM

7.1.1.1. HIDINIM Digiteo project
Participants: Bertrand Thirion [Correspondant], Virgile Fritsch.

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

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

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

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

7.1.1.2. ICOGEN Digiteo project
Participants: Bertrand Thirion, Benoit Da Mota [Correspondant].

ICOGEN : Intensive COmputing for GEnetic-Neuroimaging studies

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

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

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

7.1.1.3. SUBSAMPLE Digiteo chair
Participants: Bertrand Thirion [Correspondant], Gaël Varoquaux, Alexandre Abraham.

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

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

7.1.1.4. MMoVNI Digiteo project

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

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

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

7.2. National Initiatives

7.2.1. ANR

7.2.1.1. Vimagine project

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

Vimagine is an ANR blanc project (2008-2012), which aims at building a novel view on the retinotopic organization of the visual cortex, based on MEG and MRI. Vimagine should open the way to understanding the dynamics of brain processes for low-level vision, with an emphasis on neuropathologies. This project is leaded by S. Baillet (Dynamic Neuroimaging Lab, McGill University), in collaboration with M.Clerc, T. Papadopoulos (Inria Sophia-Antipolis, Odyssée) and J. Lorenceau(LPPA, CNRS, Collège de France). The fMRI part of the project will be done by PARIETAL, and will consist in a study of spatially resolved retinotopic maps at the mm scale, the decoding of retinotopic information and the comparison of retinotopy with sulco-gyral anatomy.

7.2.1.2. BrainPedia project

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

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

7.2.1.3. IRMgroup project

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

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

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

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

7.2.1.4. Niconnect project

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

- **Context:** The project NiConnect 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 will push forward algorithms and statistical models for brain functional connectivity. In particular, we are investigating structured and multi-task graphical models to learn high-dimensional multi-subject brain connectivity models, as well as spatially-informed sparse decompositions for segmenting structured from brain imaging. With regards to neuroimaging methods development, NiConnect will provide 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 will also play a support role in on going medical studies and clinical trials on neurodegenerative diseases.

- **Consortium**
  - Parietal Inria research team: applied mathematics and computer science to model the brain from MRI
  - LIF INSERM research team: medical image data analysis and modeling for clinical applications
  - CATI center: medical image processing center for large scale brain imaging studies
  - Henri-Mondor hospital neurosurgery and neuroradiology: clinical teams conducting research on treatments for neurodegenerative diseases, in particular Huntington and Parkinson diseases
  - Logilab: consulting in scientific computing

7.3. International Initiatives

7.3.1. Inria Associate Teams

Title: Analysis of structural MR and DTI in neonates

Inria principal investigator: Pierre Fillard

International Partner:

Institution: University of Southern California (United States)

Laboratory: Image Lab at Children Hospital at Los Angeles

Researcher: Natasha Lepore

International Partner:

Institution: University of Pennsylvania (United States)

Laboratory: Penn Image Computing and Science Laboratory

Researcher: Caroline Brun

Duration: 2011 - 2013

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

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

7.3.2. Inria International Partners

- LIAMA http://www.nlpr.ia.ac.cn/jiangtz/: B.Thirion, G.Varoquaux, V. Siless and Y. Schwartz visited LIAMA (contact person: Shan Yu) and gave a presentation. We plan to develop come collaborations on fMRI data analysis and functional connectivity in the future.

- Donders institute https://sites.google.com/a/distrep.org/distrep/marcel-van-gerven: We share with M. van Gerven some interest on biological vision and on the use of fMRI to probe specific hypotheses related to computational models of vision. We plan to exchange students in the next years.

- Biomedical Image analysis group, Imperial College, London http://www.doc.ic.ac.uk/~dr/. We have started some joint work on the comparison of functional and anatomical connectivity using machine learning tools.

- MIT, CSAIL http://www.csail.mit.edu/, P.Golland's group. We regularly visit each other and share common interests in the use of machine learning for neuroimaging, in the introduction of functional information into co-registration procedures, and in the study and comparison of anatomical and functional connectivity.

7.3.3. Participation In International Programs

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

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

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. Sofa, ADT

SOFA Large Scale Development Initiative (ADT) : the SOFA project (Simulation Open Framework Architecture) is an international, multi-institution, collaborative initiative, aimed at developing a flexible and open source framework for interactive simulations. This will eventually establish new grounds for a widely usable standard system for long-term research and product prototyping, ultimately shared by academic and industrial sites. The SOFA project involves 3 Inria teams, SHACRA, EVASION and ASCLEPIOS. The development program of the ADT started in 2007. After 3 years of development, more than 600,000 lines of code have been developed, 80,000 downloads of SOFA have been counted on the Inria gForge, and we are about to finalize a new version of the public release.

8.1.2. Sofa Intermeds, AEN

SOFA Large Scale Initiative on Medical Simulation (AEN): The variety and complexity of Medicine, as well as its ethical importance in today's society, have been a strong motivation in many scientific and technical disciplines. The medical field has already been a domain of application for computer science and several tools, such as image processing, are now an integral part of modern medicine. Yet, there is no question that the integration of new technologies in Medicine will continue to rise in the future. In this context, the simulation of medical procedures, whether it is targeted at education, planning of interventions, or even guidance during complex procedures, will be a major element of the Medicine of the twenty-first century. The main objective of this large scale initiative is to leverage expertise from a few research teams at Inria to speed up the development of new ideas, models, algorithms in this very multi-disciplinary field. This initiative started in 2008, and involves several teams at Inria: SHACRA, EVASION, ASCLEPIOS, MOAIS, MAGRIT, and BUNRAKU. This program has been evaluated by a group of international experts in October 2010.

8.1.3. ANR Acoustic

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

8.1.4. 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. For this reason, Stephane Cotin has moved to Strasbourg for two years (Sept 2011 to July 2013).

8.1.5. ANR IDeaS

IDeaS is a project targeted at per-operative guidance for interventional radiology procedures. Our main goal is to provide effective solutions for the two main drawbacks of interventional radiology procedures, namely: reduce radiation exposure and provide a fully 3D and interactive visual feedback during the procedure. To do so, our project relies on an original combination of computer vision algorithms and interactive physics-based medical simulation. Computer vision algorithms extract relevant information (like the actual projected shape of the guide-wire at any given time) from X-ray images, allowing adjusting the simulation to real data. Conversely, computer-based simulation is used as a sophisticated and trustful predictor for an improved initialization of computer vision tracking algorithms. Many outcomes may be expected both in scientific and clinical aspects. On the scientific side, we believe a better understanding of how real data and simulation should be merged and confronted must lead, as a natural by-product, to image-based figures of merit to actually validate computer-based simulation outputs against real and dynamic data. A more accurate identification of the factors limiting the realism of simulation should follow with a rebound impact on the quality of the simulation itself. An actual integration of a mechanical model into the loop will improve the tracking. We firmly believe mechanical constraints can supplement the image data such that dynamic single view reconstruction of the interventional devices will be possible. On the clinical side, using the prediction capabilities of the simulation may decrease the need for X-ray images at high rates, thus leading to lower exposure to radiations for the patients and surgical staff. Finally, the output of the simulation is the 3D shape of the tool (e.g. guide-wire or catheter), but not only. Additional information may be visualized, for instance pressure of the catheter on the arterial wall, to prevent vessel wall perforations, or reduce stress on the arterial wall to prevent spasm. More generally, richer information on the live procedure may help surgeons to reduce malpractice or medical errors.

8.2. International Research Visitors

8.2.1. Internships

Yiyi WEI (from Jan 2012 until Mar 2012)

Subject: Simulation of Coil Embolization using the Discrete Exterior Calculus Approach

Institution: Beihang University of Aeronautics and Astronautics (China)

<div align="center">

VISAGES Project-Team

</div>

8. Partnerships and Cooperations

8.1. Regional Initiatives

8.1.1. Biogenouest

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

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

8.1.2. COREC projects

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

8.1.3. Projet CRITT Santé Bretagne : AfaCorVis3D

Participants: Elise Bannier, Isabelle Corouge, Christian Barillot.

duration: 12 months from November 2011

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

8.1.4. Défis Scientifiques Emergents - Université de Rennes I

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

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

The ASLDEM project was partially funded the University of Rennes 1 "Défis Scientifiques Emergents" grant (7000 euros). The ASLDEM project is described in Sect. 6.4.7

8.1.5. Fondation de l'Avenir 2012 - Depression, suicide and fMRI

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

duration: 12 months from November 2012

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

8.1.6. Fondation de l'Avenir 2012 - Stroke, rehabilitation and fMRI

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

duration: 12 months from November 2012

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

8.1.7. *Fondation Planiol 2012*

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

duration: 12 months from November 2012

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

8.2. National Initiatives

8.2.1. *ANR*

8.2.1.1. *ANR "Neurological and Psychiatric diseases" NUCLEIPARK*
Participants: Christian Barillot, Sylvain Prima, Juan Francisco Garamendi.

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 Benoît Combès et al. [48]. The pipeline was first validated on controlled synthetic data. For Parkinson disease, a total of 16 patients and 11 healthy controls were evaluated. The structuctures analyzed were: PPN, GPe, GPi, Caudatge, Putamen, SN, STN, RN. Differences (uncorrected P <0.001) were found in the right putamen and caudate structures. And slight difference (uncorrected P<0.05) in the right GPe. No significant correlation was found in PPN, GPi, SN, STN, and RN structures. In the case of PSP disease, a total of 10 patients and 11 healthy controls were evaluated. the structures analyzed were: PPN, GPe, GPi, Caudate, Putamen, SN, STN, RN. Differences (uncorrected P <0.001) were found in the left caudate structure. No significant correlation was found in PPN,GPe, GPi, Putamen, SN, STN, and RN structures.

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

8.2.1.2. *ANR Cosinus VIP*
Participants: Fang Cao, Olivier Commowick, Christian Barillot.

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

8.2.1.3. *AINSI Inria joint project*
Participants: Christian Barillot, Pierre Maurel, Jean-Christophe Ferré, Elise Bannier, Camille Maumet, Isabelle Corouge.

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

8.3. European Initiatives

8.3.1. Collaborations in European Programs, except FP7

Program: COST

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

Project title: Arterial spin labelling Initiative in Dementia

Acceptation date: 18/05/2011

Coordinator: X. Golay, UCL, London, UK

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

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

8.4. International Initiatives

8.4.1. Inria Associate Teams

8.4.1.1. BARBANT

Title: Boston and Rennes, Brain image Analysis Team

Inria principal investigator: ChristianBarillot

International Partner (Institution - Laboratory - Researcher):

Children's Hospital Boston - Harvard Medical School (United States) - Computational Radiology Laboratory - Simon K. Warfield

Duration: 2012 - 2014

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

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

CLIME Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

- Clime is involved in the project PREQUALIF–IZNOGOUD–BARC, with many partners including the leading partner LSCE ("Laboratoire des Sciences du Climat et l'Environnement"), which aims at designing methods for the evaluation of the measures to be taken in the ZAPA areas ("Priority Areas for Air Quality Measures"). Clime focuses on the assimilation of observations to better evaluate the actual air quality.

8.2. National Initiatives

8.2.1. ANR

- Clime is one partner of the ANR project GeoFluids. It focuses on the specification of tools to analyse geophysical fluid flows from image sequences. Clime objectives concern the definition of reduced models from image data.

- Clime takes part to the ANR project IDEA that addresses the propagation of wildland fires. Clime is in charge of the estimation of the uncertainties, based on sensitivity studies and ensemble simulations.

- The MSDAG project (Multiscale Data Assimilation in Geophysics) is an ANR project. Fours partners are in the project: CEREA (Clime project-team, Marc Bocquet, PI of the whole project), Fluminance (Étienne Mémin), Moise Project-team (Laurent Debreu), LSCE (Frédéric Chevallier). It has ended the 30th of September 2012.

8.2.2. INSU

- Clime is running the project MIDAR "Inverse modeling of deposition measurements in case of a radiological release", under the framework of the LEFE-ASSIM program of INSU. This includes a cooperation with the Institute for Safety Problems of Nuclear Power Plants (National Academy of Sciences of Ukraine). This project has ended in summer 2012.

- Clime is part of the INSU/LEFE project ADOMOCA-2, with about ten French teams working in atmospheric chemistry data assimilation.

8.3. European Initiatives

8.3.1. Collaborations in European Programs, except FP7

Program: COST Action ES104.

Project acronym: EuMetChem.

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

Duration: January 2011 - December 2014.

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

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

Abstract: European framework for online integrated air quality and meteorology modeling (Eu-MetChem) will focus 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. At least, two application areas of the integrated modeling are planned to be 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 will consist 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) will enable the EU to develop world class capabilities in integrated ACT/NWP-Climate modeling systems, including research, forecasting and education.

8.3.2. 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. In 2012, the working group organized sessions during IEMSs conference in Leipzig, Germany.

8.4. International Initiatives

8.4.1. Inria 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.cl/modelos.html).

Partner: Marine Hydrophysical Institute, Ukraine.

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

Partner: Institute of Numerical Mathematics, Russia.

The collaboration concerns the estimation of uncertainty of the motion field derived from image data with data assimilation technics.

8.4.2. Participation In International Programs

- Clime is running a two-year project under the PHC-DNIPRO program with Taras Shevchenko University of Kyiv, Ukraine. The subject concerns a posteriori minimax motion estimation from images.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Sergii Demydenko, Taras Shevchenko University of Kyiv, Ukraine,July 2012.
- Andrii Filipenkov, Taras Shevchenko University of Kyiv, December 2012.
- Takemasa Myoshi, University of Maryland, USA, June 2012.
- Oleksandr Nakonechnyi, Taras Shevchenko University of Kyiv, December 2012.
- Sergiy Zhuk, IBM, Dublin Research Lab, Ireland, December 2012.

8.5.2. Visits to International Teams

- Vivien Mallet took part in June to a HARVEST project, funded by Pascal2. He visited the Department of Statistical Science at University College London. The project dealt with uncertainty quantification using statistical emulation of geophysical models, mainly for climate modeling.

<div align="center" style="color:red">**FLUMINANCE Project-Team**</div>

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. *Britanny concil ARED IMAGEO:*
Participants: Cédric Herzet, Etienne Mémin, Véronique Souchaud.

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

7.2. National Initiatives

7.2.1. *ANR-COSINUS PREVASSEMBLE: Ensemble methods for assimilation of observaions and for prevision in Meteorology and Oceanography*
Participants: Sébastien Béyou, Anne Cuzol, Etienne Mémin.

duration 36 months.

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

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

7.2.2. *ANR SYSCOMM MSDAG: MultiScale Data Assimilation in Geophysics*
Participants: Pierre Dérian, Patrick Héas, Dominique Heitz, Cédric Herzet, Etienne Mémin.

duration 36 months.

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

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

7.2.3. *ANR SYSCOMM GeoFluids:*
Participants: Patrick Héas, Dominique Heitz, Souleymane Kadri Harouna, Etienne Mémin, Véronique Souchaud.

duration 48 months.

The project Geo-FLUIDS focuses on the specification of tools to analyse 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, IPSO, 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.

7.3. International Initiatives

7.3.1. Inria Associate Teams

7.3.1.1. HURACAN

Title: Analysis and control of fluid flows from image sequences

Inria principal investigator: Etienne Memin

International Partners (Institution - Laboratory - Researcher):

IRSTEA (France)

University of Buenos Aires (Argentina)

Duration: 2010 - 2012

See also: http://huracan.inria.fr

The HURACAN associated team is centered on the analysis and the control of fluid flows from image sequences. The research objectives of this team are organized into two distinct work axes. The first one aims at defining and studying visual servoing techniques for fluid flows control. In addition to the definition of efficient visual servoing schemes this axis of work gathers research issues related to fluid flows velocity measurement from images and to flows excitation through plasma actuators. The second research axis focuses on the coupling between large scales representations of geo-physical flows and image data. More precisely, it aims at studying means to define directly from the image sequences the small scales terms of the dynamics. This research axis includes the study of coupling models and data defined at different scales, problems of multiscale velocities estimation respecting turbulence phenomenological laws and issues of experimental validation.

7.3.2. Participation In International Programs

STIC AmSud project "Physics-based modeling of voice production" leaded by D. Sciamarella CNRS/LFD-FIUBA.

This project is an interdisciplinary project with researchers spanning from aeroacoustics to physiology, and from computational physics to phonetics. It aims at studying the mechanisms of human voice production system for applications ranging from man-machine communication to medical diagnosis.

MAGIQUE-3D Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

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

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

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

The Post-Doctoral fellowship of Ángel Rodríguez Rozas is partially (50%) financed 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 and with the collaboration of Henri Calandra from Total, Magique-3D coordinates research activities dealing with the development of high-performance numerical methods for solving wave equations in complex media. This project involves French academic researchers in mathematics, computing and in geophysics, and is funded by Total. Currently, two project-teams are involved: Hiepacs and Nachos.

In the framework of DIP, three PhD students are working in Magique 3D and two new PhD students have been hired this year. One of them is shared with the project team Nachos (http://www-sop.inria.fr/nachos/). Moreover, one internship has been realized. Always in the framework of DIP, Magique-3D has a collaboration with Prof. Changsoo Shin who is an expert of Geophysics and works at the Department of Energy resources engineering (College of Engineering, Seoul National University). Jewoo Yoo, who is a first year PhD student advised by Prof.Changsoo Shin, has visited Magique-3D during four months, from November 2011 to February 2012.
The contract ends in 2012 and a second period will start in 2013. We aggreed with Total hat the new contract will be signed for five years and that Magique 3D will strenghten its collaboration with Professor J. Tromp at Princeton on the topic of full wave inversion.

8.3. European Initiatives

8.3.1. *FP7 Projects*

8.3.1.1. HPC-GA

Title: High Performance Computing for Geophysics Applications

Type: PEOPLE

Instrument: International Research Staff Exchange Scheme (IRSES)

Duration: January 2012 - December 2014

Coordinator: Inria (France)

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

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

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

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

The HPC-GA project is unique in gathering an international, pluridisciplinary 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.

8.3.2. Collaborations in European Programs, except FP7

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

Program: Fonds commun de coopération Aquitaine/Euskadi

Project acronym: AKELARRE

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

Duration: février 2011 - février 2013

Coordinator: Hélène Barucq

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

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

Joint project with the Matheon Research Center in Berlin funded by the European Union in the framework of the Procope 2012 Call. Total Amount: 4200 euros.

Program: PHC Procope 2012

Project acronym: Procope Inria - TU Berlin

Project title: Procope Inria - TU Berlin

Duration: January 2012 - December 2014

Coordinator: Sébastien Tordeux

Other partners: Matheon Research Center, TU Berlin, Germany

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

8.4. International Initiatives

8.4.1. Inria International Partners

8.4.1.1. MAGIC

Title: Advance Modeling in Geophysics

Inria principal investigator: Hélène Barucq

International Partner:

Institution: California State University at Northridge (United States)

Laboratory: Department of Mathematics

Duration: 2006 - 2012

See also: http://uppa-inria.univ-pau.fr/m3d/Equipe-associee/index.html

The main objective of this collaboration is the design of an efficient solution methodology for solving Helmholtz problems in heterogeneous domains, a key step for solving the inversion in complex tectonics. The proposed research program is based upon the following four pillars:

1. The design, implementation, and the performance assessment of a new hybrid mixed type method (HMM) for solving Helmholtz problems. 2. The construction of local nonreflecting boundary conditions to equip HMM when solving exterior high-frequency Helmholtz problems. 3. The design of an efficient numerical procedure for full-aperture reconstruction of the acoustic far-field pattern (FFP) when measured in a limited aperture. 4. The characterization of the Fréchet derivative of the elasto-acoustic scattered field with respect to the shape of a given elastic scatterer.

8.4.2. Participation In International Programs

8.4.2.1. GEO3D

Joint project with the Novosibirsk state University in Russia funded by the Poncelet laboratory in the framework of the Inria Russia Call. Total Amount: 8000 euros for 2012.

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 - Yuri Laevsky

Duration: January 2012 to 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) in the context of geosciences. We are mainly interested to the derivation of numerical methods (discontinuous Galerkin approximation, space-time refinement), to the design of direct and inverse high performance solver, and to the modeling of complex media.

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Jewoo Yoo, Ph.D Student at Seoul University spent five months MAGIQUE-3D from December 2011 to April 2012.
- Rabia Djellouli spent one week in MAGIQUE-3D in November 2012.
- Patrick Dular (Université de Liège) is visiting MAGIQUE-3D from December 2012 to February 2013.

<p style="text-align:center;color:red;font-weight:bold;">MOISE Project-Team</p>

8. Partnerships and Cooperations

8.1. Regional Initiatives

- E. Blayo is a member of the scientific committee of the regional Institut des Sciences Complexes (IXXI) http://www.ixxi.fr.
- E. Blayo is a member of the scientific committee of the Pôle Alpin Risques Naturels http://www.risknat.org.
- E.Blayo and M. Nodet are responsible for the workpackage "numerical modelling" within the regional project (Région Rhône-Alpes) "**Envirhonalp**" http://www.envirhonalp.fr.
- A. Rousseau leads the working group *Couplage Fluide/Vivant* in Montpellier for the study of coupled systems (fluid dynamics and life sciences) in nearshore regions. This research is funded by the Labex NUMEV in Montpellier.
- M. Nodet is involved in E. Maitre MSTIC project MENTOL about Optimal Transport.
- Nicolas Papadakis is responsible of the ASIOME project (Assimilation de Structures d'Images Océanographiques et Modélisation d'Erreurs) funded by the Pôle Mathématiques Sciences et Technologies de l'Information et de la Communication (MSTIC) of the Joseph Fourier University, Grenoble. and the LEFE/MANU program of INSU (CNRS).6.3.4

8.1.1. Collaborations with Various Regional Research Teams

- LEGI, MEOM team : 6.3.4 ,6.1.2 ,6.2.1 ,6.3.3 .
- LGGE Grenoble, Edge team (C. Ritz, O. Gagliardini, F. Gillet-Chaulet, G. Durand), see paragraphs 6.2.3 , 6.2.4 and 6.2.5 .
- LGGE, Statistical methodology,6.4.1
- LGGE, DatIce tool, 5.3
- LTHE, Anne-Catherine Favre: multivariate extremal risk indicators, project "Soutien à l'Excellence et à l'Innovation Grenoble INP" MEPIERA (MEthodologies innovantes Pour l'Ingénierie de l'Eau et des Risques Associés)
- LTHE, Thierry Lebel, Théo Vischel: tracking of mesoscale convective systems,
- Building energy (G2ELab, Mathilde Grandjacques). : 6.4.1 ,6.4.2

8.2. National Initiatives

8.2.1. Interactions with other Inria Project-Teams or Actions

Participants	Inria Project-Team	Research topic	Link
L.Debreu, E.Blayo	CLIME, FLUMINANCE	Multiscale data assimilation	6.2.1
N. Papadakis	MC2	Image segmentation and assimilation for tumor growth modeling	6.5.1
M. Nodet	SCIPORT	Automatic differentiation	6.2.3
C.Prieur, Laurence Viry	GRAAL	Grid deployment for the study of West African Monsoon	6.4
C. Helbert, C.Prieur	STEEP	Sensitivity analysis for LUTI models	6.4
A. Rousseau	TOSCA	Stochastic Downscaling Method	
A. Rousseau	MODEMIC	Bioremediation of natural resources	6.6
A. Vidard M. Nodet F.X. Le Dimet	CLIME, FLUMINANCE	Image assimilation	6.3.3
A. Vidard, M. Nodet, E.Kazantsev	TROPICS	Ocean Adjoint Modelling	6.2.1 ,6.3.2
C. Prieur, A. Vidard, N. Papadakis	STEEP	Calibration of Land Use and Transport Integrated (LUTI) models.	6.8

8.2.2. Collaborations with other Research Teams in France

Participants	Research Team	Research topic	Link
N. Papadakis	(Labri, IMB, Bordeaux)	image processing problems (histogram equalization and image inpainting)	6.5.1
C. Prieur	IMT Toulouse, IFP Rueil, EDF, CEA Cadarache	Sensitivity analysis	6.4.1
C. Prieur	ISFA Lyon 1, Université de Bourgogne	Multivariate risk indicators	6.4.4
A. Rousseau	Institut de Mathématiques et de Modélisation de Montpellier (I3M)	Modelling and simulation of coastal flows	6.1
A. Rousseau	Laboratoire de Météorologie Dynamique (Ecole Polytechnique)	Stochastic Downscaling Method	
E.Blayo, A.Rousseau	LAMFA (Amiens), LAGA (Paris 13)	Coupling methods	6.1.2
A. Rousseau	IFREMER (Sète), UMR Ecosym (Montpellier)	Coupling fluids and life sciences	6.6
A. Vidard	Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique (Toulouse), Mercator-Océan (Toulouse), Laboratoire de Physique des Océans (Brest),	Ocean Data Assimilation	6.2.1
A. Vidard	LOCEAN (Paris)	Ocean Adjoint Modelling	6.2.1
A. Vidard	LPO (Brest), CERFACS	Ocean data assimilation	6.2.1
B.Lemieux	LSCE (Laboratoire des Sciences de l'Environnement et du Climat)	DatIce tool	5.3

8.2.3. Other National Initiatives:

- 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
- E. Blayo was a member of the 2012 ANR evaluation panel "Earth, Environment, Space".
- Nicolas Papadakis is involved in the SWOT-Ocean group in charge of the use of the high resolution data that will be provided by the future SWOT satellite (CNES/NASA mission). This work is realized in collaboration with Jacques Verron of the Laboratoire des Écoulements Géophysique et Industriels. 6.3.4
- M. Nodet is PI of the project "Méthodes inverses en glaciologie" supported by INSU-LEFE.
- M. Nodet is involved in GDR Calcul and GDR Ondes.
- C. Prieur chairs GdR MASCOT NUM, in which are also involved M. Nodet, E. Blayo, A. Rousseau, C. Helbert, L. Viry, A. Janon, S. Nanty, J.-Y. Tissot and G. Chastaing. http://www.gdr-mascotnum.fr/doku.php
- L. Debreu is the coordinator of the national group COMODO (Numerical Models in Oceanography)
- A. Vidard leads a group of projects gathering multiple partners in France and UK on the topic "Variational Data Assimilation for the NEMO/OPA9 Ocean Model", see 6.2.1 .

8.2.4. ANR

- A 4-year ANR contract: ANR TOMMI (Transport Optimal et Modèles Multiphysiques de l'Image), see paragraphs 6.5.2 ,6.3.3 .

- A 4-year ANR contract: ANR ADAGe (Adjoint ice flow models for Data Assimilation in Glaciology, see paragraph 6.2.3) .

- A 4-year ANR contract: ANR Geo-FLUIDS (Fluid flows analysis and simulation from image sequences: application to the study of geophysical flows, see paragraph 6.3.3) .

- A 4-year ANR contract: ANR COSTA-BRAVA (Complex Spatio-Temporal Dynamics Analysis by Reduced Models and Sensitivity Analysis)http://www.math.univ-toulouse.fr/COSTA_BRAVA/index.html

- CITIES ANR project (numerical models project selected in 2012). http://steep.inrialpes.fr/?page_id=46

- A 4 year ANR contract (2011-2015): ANR COMODO (Communauté de Modélisation Océanographique) on the thematic "Numerical Methods in Ocean Modelling". (coordinator L. Debreu) 6.1.3

- A. Vidard was the coordinator of the ANR VODA (Variational Ocean Data Assimilation for multi-scales applications) 4-year contract ended mid 2012.

8.3. European Initiatives

8.3.1. 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: Vicent Caselles of the Pompeu Fabra University, Barcelona Spain

Subject: Image processing problems such as histogram transfer [18] or optical flow estimation. 6.5.1

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

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

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

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

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

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

Partner: British Antarctic Survey, Cambridge, UK,

Subject: Antarctic ice core chronology (AICC2012).

Partner: University of Copenhagen, Ice and Climate Group, Denmark

Subject: Antarctic ice core chronology (AICC2012).

Partner: University of Strathclyde (Glasgow, UK)

Subject: Quasi-second order analysis for the propagation and characterization of uncertainties in geophysical prediction 6.4.5

Partner: Institute of Numerical Mathematics, Russian Academy of Sciences

Subject: Quasi-second order analysis for the propagation and characterization of uncertainties in geophysical prediction 6.4.5

8.4. International Initiatives

8.4.1. Participation In International Programs

- F.-X. Le Dimet collaborates with Vietnamese Academy of Sciences (Institute of Mechanics, Hanoi) on the quality of water ressources, that is an important problem for Vietnam (see 6.2.2)
- F.-X. Le Dimet collaborates with Florida State University on subjects of Identification of pollution (see 6.2.2) and Assimilation of Images (see 6.3.3).
- C. Prieur collaborates with Antonio Galves (University Sao Paulo) and Jose R. Leon (UCV, Central University of Caracas). She is a member of a USP-COFECUB project on the study of stochastic models with variable length memory (2010-2013) with University of Sao Paulo.
- C. Prieur is leader of a project ECOS Nord with Venezuela (2012-2015).

8.5. International Research Visitors

8.5.1. Visits of International Scientists

- Angie Pineda (invited 6 weeks in 2012 by C. Prieur through the ECOS Nord project),
- Jose R. León (invited 2 weeks in 2012 by C. Prieur through the ECOS Nord project).
- Victor Shutyaev, Institute of Numerical Mathematics, Russian Academy of Sciences, Moscow (invited for 2 weeks by F.-X. Le Dimet, see 6.4.5)
- Igor Gejadze, University of Strathclyde, Glasgow, UK (invited for 1 week by F.-X. Le Dimet, see 6.4.5)
- Nancy Nichols, University of Reading, invited for 1 week by A. Vidard and M. Nodet

8.5.2. Visits to International Teams

- F.-X. Le Dimet has been elected « Fellow of the American Meteorological Society », he is the second French scientist (after Michel Jarraud, General Secretary of the World Meteorological Organization) to get this distinction.
- F.-X. Le Dimet has been named « Adjunct Professor » at the Department of Mathematics at Florida State University, (USA) This nomination is valid from 2012 to 2016.
- F.X. Le Dimet has been invited to Caltech (USA) and Jet Propulsion Laboratory in May 2012 where he gave seminars on Assimilation of Images. Invited Speaker at the International Conference ACME in July 2012.

<p style="text-align:center;color:red;font-weight:bold;">POMDAPI Project-Team</p>

5. Partnerships and Cooperations

5.1. National Initiatives

ANR Fost: *Formal prOofs about Scientific compuTations*, with EPI Proval (Inria Saclay - Île-de-France), Laboratoire de Recherche en Informatique (University of Paris 11), and Laboratoire d'Informatique de l'Université Paris-Nord (University of Paris 13). Until May 31st.

ANR MANIF: *Problèmes mathématiques et numériques en simulation moléculaire ab initio*, with CERMICS (Ecole Nationale des Ponts et Chaussées), and LJLL (Université Pierre et Marie Curie).

ARC Geofrac: Action de Recherche coopérative Inria "Large-scale computation of flow in complex 3D geological fractured porous media" rassemblant les équipes Inria Sage, Gamma3 et Pomdapi. From 2011.

5.2. European Initiatives

5.2.1. Collaborations in European Programs, except FP7

Program: ERC République tchèque

Project acronym: MORE

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

Duration: September 2012 – August 2017

Coordinator: Josef Málek, Université Charles à Prague

Other partners: Université Charles à Prague, République tchèque; Institut des mathématiques, Académie des Sciences de la République tchèque, République tchèque; Oxford Centre for Nonlinear Partial Differential Equations, UK.

5.3. International Initiatives

5.3.1. Participation In International Programs

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

- Pomdapi is part of the EuroMediterranean 3+3 program with the project HYDRINV (Direct and inverse problems in subsurface flow and transport). Besides Inria institutions participating in this project are Universitat Politècnica de Catalunya, Universidad de Sevilla, université Ibn Tofaïl (Kenitra, Maroc), University Centre of Khemis Miliana (Algeria), Ecole Nationale d'Ingénieurs de Tunis.

5.4. International Research Visitors

5.4.1. Internships

Mohamed Hedi Riahi (from May 2012 until Aug 2012)

Subject: Implémentation d'un algorithme d'estimation de paramètres

Institution: Ecole Nationale d'Ingénieurs de Tunis (Tunisia)

Fatma Cheikh (from Sep 2012 until Nov 2012)

Subject: Implémentation d'indicateurs de localisation de failles en milieux poreux

Institution: Ecole Nationale d'Ingénieurs de Tunis (Tunisia)

Emna Mejri (from Jun 2012 until Jul 2012)

Subject: Ecoulements eau-air en milieu poreux

Institution: Ecole Nationale d'Ingénieurs de Tunis (Tunisia)

5.4.2. Visits to International Teams

J. Jaffré and J. E. Roberts were invited by Rainer Helmig to visit the Department of Hydromechanics and Modelling of Hydrosystems (March 14 – April 6 2012).

<p style="text-align:center">**SAGE Project-Team**</p>

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. *ANR-MN: H2MNO4 project*

Participants: Thomas Dufaud, Jocelyne Erhel, Grégoire Lecourt, Aurélien Le Gentil, 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.
Web page: http://www.irisa.fr/sage/
Abstract: The project H2MNO4 will develop 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 6.4.1 , 6.4.3 , 5.1).

8.1.2. *Inria Large Wingspan intiative: HEMERA project*

Participants: Jocelyne Erhel, Géraldine Pichot.

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

The team Sage is the leader of the Scientific Challenge Hydro: Multi-parametric intensive stochastic simulations for hydrogeology. The objective is to run multiparametric large scale simulations (see 6.4.1 , 6.5).

8.1.3. *Inria Large Wingspan intiative: C2S@EXA project*

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

Title: C2S@EXA
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 large-scale initiative is concerned with the development of numerical modeling methodologies that fully exploit the processing capabilities of modern massively parallel architectures in the context of a number of selected applications related to important scientific and technological challenges for the quality and the security of life in our society (see 6.1.2 , 6.1.3 , 6.1.5 , 6.4.5). The team participated in the first workshop France-Brazil on HPC (Nice, July 2012).

8.1.4. *Inria Technological development actions: H2OGuilde project*

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

Title: H2OGuilde
Duration: October 2011 - October 2013.
Coordination: J. Erhel and G. Pichot.
Partner: Charles Deltel, SED Inria Rennes
Webpage: http://www.irisa.fr/sage/
Abstract: The project H2OGuilde aims at developing an interface for the platform H2OLab (see 5.1) and at designing software libraries with a large academic diffusion (see 6.4.1 ,6.5 , 8.1.1).

8.1.5. *Inria Collaborative Research Action: GEOFRAC project*

Participants: Thomas Dufaud, Jocelyne Erhel, Géraldine Pichot.

Title: GEOFRAC
Duration: June 2011-June 2013.
Coordinator: J. Erhel and G. Pichot.
Partners: Pomdapi and Gamma3 Inria teams, Géosciences Rennes.
Webpage: http://www.irisa.fr/sage/geofrac/
Abstract: In the last twenty years, the interest of geological fractured rocks has been renewed by a variety of energy-related applications, such as carbonate oil reservoirs, geothermic energy production, geological storage of high level nuclear waste, geological sequestration of CO2. Fractures are highly permeable pathways within a less pervious but more porous medium generally called matrix. The discrete modeling of fractures faces at least two challenging numerical issues. First, the fracture and matrix phases have very different hydraulic properties. Permeability is at least two orders of magnitude larger in the fractures than in the matrix. Second, the fracture structure complexity yield intricate geometrical configurations difficult to mesh. We propose to address these limitations by developing new numerical methods (see 6.5 , 5.1).

8.1.6. *GENCI: project on advanced linear solvers*

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

Title: Scalabilité de méthodes numériques pour l'hydrogéologie
Duration: 2012
Coordination: J. Erhel and G. Pichot.
Webpage: http://www.genci.fr/
Abstract: To run large scale simulations, we defined a project, based on the software H2OLab, AGMRES, GRT3D and MUESLI (see 5.1 , 5.9 , 5.6 , 5.11). We obtained and used computing time on machines located at Idris supercomputing center (see 6.1.2 , 6.1.3 , 6.4.1 , 6.5).

8.1.7. *GNR MOMAS: project on reactive transport*

Participants: Jocelyne Erhel, Souhila Sabit.

Webpage: http://momas.univ-lyon1.fr/

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.

8.2. European Initiatives

8.2.1. 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 , 6.4.1 , 6.5).

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 editing a book, in writing a book, and in common research on low rank approximations of matrix functions (see 6.2.1).

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

8.3. International Initiatives

8.3.1. Inria International Partners

University of Kent (USA)

Krylov methods (see 6.1.1)

University of Purdue (USA)

High Performance Scientific Computing (see 6.2.1)

8.3.2. Cedre (Lebanon): MODNUM project

Participants: Édouard Canot, Jocelyne Erhel, Bernard Philippe.

Program: CEDRE Lebanon

Title: Modélisation numérique pour des applications libanaises

Inria principal investigator: Jocelyne Erhel and Bernard Philippe

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

Duration: Jan 2012 - Dec 2013

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

8.3.3. 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.

8.3.4. Inria Euro Med 3+3: HYDRINV project

Participants: Amine Abdelmoula, 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 Anålisis 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

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

8.3.5. LIRIMA laboratory: MOMAPLI team (Cameroon)

Participant: Bernard Philippe.

Program: Laboratoire International de Recherche en Informatique et Mathématiques Appliquées

Title: Modélisation Mathématique et Applications

Inria principal investigator: Bernard Philippe

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

Duration: 2010-2013

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

Abstract: The team deals with high performance scientific computing, with a focus on reliable tools for localizing eigenvalues of large sparse matrices (see 6.2.2).

8.3.6. *LIRIMA laboratory: EPIC team (Tunisia)*

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

Program: Laboratoire International de Recherche en Informatique et Mathématiques Appliquées

Title: Problèmes Inverses et Contrôle

Inria principal investigator: Houssem Haddar, Defi team

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

Duration: 2011-2013

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

Abstract: The team deals with nonlinear and inverse problems.

8.3.7. *Joint Laboratory for Petascale Computing (USA)*

Participant: Jocelyne Erhel.

Program: Joint Laboratory for Petascale Computing

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

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

Duration: 2011-2013

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

abstract: The team works on deflation methods and their integration into the software PETSc (see 6.1.2) and on domain decomposition methods (see 6.5.4). The team Sage participated in the workshop organized in June in Rennes (France).

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

Program: International joint supervision of PhD agreement

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

Inria principal investigator: Jocelyne Erhel

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

Duration: Jan 2009 - Aug 2012

Abstract: see 6.4.4 .

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

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 - 2013

Abstract: The objective is to solve data completion problems applied to hydrogeology (see 8.3.4 , 8.3.6).

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

Program: International joint supervision of PhD agreement

Title: Résolution de problèmes inverses en géodésie physique

Inria principal investigator: Bernard Philippe

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

Duration: 2005 - 2013

Abstract: The objective is to compute a set of point-mass which generate an a priori given gravitational field (see 8.3.4 , 8.3.6).

8.4. International Research Visitors

8.4.1. Visits of International Scientists

- Basile Louka, 3 weeks, December 2011-January 2012; see 8.3.5 .
- Norbert NOUTCHEGUEME, 2 weeks, January 2012; see 8.3.5 .
- Stratis Gallopoulos, 1 week in January 2012 and 1 week in December 2012; see 6.2.1 , 8.2.1 .
- Ahmed Sameh, 1 week in January 2012 and 1 week in December 2012; see 6.2.1 , 8.3.1 .
- Emmanuel Kamgnia, 2.5 months, March-April 2012 and December; see 8.3.5 , 6.2.2 .
- Dani Mezher, 1 week, March 2012.
- Nabil Nassif, 1.5 month, June-July 2012; see 6.2.3 .
- Noha Makhoul, 1 week, July 2012; see 6.2.3 .
- Myriam El Fergougui, 1 month, March 2012.

8.4.2. Internships

- Salwa Mansour, 1.5 month, June-August 2012; see 8.3.2 , 6.3.1 .
- Mestapha Oumouni, 1.5 month, May-June 2012; see 8.3.8 , 6.4.4 .

8.4.3. Visits to International Teams

- B. Philippe, 2 weeks, February 2012, University of Yaoundé I, Cameroon; see 8.3.5 , 6.2.2 .
- B. Philippe, 2 weeks, May 2012, Purdue University, USA; see 8.3.1 , 6.2.1 .
- B. Philippe, 1 week, December 2012, ENIT, Tunisia; see 8.3.6 , 8.3.4 , 8.3.10 .

<p style="text-align:center; color:red">STEEP Exploratory Action</p>

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. 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.

8.1.2. 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 co-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.

8.2. European Initiatives

8.2.1. Collaborations in European Programs, except FP7

Program: European Space Agency call: "Camera-aided Mars Landing and Rendezvous Navigation System"

Project acronym: MREP Camera

Project title: Camera-aided Mars Landing and Rendezvous Navigation System

Duration: Apr 2012 – Dec 2013

Coordinator: EADS Astrium (France)

Other partners: DEIMOS (Portugal), TNO (Netherlands), Sodern (France), NGC Aerospace (France)

Abstract: Our main goal in this project is the 3D modeling of planetary surfaces and the detection of potential landing zones of space vessels.

8.2.2. Collaborations with Major European Organizations

Partner 1: organisme 1, labo 1 (pays 1)

Sujet 1 (max. 2 lignes)

8.3. International Initiatives

8.3.1. Inria International Partners

Universidad Central de Venezuela (Urban Department) and its spin-off Modelistica: The TRANUS model was developed there. Prof. Tomás de la Barra visited us in 2011 and is an associated partner of our ANR project CITiES.

8.3.2. Participation In International Programs

TRACER   (*TRanus, Analyse de la Calibration et des Erreurs, Retours sur Grenoble et Caracas*)
Program: ECOS NORD Venezuela
Duration: 2012 – 2016
Coordinators: Laurence Tubiana (IDDRI), Tomás de le Barra (*Universidad Central de Venezuela*)
Other partners: IDDRI, STEEP, Universidad Central de Venezuela (Urban Institute)
Abstract: The objective of this project is to study robustness and calibration issues on the TRANUS land use model.

8.4. International Research Visitors

8.4.1. Visits of International Scientists

Juho Kannala, Feb+Mar 2012, Oulu University, Finland

8.4.2. Internships

Franco Pestarini (from Apr 2012 until Sep 2012)

Subject: Re-implementation of a land use / transport model

Institution: National University of Rosario (Argentina)

Martin Crespo (from Jul 2012 until Dec 2012)

Subject: Parameter optimization algorithm for a Transport/land use model via adjoint method.

Institution: Universidad National de Rosario (Argentina)

8.4.3. Visits to International Teams

Anthony Tschirhard carried out his MSc project at UC Berkeley, under the supervision of Paul Waddell, the chief developer of the UrbanSim model.

<p align="center" style="color:red">BANG Project-Team</p>

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. CIRB-Collège de France

Jonathan Touboul is leading the team "Mathematical Neuroscience Laboratory" in the Centre for Interdisciplinary Research in Biology of the Collège de France. Several collaborations have been initiated, a postdoc has been recruited, student scholarships have been provided and 3 PhD students have started their research in the laboratory (J. Scher, C. Quininao and L. C. García del Molino).

7.1.2. DIGITEO and Cancéropôle IdF

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

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

7.1.3. INRA

Collaboration with INRA (Isabelle Hue, Juhui Wang, Alain Trubuil) on Trophoblast development. One PhD student position in Bang has been funded within the Doctoral School *Ecole du Vivant*, Paris for Chadha Chettaoui), who has defended her thesis in July 2012.

7.2. National Initiatives

7.2.1. ANR and other national projects

7.2.1.1. ANR program Bimod.

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

7.2.1.2. ANR Sine2Arti

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

7.2.1.3. ANR TOPPAZ

(url http://www-roc.inria.fr/bang/TOPPAZ/index.html)

TOPPAZ (Theory and Observations of Polymerisation processes in Prion and Alzheimer diseases) is a 3-year (2009-2012) research project financed by ANR grant "programme blanc" and headed by Marie Doumic-Jauffret.

It involves two teams, a mathematical and numerical team (B. Perthame, V. Calvez, P. Gabriel, T. Lepoutre, P. Michel, and a team in Brazil headed by J. Zubelli) and a biophysicist team headed by H. Rezaei. It has allowed to finance the post-doctoral contract of F. Charles and the 1-year grant of L. M. Tine.

The general goal is to develop new mathematical and numerical tools for polymerisation processes, in a strong link with experimentalists and with direct application to experimental data designed by the biologists' team. The achievements of ANR TOPPAZ are described in Sections 6.1.4 and 6.1.5 .

7.2.1.4. GDR DarEvCan

The GDR DarEvCan, for Darwinian Evolution and Cancer, is a interdisciplinary consortium which associates 10 teams in France around the theme of evolution and cancer, in particular evolution of cancer cell populations towards drug resistance [27]. It has held its first national meeting in December 2011 in Paris, and another one in April 2012 in Montpellier. The Bang team takes an active part in its development, which relies mainly on applying methods from evolutionary theory to cancer biology [33]. (url http:///www.darevcan.univ-montp2.fr/)

7.2.1.5. GdR EGRIN

The CNRS supports the creation of a "research group" called EGRIN, starting in january 2013 and devoted to the modelling, analysis and simulation of gravity driven flows. J Sainte-marie is the head of the scientific committee of this research group.

(url http://gdr-egrin.math.cnrs.fr/)

7.2.1.6. Green Stars

Participation in the Green Stars project ("Investissement d'avenir") on the production of biofuel using microalgae in collaboration with the EPI COMORE, LOCEAN, INRAA, LOV.

7.2.1.7. PEPS PTI 'Ondes de concentration en bactéries'

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

7.2.1.8. ITMO-Cancer grant PhysCancer

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

7.3. European Initiatives

7.3.1. FP7 Projects

7.3.1.1. ERASysbio+ C5Sys European network.

This European program (url http://www.erasysbio.net/index.php?index=272) has begun in April 2010, with the title "Circadian and cell cycle clock systems in cancer". Coordinated by F. Lévi (Villejuif) and D. Rand (Warwick), it studies both from a theoretical and from an experimental viewpoint the relationships between molecular circadian clocks and the cell division cycle, in cancer and in healthy tissues. It has been granted for 3 years. A postdoctoral fellow (F. Billy) has been hired at Inria-Bang until November 2012 on this funding, giving rise to various publications in 2012 [10], [11], [12], [39], [42].

7.3.1.2. NOTOX

NOTOX will develop and establish a spectrum of systems biological tools including experimental and computational methods for (i) organotypic human cell cultures suitable for long term toxicity testing and (ii) the identification and analysis of pathways of toxicological relevance. NOTOX will initially use available human HepaRG and primary liver cells as well as mouse small intestine cultures in 3D systems to generate own experimental data to develop and validate predictive mathematical and bioinformatic models characterizing long term toxicity responses. Cellular activities will be monitored continuously by comprehensive analysis of released metabolites, peptides and proteins and by estimation of metabolic fluxes using 13C labelling techniques (fluxomics). At selected time points a part of the cells will be removed for in-depth structural (3D-optical and electron microscopy tomography), transcriptomic, epigenomic, metabolomic, proteomic and fluxomic characterisations. When applicable, cells derived from human stem cells (hESC or iPS) and available human organ simulating systems or even a multi-organ platform developed in 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/

7.3.1.3. EU-project PASSPORT

Participation in the European network PASSPORT on modelling liver regeneration after partial hepatectomy (url http://www.vph-noe.eu/vph-projects/74-eu-fp7-vph-projects/50-passport-strep)

7.3.1.4. ERC Starting Grant SKIPPERAD

The ERC Starting Grant allocated to M. Doumic-Jauffret in december 2012 will last for five years. The acronym standing for *Simulation of the Kinetics and Inverse Problem for protein Polymerisation in Amyloid Diseases* (Prion, Alzheimer's), its main goal is to contribute to the design of new methods for protein polymerisation simulation and prediction, a major issue in amyloid diseases.

7.4. International Initiatives

7.4.1. Inria Associate Teams

7.4.1.1. QUANTISS, with BMBF

Title: Towards quantitative tissue simulations
Inria principal investigator: Dirk Drasdo
International Partner (Institution - Laboratory - Researcher):
University of Liepzig (Germany) - IZBI
Duration: 2010 - 2012
See also: http://www.msysbio.com/ea

The scientific achievements addressed tissue organisation processes such as tissue regeneration, degeneration and growth. Our main contribution was the development of concepts, a process chain, and software suite to permit quantitative simulations of tissue organisation processes on histological scales. Our main applications were multiple projects on liver, lung cancer and mesenchymal stem cell differentiation. The results of the main projects for 2012 have briefly been summarised the results section (liver regeneration, multiscale liver modelling, blood flow modelling, software generation CellSys, etc. most based on the grant projects LUNGSYS and Virtual Liver network).

7.4.2. ECOS-CONICYT

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

7.4.3. EuroMed 3+3

M3CD, *Mathematical Models and Methods in Cell Dynamics*, a transmediterranean EuroMed3+3 program, has begun in January 2012 for 2 [+ 2: renewal] years, under the coordination of J. Clairambault. It associates 2 Inria teams: Bang and Dracula (Mostafa Adimy, Lyon) with the IAC-CNR in Rome (Roberto Natalini), the LMDP team in Marrakech (Hassan Hbid) and the MoMinBi team at Institut Pasteur, Tunis (Slimane BenMiled) to work on the general theme "Mathematical Models and Methods in Cell Dynamics". It has fostered visits of students (in particular to Paris and Lyon, for Y. Bourfia, PhD student at Marrakech and UPMC, who works under the supervision of H. Hbid, M. Adimy and J. Clairambault) and researchers, participation in the international SM2A conference in Marrakech (June 2012, url http://sm2a-2012.ucam.ac.ma/en/), and a M3CD 2-day workshop in Tunis (Institut Pasteur, November 2012, (url http://euromedbiomaths.org/atelier-M3CD-Tunis/)) organised by Amira Kebir (MoMinBi).

7.4.4. Inria International Partners

7.4.4.1. 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 ($http://www.lungsys.de/$)

7.4.4.2. German Research Ministry (BMBF) funded project on the systems biology of liver (Virtual Liver Network)

The aim of the VLN project is to set up multiscale models of liver. The Virtual Liver will be a dynamic model that represents, rather than fully replicates, human liver physiology morphology and function, integrating quantitive data from all levels of organisation. Our part ranges from the intracellular up to the level of groups of liver lobules. A liver lobule is the basic repetitive functional unit of liver. Applications are explained in the text. The networks has 69 Principle Investigators organised in about 10 work packages, each of which have a number of sub-projects.

($http://www.virtual-liver.de/about/$)

BIGS Project-Team

8. Partnerships and Cooperations

8.1. Regional Initiatives

Co-direction of a PhD thesis by J-M. Monnez:

 Partner: Ecole de Hautes Etudes en Santé Publique (Rennes).

 Title: Influence of socio-economic and environmental characteristics on infant mortality.

 PhD thesis of M. Lalloué.

Regional project leaded by T. Bastogne:

 Partners: Contrat de Projets Etat-Région, MISN (Modélisation, Information et Système Numérique), Thème AOC (Analyse, Optimisation et Contrôle).

 Title: EMC2 (Experimental design, Modeling and Control in Cancerology).

8.2. National Initiatives

- C. Lacaux is member of the MATAIM (Modèles Anisotropes de Textures. Applications à l'Imagerie Médicale) ANR project, leaded by F. Richard (University of Provence).

- P. Vallois is member of the MASTERIE (Malliavin Stein Random Irregular Equation) ANR project, leaded by F. Russo (ENSTA, Paris).

- T. Bastogne is leader of the MOCOBIO (MOdeling and COntrol of heterogeneous systems in BIOlogy) CNRS-PEPS project.

- T. Bastogne is member of the PDTX (Active Nanoplatforms for Photodynamic Therapy) ANR project, lead by M. Verelst (Université Paul Sabatier, Toulouse)

- T. Bastogne is member of the Nano-VTP (Nanoparticles for Imaging and Vascular Photodynamic Treatment of Brain Tumors) ANR project, lead by M. Barberi-Heyob (Centre de Recherche en Automatique de Nancy, Centre Alexis Vautrin).

- T. Bastogne, C. Lacaux and S. Tindel are members of the OPTIQUE CNRS-PEPS project, lead by M. Thomassin (CRAN) and managed within Inria's framework by BIGS.

8.3. European Initiatives

8.3.1. *Collaborations with Major European Organizations*

Collaboration 1: Smoothness of density for noisy differential systems

 Partner 1: Imperial College, London (UK)

 Partner 2: Warwick University (UK)

 Subject: Smoothness of density for noisy differential systems

8.4. International Research Visitors

8.4.1. *Visits of International Scientists*

Visit of D. Nualart (Kansas University) for 1 month, May 2012.

8.4.1.1. Internships

- Raouf Souabni: Simulation of the light propagation in biological tissues. Application to interstitial photodynamic therapy. Advisor: T. Bastogne.
- Yosra Chemli: Applicability of an Exponential-Linear (E-L) model to describe the in vitro cell responses in photodynamic therapy. Advisor: T. Bastogne.
- Kevin Ziegelmeyer: Data Analysis for for liver cirrhosis prediction. Advisor: A. Muller-Gueudin.

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 coordinated by M. Chaves (BIOCORE, Inria)

- **ANR-Symbiose:** The objective of this project is both to improve the energetic balance of biofuel microalgal productions and to recycle nitrogen and phosphorus. The project proposes to study the coupling between a microalgal production system and an anaerobic digester. The objectives of BIOCORE are to propose a model of the coupled system, and to compute the optimal fluxes between the various compartments in order to optimize the energy recovery. See http://anr-symbiose.org/

- **ANR-Facteur 4:** The objective of this project to propose non GMO 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.

- **RESET:** The objective of this project is to control the growth of *E. coli* cells in a precise way, by arresting and restarting the gene expression machinery of the bacteria in an efficient manner directed at improving product yield and productivity. RESET is an "Investissements d'Avenir" project in Bioinformatics (managed by ANR) and it is coordinated by H. de Jong (Ibis, Inria)

- **FUI-Salinalgue:** The objective of this project is to take benefit of endemic microalgae species in areas of high salinity (previously used to produce salt) to produce both biofuel (either lipid based or methane) and co-products. BIOCORE is in charge of lab scale experiments and of the modeling of the process.

- **Green Stars:** Green Stars was laureate of the French call for projects known as the "French Stimulus Initiative" (Investissements d'Avenir), Institute of Excellence on Carbon-Free Energies. It federates a network of collaborative platforms bringing together all the players in the development of microalgae in France. The Institute includes 45 partners, including academics, large companies and SME. BIOCORE plays a key role in the project set up.

8.1.2. Inria funding

- **ColAge:** The goal of this joint Inria-INSERM consortium is to study bacterial growth and aging by using mathematical modeling and computational predictions to design and implement a *de novo* biological system. This Large-Scale Initiative Action is partly funded by Inria and supervised by H. Berry (Beagle, Inria).

- **Nautilus:** O. Bernard is coordinating the Inria-Nautilus ARC whose objective is to understand and model the coupling between hydrodynamics and microalgae photosynthesis.

8.1.3. INRA funding

- **Eco-tuta:** INRA-SPE is funding the project "Ecologie des communautés dans les agro-écosystèmes et implications pour la lutte biologique contre une espèce invasive: le cas Tuta absoluta sur tomate" in which BIOCORE is a partner with INRA Sophia Antipolis (2010-2012).

- **Propagules:** INRA-SPE is funding the project "Effet de différentes composantes de la pression de propagules sur le succès d'établissement d'un auxiliaire de lutte biologique" in which BIOCORE is a partner with INRA Sophia Antipolis (2011-2013).

- **Dynamique spatiale:** INRA-SPE is funding the project "Intégration des approches comportementales et démographiques de la dynamique spatiale des populations d'insectes" in which Biocore is a partner with INRA Sophia Antipolis and Agrocampus Ouest (2012-2014).
- **Metacarpe:** This INRA SPE-GAP-EFPA-EA project (call "Gestion durable des résistances des bio-agresseurs") is entitled "Modélisation de l'évolution des traits d'histoire de vie en lien avec l'agressivité des champignons parasites biotrophes : application au pathosystème rouille-peuplier". BIOCORE is taking part with CIRAD, INRA Sophia Antipolis, Nancy and Rennes (2010-2012).

8.1.4. Networks

- **RTP-M3D:** BIOCORE is a participant in the RTP-M3D workgroup (Mathématiques et décision pour le développement durable) that is supported by the "Environment and sustainable growth" department of CNRS. L. Mailleret is one of the co-leaders of M3D.
- **GDR PROBBE:** The objective of this GDR is the development of new biotechnological processes based on microorganisms producing metabolites which can be used as fuel for transportation (lipids, sugars, methane, hydrogen, ...). BIOCORE is taking part mainly in the modeling and control aspects of the processes involving anaerobic bacteria or microalgae.
- **COREV:** BIOCORE is an active participant in the research group COREV (Modèles et théories pour le contrôle de ressources vivantes et la gestion de systèmes écologiques).
- **Seminar:** BIOCORE organizes a regular seminar "Modeling and control of ecosystems" at the station zoologique of Villefranche-sur-Mer or at Inria.

8.2. European Initiatives

8.2.1. FP7 Projects

8.2.1.1. PURE

Title: Pesticide Use-and-Risk reduction in European farming systems with Integrated Pest Management

Type: COOPERATION (ICT)

Instrument: Collaborative Project (CP)

Duration: 2011 - 2014

Coordinator: Françoise Lescourret (INRA Avignon, FR)

Other partners: **Research:** Institut National de la Recherche Agronomique - INRA (FR) Rothamsted Research - RReS (UK) Aarhus University - AU (DK) Julius Kühn Institut - JKI (DE) Stichting DLO - DLO (NL) Wageningen University - WU (NL) Consiglio Nazionale delle Ricerche - CNR (IT) Agricultural Institute of Slovenia - KIS (SLO) James Hutton Institute - JHI (UK) Fondazione Edmund Mach - FEM (IT) Instituto Valenciano de Investigacio- nes Agrarias - IVIA (ES) Institute of Plant Protection - IOR (PL) University of Debrecen - Centre of Agricultural Sciences - UDCAS (HU) Joint Research Centre - Institute for Prospective Technological Studies - JRC-IPTS (EU **Extension:** Knowledge Centre for Agriculture - VFL (DK) Association de Coordination Technique Agricole - ACTA (FR) **Industry:** Bayer Crop Science (DE) BIOTOP (FR) Natural Plant Protection (FR) Burkard Manufacturing Co Ltd (UK) Blgg Bv (NL) **Management:** INRA Transfert (FR)

See also: http://www.pure-ipm.eu/project

Abstract: The overall objective of PURE is to provide practical integrated pest management (IPM) solutions to reduce dependence on pesticides in selected major farming systems in Europe, thereby contributing to a reduction of the risks to human health and the environment and facilitating the implementation of the pesticides package legislation while ensuring continued food production of sufficient quality.

PURE will provide IPM solutions and a practical toolbox for their implementation in key European farming systems (annual arable and vegetable, perennial, and protected crops) in which reduction of pesticide use and better control of pests will have major effects. In that project, L. Mailleret develops modeling approaches dedicated to the optimization of plant protection methods relying on biological control and integrated pest management.

8.2.2. Collaborations with Major European Organizations

Univ. Polytechnique Mons: Service d'Automatique (B)

Modeling of photosynthesis

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 Partners

Universidad Técnica Federico Santa María, Departamento de Matemática, Valparaíso, Chile
Universidad de Chile, Departamento de Matemáticas, Ñuñoa Santiago, Chile
Ben-Gurion University of the Negev, Microalgal Biotechnology Laboratory, Beer Sheva, Israel
Center for Environmental Technology and Engineering, Massey University , Palmerston North, New Zealand.

8.3.2. Participation In International Programs

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

8.4. International Research Visitors

8.4.1. Visits of International Scientists

We only list the visitors that stayed more than 2 days in our project-team

- Benoit Chachuat (Imperial College, Department of Chemical Engineering, UK), 1 week;
- Andreas Nikolaou (Imperial college, Department of Chemical Engineering, UK), 2 months;
- Claude Aflalo (Ben Gurion University of the Neguev, Israel), 1 week;
- Jaime Moreno (UNAM, Automation and Environmental Bioprocesses Departments, Institute of Engineering, Mexico), 1 week;
- Andrei Akhmetzhanov (McMaster University, Department of Biology, Canada), 2 weeks;
- Gonzalo Robledo (Universidad de Chile, Facultad de Ciencias, Departamento de Matemáticas, Chile) , 2 weeks;
- Tomas Gedeon (Montana State University, Department of Mathematical Sciences, USA), 2 days.

8.4.1.1. Internships

Luis CASACCIA (from Apr 2012 until Sep 2012)

Subject: Mathematical and computational analysis of genetic regulatory networks

Institution: National University of Rosario (Argentina)

8.5. Project-team seminar

BIOCORE organized a 3-day seminar in October in Peyresq. On this occasion, every member of the project-team presented his/her recent results and brainstorming sessions were organised. Jérôme Harmand of the Inria MODEMIC team was invited to give talks on this occasion.

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

<p style="text-align:center; color:red;">**CARMEN Team**</p>

6. Partnerships and Cooperations

6.1. Regional Initiatives

- Project *Modélisation pour les données multimodales* (2012-2015) funded by the *Conseil Regional Aquitaine*. Coordinator J.-F. Aujol (Pr University Bordeaux 1). The PhD of G. ravon is funded within this project: 3D reconstruction by inverse problem in cardiac optical mapping.

6.2. National Initiatives

6.2.1. IHU Liryc

Our work is partially funded by the Liryc project.

- For 2012-2015: 1/2 PhD thesis associated to the project *Modélisation pour les données multimodales* (see section Regional Initiaves).

6.3. European Initiatives

6.3.1. Collaborations with Major European Organizations

Partner 1: CNR, IMATI (Italie) – G. Manzini.

Finite volume discretization on general, distorted meshes, for second order operators with anisotropy and discontinuities. Applications to the simulation of ECG.

Partner 2: Computational Biology Group, University of Oxford. Department of Computer Science (United Kingdom).

Our work with the computational biology group concerns the development of multi-scale models of the drugs and their effect on the electrical activity of the heart. The main goal is to assess the drug-induced effects on the electrocardiogram, using a computational model describing the physiology from ion channel to body surface potentials.

6.4. International Initiatives

6.4.1. Inria International Partners

- Collaboration with the Pr. Y. Bourgault (http://aix1.uottawa.ca/~ybourg/personal.html) from the department of Mathematics and statistics of the University of Ottawa (Canada).
    - *Subject:* models and numerical methods for cardiac electrophysiology.
    - *Support:* for the last years the collaboration was supported by the ANR project Momme (ANR-JCJC-07-0141), the *Region des Pays de la Loire* and the Natural Sciences and Engineering of Research council of Canada
- Equipe Problèmes Inverses et Contrôle (EPIC), University Tunis Al Manar. 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.

6.5. International Research Visitors

6.5.1. Visits of International Scientists

- Y. Bourgault, Pr. Univeristy of Ottawa, Department of mathematics and statistics. 22/10/2012 to 26/10/2012.

  Comparison between the monodomain and bidomain models for cardiac electrophysiology.

- Moncef Mahjoub, Teaching assistant at University of Tunis Al Manar (ENIT-LAMSIN), Tunisia. 01/10/2012 to 06/10/2012.

  Inverse problems.

- Fadhel Jeday. Teaching assistant at University of Sousse, Tunisia. 03/12/2012 to 07/12/2012.

  Inverse problems.

6.5.1.1. Internships

Nicolas Claude (from July 2012 until September 2012)

  Subject: Real-time simulation of ECGs based on the finite element Sofa library developed at Inria Lille.

  Institution: ENSEIRB-MATMECA, Bordeaux (Master 1 student).

Jamila Lassoued (from August 2012 until November 2012)

  Subject: application of model reduction techniques to the inverse problems in cardiac electrophysiology.

  Institution: Ecole Nationale d'Ingénieurs de Tunis (Tunisia – Master 2 student)

Sinda Ben Khalfalla (from 04/12/2012 to 21/12/2012)

  Subject: Inverse problems for the quasistatic inverse problem in electrocardiology.

  Institution: Ecole Nationale d'Ingénieurs de Tunis (Tunisia – PhD student)

Mohammed Addouche (from 08/12/2012 to 05/01/2013)

  Subject: On using factorisation methods for the quasistatic inverse problems of electrocardiology.

  Institution: University of Tlemcen (Algeria – PhD student)

<p style="text-align:center;">**DRACULA Project-Team**</p>

8. Partnerships and Cooperations

8.1. Regional Initiatives

Collaboration with the Immune Lab of Jacqueline Marvel in Lyon (Immunité, Infection et Virus), one paper published together in 2012 and one grant obtained from the FINOVI foundation.

8.2. National Initiatives

8.2.1. ANR

Projects coordination by a member of Dracula

+ ANR (jeunes chercheurs) MADCOW "Modelling amyloid dynamics and computation output work: applications to Prion and Alzheimer's disease", 2008-2012.
  Participants: Samuel Bernard, Fabien Crauste, Erwan Hingant, Laurent Pujo-Menjouet [Coordinator], Vitaly Volpert.

+ ANR (jeunes chercheurs) ProCell "Mathematical Methods for Erythropoiesis Modelling: from Proteins to Cell Populations", 2009-2013.
  Participants: Samuel Bernard, Fabien Crauste [Coordinator], Olivier Gandrillon, Laurent Pujo-Menjouet, Emmanuelle Terry, 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

+ Thomas Lepoutre participates in the ANR project (jeunes chercheurs) MODPOL "cell polarization modeling", 2011-2015, Vincent Calvez (ENS Lyon) [Coordinator].

+ Olivier Gandrillon participates in the ANR (Investissement d'Avenir) Iceberg "From population models to model populations: single cell observation, modeling, and control of gene expression", Gregory Batt (Inria) [Coordinator].

8.3. European Initiatives

8.3.1. Collaborations in European Programs

Program: PICS CNRS - RUSSIE

Project title: Mathematical modelling of blood diseases

Duration: 2010-2012

Participants: Samuel Bernard, Fabien Crauste, Laurent Pujo-Menjouet, Alen Tosenberger, Vitaly Volpert [Coordinator].

8.3.2. 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.

8.4. International Initiatives

8.4.1. Participation In International Programs

8.4.1.1. 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.

8.5. International Research Visitors

8.5.1. *Visits of International Scientists*

- Michal Komorowski - Institute of Fundamental Technological Research of Polish Academy of Science, Warsaw, Pologne - February 2012.
- Oscar Angulo - University of Valladolid, Spain - March 2012.
- Konstantinos Tzirakis - Institute of Applied and Computational Mathematics, Foundation for Research and Technology, Greece - April 2012.
- Thomas Höfer - German Cancer Research Center, Heidelberg - April 2012.
- John Lygeros - Automatic Control Laboratory, ETH Zurich, Switzerland - June 2012.
- Hassan Hbid - University of Marrakech - June 2012.
- Khalil Ezzinbi (chercheurs invités) - University of Marrakech - September 2012.
- Michael C. Mackey - McGill University, Montréal, Canada - September 2012.
- Marta Tyran-Kaminska - University of Silesia, Pologne - September 2012.
- Sergei Fedotov - School of Mathematics, The University of Manchester, UK - October 2012.
- Amira Kebir - Institut Pasteur de Tunis - December 2012.

MACS Project-Team

7. Partnerships and Cooperations

7.1. European Initiatives

7.1.1. FP7 Projects

7.1.1.1. EUHEART

Title: euHeart

Type: COOPERATION (ICT)

Defi: Virtual Physiological Man

Instrument: Integrated Project (IP)

Duration: June 2008 - May 2012

Coordinator: Philips Technologie GmbH Forschungslaboratorien (Germany)

Others partners: Philips Technologie GmbH (DE), The University of Oxford (UK), Universitat Pompeu Fabra (SP), The University of Sheffield (UK), Inria, French National Research Institute in Informatics and Mathematics (FR), King's College London (UK), Academisch Medisch Centrum bij de Universiteit van Amsterdam (NL), Universität Karlsruhe (TH) (DE), Institut National de la Santé et de la Recherche Médicale, INSERM (FR), Philips Medical Systems Nederland BV (NL), Berlin Heart GmbH (DE), HemoLab BV (NL), Universitätsklinikum Heidelberg (DE), Volcano Europe SA / NV (BE), Hospital Clínico San Carlos de Madrid (SP), Philips Ibérica S.A. (SP)

See also: http://www.euheart.eu/

Abstract: The euHeart project (Ref 224495), is a 4-year integrated European project which aims at developing personalized, and clinically validated multi-physics, multi-level models of the heart and great vessels. Those models need to be tightly integrated with signal and image processing tools in order to assist clinical decision making and to help reducing morbidity and mortality rates associated with cardiovascular diseases. Asclepios is leading a workpackage on radiofrequency ablation for which electromechanical models of the heart are used to improve the planning of radiofrequency ablation lines for patient suffering from atrial fibrillation and ventricular tachycardia.

7.1.1.2. VPH-Share

Title: VPH-Share

Type: COOPERATION (ICT)

Defi: Virtual Physiological Human : Sharing for Healthcare

Instrument: Integrated Project (IP)

Duration: March 2011 - February 2015

Coordinator: Univ. Sheffield (UK)

Others partners: Cyfronet (Cracow), University College London, Istituto Ortopedico Rizzoli (Bologna), NHS, IBM Israel, Univ. Auckland, Agència d'Informació, Avaluació i Qualitat en Salut (Barcelona), Biocomputing Competence Centre (Milano), Universitat Pompeu Fabra (Barcelona), Philips Research, TUE (Eindhoven), Sheffield Teaching Hospitals, Atos Origin (Madrid), the Open University (UK), Univ. Vienna, King's College London, Empirica (Bonn), Fundació Clínic (Barcelona), Univ. Amsterdam

See also: http://vph-share.org/

Abstract: VPH-Share aims at developing the organisational fabric (the infostructure) and integrate the optimised services to expose and share data and knowledge, to jointly develop multiscale models for the composition of new VPH workflows, and to facilitate collaborations within the VPH community. Within this project, the Macs team is in charge of developing some high-performance data assimilation software tools.

7.2. International Initiatives

7.2.1. Inria Associate Teams

7.2.1.1. CARDIO

Title: Mathematical modelling and Numerical Simulation for Cardiovascular Applications

Inria principal investigator: Philippe Moireau

International Partner (Institution - Laboratory - Researcher):

University of California San Diego (United States) - Mechanical and Aerospace Engineering - Alison MARSDEN

Duration: 2008 - 2013

See also: https://idal.inria.fr/cardio/

To improve disease understanding, surgical repair or medical device design, mathematical and numerical tools have been the subject of much efforts over the last decades. In this context, we propose a research subject on cardiovascular and air flow modeling. It extends the project of the previous associated team on blood flow modeling to flow of air in the lungs. The goal is to continue to work on bringing together methods developed in the different teams, to compare them if necessary, and to apply them to in-vivo (animal or human) physiologically relevant situations. All the different team members have a strong will to work close to the applications. They all have links to clinicians or biologists, which drive the concrete applications that will be studied: congenital heart disease pathophysiology and repair, artery wall compliance study in normal and pathophysiological cases, heart valve pathophysiology assessment, aerosol deposition in the lungs. Furthermore, the associated team facilitates the breadth of researcher knowledge by exposure to different ways of thinking, methods and/or applications, and by the training of students as they interact with the other institutes.

MASAIE Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

MASAIE has obtained a grant from Région Lorraine for a research project : "Dynamique des populations de pathogènes".

7.2. International Initiatives

7.2.1. *Inria International Partners*

- University Gaston Berger, St Louis, Senegal.
- University of Ouagadougou and Université Polytechnique de Bobo-Dioulaso, Burkina-Faso.
- University Hassan II, Casablanca, Morocco.
- University of Manitoba, Winnipeg, Canada.

7.2.2. *Participation In International Programs*

7.2.2.1. CAPES-COFECUB

MASAIE is the french correspondent in a cooperation program with Brazil. This project, funded by CAPES-COFECUB, "new methods in epidemiology and early detection of events" for 4 years, has begun in January 2011.

A Brazilian network has been built in 2011, 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 :
- Fondation Oswaldo Cruz (Fiocruz, Rio). Principal investigator : Claudia Codeço
- l'université fédérale de l'état de Pernambuco, Recife (http://www.ufpe.br/ufpenova/); Principal investigator César Castilho;
- IMPA Rio de Janeiro

We investigate in 2012 the biological control of dengue by *Wolbachia*.

7.2.2.2. PAES-UEMOA

A research project on Bilharzia was deposed November 2, 2012, by the universities of Ouagadougou and Gaston Berger of Saint-Louis, in the framework of PAES(projet d'appui à l'enseignement supérieur) of UEMOA (Union Economique et Monétaire de l'Afrique de l'Ouest). MASAIE is an important component of this network. This project has been accepted July, 1, 2012 and funded with 30 000 000 CFA (XOF) ($\approx$ 45 000 euro).

The Phd thesis of Lena Tendeng (MASAIE) is part of this project.

7.3. International Research Visitors

7.3.1. Visits of International Scientists

- Aboudramane GUIRO, Université Polytechnique de Bobo-Dioulaso, Burkina-Faso, March 25 to April 22, 2012.
- Patrick Deleenheer, University of Florida, Gainesville, FL, June 24-28, 2012.
- Diène Ngom, Université de Ziguinchor, Senegal, September 25 to October 18, 2012.
- Blaise Kone (université Ouagadougou) October 26-November 16, 2012.
- Beranrd Bonzi (université Ouagadougou) October 29-November 13,2012.

In the framework of CAPES-COFECUB

- Hyun Mo Yang (UNICAMP) : February 4-February 8, 2012.
- Max Oliveira de Souza (UFF Rio) February 19-March 3, 2012.
- Max Oliveira de Souza (UFF Rio) November 20-December 3, 2012.
- Moacyr Alvim Barbosa da Silva (FGV Rio) November 20-December 3, 2012.

7.3.2. Visits to International Teams

In the framework of CAPES-COFECUB, A. Iggidr and G. Sallet visit FGV and UNICAMP from October 28 to November 19, 2012 (see CAPES-COFECUB).

<p style="text-align:center">**MODEMIC Project-Team**</p>

8. Partnerships and Cooperations

8.1. International Initiatives

8.1.1. Inria Associate Teams

8.1.1.1. Associated team DYMECOS

Participants: Térence Bayen, Fabien Campillo, Jérôme Harmand, Claude Lobry, Alain Rapaport, Alejandro Rojas-Palma, Tewfik Sari, Matthieu Sebbah.

Program: Associate Teams

Title: DYnamical Microbial and Environmental eCOSystems

Inria principal investigator: Alain Rapaport

International Partners (Institution - Laboratory - Researcher):

Universidad de Chile / Departamento de Ingeniería Matemática - Universidad de Chile / CNRS (Chile) / Centro de Modelamiento Matemático (CMM) - Héctor Ramìrez

Universidad Tecnica Federico Santa Maria (Chile) - Departamento de Matematica - Pedro Gajardo

Duration: 01/01/2010 - 31/12/2012

DYMECOS is an associated team with Chile, mainly with CMM (Centro de Modelamiento Matemático), Univ. de Chile, Santiago, DIM (Departamento de Ingeniería Matemática), Universidad de Chile, Santiago and Departamento de Matematica, Universidad Tecnica Federico Santa Maria (UTFSM).

Two kinds of investigations have been conducted:

- minimal time control problems of fedbatch processes with several species, and optimal strategies for the bioremediation of natural water resources,
- stochastic modelling of the chemostat.

The second Franco-Chilean Workshop on Bioprocess Modelling has been co-organized by the team and the Chilean partners in January at Pucón (see https://sites.google.com/site/eadymecos/evenements). The workshop gathers mathematicians, process engineers and micro-biologists.

C. Lobry, A. Rapaport and T. Sari have participated to the 3rd LAWOC (Latin American Workshop on Optimization and Control) held in Valparaiso, Chile [48], [52], [54].

This year, the team has received A. Rojas-Palma as a MSc Internship for 3 months, and M. Sebbah has been hired by Inria-CIRIC for a postdoctoral stay of 3 months in the team (Oct.-Nov. 2012) followed by 13 months in Chile (starting Jan. 2013).

8.1.2. Participation In International Programs

8.1.2.1. CIRIC-Bionature

The team has contributed to the writing proposal of the Bionature line of the CIRIC (Communication and Information Research and Innovation Center) in Chile.

The 16 months postdoctoral grant of M. Sebbah (3 months in France, 13 months in Chile) is supported by Inria-Chile within this research program (see Section 8.1.1.1).

8.1.2.2. TREASURE

Participants: Fabien Campillo, Jérôme Harmand, Claude Lobry, Tewfik Sari.

Program: Euromediterranean 3+3

Title: Treatment and Sustainable Reuse of Effluents in semiarid climates

Inria principal investigator: Jérôme HARMAND

International Partners (Institution - Laboratory - Researcher):

University of santiago de compostella (Spain) - Environmental engineering - Juan GARRIDO

National Research Center (Egypt) - Water Pollution Control - Helmy EL-ZANFALY

Université Française d'Egypte (Egypt) - mathematiques - Mohamed JAOUA

Institut National de la Recherche Agronomique (France) - dpts EA, MICA et MIA - Pascal NEVEU

University of Tlemcen (Algeria) - Automatic control - Brahim CHERKI

University of Patras (Greece) - Process Control Laboratory - Costas KRAVARIS

Centre de Biotechnology de Sfax (Tunisia) - Department of environmental engineering - Sami SAYADI

Université Cadi Ayyad de Marrakech -Faculté des Sciences de Semlalia - Dépt. de Mathématiques (Morocco) - Centre National de Recherche sur l'Eau et l'Energie - Laila MANDI

Ecole Nationale des Ingénieurs de Tunis (Tunisia) - Mathématiques - Nabil GMATI

The TREASURE network aims at integrating knowledge on the modelling, the control and the optimization of biological systems for the treatment and reuse of wastewaters 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 parters from South.

8.1.2.3. LIRIMA Stic-Mada

Participants: Fabien Campillo, Angelo Raherinirina.

Program: LIRIMA

Title: Stic-Madagascar

Inria principal investigator: Fabien Campillo

International Partners (Institution - Laboratory - Researcher):

University of Antananarivo (Madagascar) - Lala Andriamampianina

University of Fianarantsoa (Madagascar) - Rivo Rakotozafy

The MODEMIC Project-Team is coordinator of the LIRIMA/Stic-Mada project for the theme: modelling and management of natural resources. In 2012, Angelo Raherinirina (co-advised with F. Campillo and R. Rakotozafy) made a 6 months stay in MODEMIC team-project, he will defend his thesis in January 2013 (see Section 6.2.8).

8.2. International Research Visitors

8.2.1. Visits of International Scientists

D. Dochain, from CESAME, Univ. Louvain-la-Neuve (Belgium), has spent one month in the team. D. Dochain is the coordinator of the CAFE project (see Section 7.1).

8.2.1.1. Internships

A. Rojas-Palma, MSc student at Univ. of Chile, has spent 3 months in the team, in the scope of the Inria Internships (see Section 8.1.1.1).

8.2.2. Visits to International Teams

B. Haegeman is on secondment to CNRS since September 2012. He is working at the Centre of Biodiversity Theory and Modelling which is part of the Station for Experimental Ecology in Moulis (Ariège).

NUMED Project-Team

8. Partnerships and Cooperations

8.1. National Initiatives

8.1.1. ANR

Vincent Calvez is head of on ingoing ANR contract on cell mobility.

8.1.2. Competitivity Clusters

Vincent Calvez organizes a special semester on mathematical biology within Lyon mathematical and computer science LABEX Milion.

8.2. European Initiatives

8.2.1. FP7 Projects

8.2.1.1. DDMoRE

Title: DDMoRE

Duration: February 2011 - January 2016

Coordinator: Pfizer (United Kingdom)

8.3. International Initiatives

8.3.1. Participation In International Programs

8.4. International Research Visitors

8.4.1. Visits of International Scientists

8.4.1.1. Internships

Nuria BUIL-BRUNA (from Oct 2012 until Dec 2012)

Subject: Prediction of long-term clinical outcome in cancer patients based on the modeling of tumor size dynamic

Institution: University of Malaga (Spain)

8.4.2. Visits to International Teams

B. Ribba has visited UCSB in autumn.

REO Project-Team

7. Partnerships and Cooperations

7.1. National Initiatives

7.1.1. ANR

7.1.2. ANR Project "M3RS"

Participants: Laurent Boudin, Muriel Boulakia, Paul Cazeaux, Anne-Claire Egloffe, Céline Grandmont [Principal Investigator], Bérénice Grec, Sébastien Martin, Irène Vignon-Clementel.

Period: 2008-2013.

This project, coordinated by C. Grandmont, aims at studying mathematical and numerical issues raised by the modeling of the lungs.

7.1.3. ANR Project "Epsilon"

Participants: Marina Vidrascu, Sofiene Hendili.

Period: 2009-2013

This project, coordinated by Jean-Jacques Marigo (LMS-Ecole polytechnique) aims to study Domain decomposition and multi-scale computations of singularities in mechanical structures.

7.1.4. ANR Project "EXIFSI"

Participants: Miguel Ángel Fernández Varela, Mikel Landajuela Larma, Vincent Martin, Marina Vidrascu.

Period: 2012-2016

The aim of this project, coordinated by Miguel Ángel Fernández Varela is to study mathematically and numerically new semi-explicit fluid-structure interaction schemes.

7.2. European Initiatives

7.2.1. FP7 Projects

7.2.1.1. EUHEART

Title: euHeart
Type: COOPERATION (ICT)
Defi: Virtual Physiological Man
Instrument: Integrated Project (IP)
Duration: June 2008 - September 2012
Coordinator: Philips Technologie GmbH Forschungslaboratorien (Germany)
Others partners: Philips Technologie GmbH (DE), The University of Oxford (UK), Universitat Pompeu Fabra (SP), The University of Sheffield (UK), Inria, French National Research Institute in Informatics and Mathematics (FR), King's College London (UK), Academisch Medisch Centrum bij de Universiteit van Amsterdam (NL), Universität Karlsruhe (TH) (DE), Institut National de la Santé et de la Recherche Médicale, INSERM (FR), Philips Medical Systems Nederland BV (NL), Berlin Heart GmbH (DE), HemoLab BV (NL), Universitätsklinikum Heidelberg (DE), Volcano Europe SA / NV (BE), Hospital Clínico San Carlos de Madrid (SP), Philips Ibérica S.A. (SP)
See also: http://www.euheart.eu/
Abstract: The euHeart project (Ref 224495), is a 4-year integrated European project which aims at developing personalized, and clinically validated multi-physics, multi-level models of the heart and great vessels.

7.3. International Initiatives

7.3.1. Inria Associate Teams

Participants: Grégory Arbia, Cristóbal Bertoglio Beltran, Miguel Ángel Fernández Varela, Jean-Frédéric Gerbeau, Céline Grandmont, Irène Vignon-Clementel [coordinator].

Period: 2008-2014

CARDIO: The aim of this project is to foster the collaboration between the Cardiovascular Biomechanics Research Laboratory (CVBRL) of C.A. Taylor (Stanford University, USA) and colleagues such as Dr. Feinstein, and the project-team REO, through research on cardiovascular and respiratory related topics (boundary conditions for complex flow, patient-specific modeling of congenital heart disease, image-based fluid solid interaction, postprocessing of numerical simulations). The associated team has been extended to other partners: team-project MACS at Inria, the Marsden group at USCD and the Flow physics group at IIT. CA Figueroa is now at KCL, UK.

7.3.2. *Inria International Partners*

7.3.3. *Trans-Atlantic Network of Excellence for Cardiovascular Research*

Participants: Grégory Arbia, Jean-Frédéric Gerbeau, Irène Vignon-Clementel [correspondant].

Period: 2010-2014

This network, funded by the Leducq fondation, is working on the multi-scale modeling of single ventricle hearts for clinical decision support [3].

7.3.4. *German BMBF national project Lungsys II*

Participant: Irène Vignon-Clementel.

"Systems Biology of Lung Cancer "Dynamic Properties of Early Spread and Therapeutic Options". In collaboration with Dirk Drasdo EPI Bang, Inria & Paris 6 UPMC

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7.4. International Research Visitors

7.4.1. *Visits of International Scientists*

- André Garon, Département Génie Mécanique de l'Ecole Polytechnique de Montréal, 10-18 may, 2012
- Michel Delfour, Département de Mathématiques et Statistiques, Université de Montréal, 12-16 may, 2012
- C. Alberto Figueroa, KCL, London, UK, Feb 7-8th 2012
- Maxim Solovchuk, Taida Institute of Mathematical Sciences, National Taiwan University, 15–30 july, 2012
- Chang-Shou Lin, Taida Institute of Mathematical Sciences, National Taiwan University, 22-24 november, 2012
- Jessica Oakes, University of California at San Diego, USA, 17-21 december, 2012

7.4.1.1. Internships

- Frédéric Jamin, MS student, Imperial College, London, UK, May 15th-Sept 14th 2012

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[3]http://modelingventricle.clemson.edu/home

SISYPHE Project-Team

7. Partnerships and Cooperations

7.1. Regional Initiatives

7.1.1. *Paris Region ASTech project MODIPRO: Modeling for diagnosis and prognosis*
Participants: Abdouramane Moussa Ali, Qinghua Zhang.

In order to improve the safety and reliability of airplanes, the MODIPRO project (Modélisation pour le Diagnostic et le Pronostic) funded by the Pôle de Compétitivité Aérospatial ASTech of Paris Region from 2009 to 2012 aims at developing a software for deriving airplane functional models for the purpose of fault diagnosis and prognosis, by analyzing the flight data of a fleet of airplanes. The involved partners are Dassault Aviation (project leader), Snecma, IT4Control, Bayesia, KBS, UPMC, Supelec and Inria.

7.2. National Initiatives

7.2.1. *ANR project DMASC: Scaling Invariance of Cardiac Signals, Dynamical Systems and Multifractal Analysis*
Participants: Julien Barral, Claire Médigue, Michel Sorine.

Collaboration with Denis Chemla (Kremlin-Bicêtre Hospital), Paulo Gonçalves (Inria Rhônes-Alpes) and Stéphane Seuret (Paris 12 University).

The ANR project DMASC (Program SYSCOMM 2008) started in January 2009 under the coordination of J. Barral.

Numerical studies using ideas from statistical physics, large deviations theory and functions analysis have exhibited striking scaling invariance properties for human long-term R-R interval signals extracted from ECG (intervals between two consecutive heartbeats). These numerical studies reveal that the scaling invariance may have different forms depending upon the states of the patients in particular for certain cardiac diseases. These observations suggest that a good understanding of multifractal properties of cardiac signals might lead to new pertinent tools for diagnosis and surveillance. However, until now, neither satisfactory physiological interpretations of these properties nor mathematical models have been proposed for these signals. For medical applications we need to go beyond the previously mentioned works and achieve a deepened study of the scaling invariance structure of cardiac signals. This is the aim of DMASC.

New robust algorithms for the multifractal signals processing are required ; specifically, it seems relevant to complete the usual statistical approach with a geometric study of the scaling invariance. In addition, it is necessary to apply these tools to a number of data arising from distinct pathologies, in order to start a classification of the different features of the observed scaling invariance, and to relate them to physiology. This should contribute to develop a new flexible multifractal mathematical model whose parameters could be adjusted according to the observed pathology. This multifractal analysis can be applied to another fundamental signal, the arterial blood pressure, as well as to the couple (R-R, Blood Pressure). The main results of this project can be found in [15].

7.2.2. *ANR project EBONSI: Extended Block-Oriented Nonlinear System Identification*
Participants: Pierre-Alexandre Bliman, Michel Sorine, Qinghua Zhang.

The main idea of block-oriented nonlinear system identification is to model a complex system with interconnected simple blocks. Such models can cover a large number of industrial applications, and are yet simple enough for theoretic studies. The objectives of the EBONSI project are to extend classical block-oriented nonlinear models to new model structures motivated by industrial applications, and to relax some traditional restrictions on experimental conditions. This is an international project jointly funded by the French Agence Nationale de la Recherche (ANR) and the Chinese National Natural Science Foundation (NSFC) from 2011 to 2014. The project partners are the SISYPHE project-team of Inria (project leader), the Centre de Recherche en Automatique de Nancy (CRAN), and the Laboratory of Industrial Process Monitoring and Optimization of Peking University.

7.2.3. ANR project 0-DEFECT: On-board fault diagnosis for wired networks in automotive systems

Participants: Mohamed Oumri, Michel Sorine, Qinghua Zhang.

The number of electric and electronic equipments is increasing rapidly in automotive vehicles. Consequently, the reliability of electric connections is becoming more and more important. The project entitled "Outil de diagnostic embarqué de faisseaux automobiles" (0-DEFECT) aims at developing tools for on-bord diagnosis of failures in electric wire connections in automotive systems. This project is funded by Agence Nationale de la Recherche (ANR) from 2009 to 2012. The involved partners are CEA LIST (project leader), Renault Trucks, Freescale, PSA, Delphi, Supelec LGEP and Inria.

7.2.4. ANR project INSCAN: Fault diagnosis for security critical long distance electric transmission lines

Participants: Leila Djaziri, Michel Sorine, Qinghua Zhang.

The wired electric networks of the French railway system cover more than 50000 km. The electric insulation of the signaling lines along the railways is monitored by regular inspections. Today these inspections are based on an expensive procedure realized by human operators located at both ends of each section of a transmission line. The service of signaling devices has to be interrupted during this procedure, and so does the railway traffic. The in situ monitoring of the transmission lines, without interruption of service, is thus an important economic issue. For this purpose, the project entitled "Diagnostic de câbles électriques sécuritaires pour grandes infrastructures" is funded by ANR from 2009 to 2012 in order to study the feasibility of in situ monitoring tools for these transmission lines. The involved partners are SNCF (project leader), CEA LIST and Inria.

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

The need for detection, localization and characterization of defects in a cables network has led to several projects, funded by the ANR: SEEDS followed by 0-DEFECT in the automotive domain, INSCAN for cables along railways. These co-operative works made it possible to 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 the SODDA project 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 will be run by an academic consortium, in close connection with an industrial board, responsible for keeping the work in realistic and relevant use cases. The Inria teams involved are POEMS and Sisyphe.

7.2.6. ANR project EPOQ2: Estimation PrOblems for Quantum & Quantumlike systems

Participants: Hadis Amini, Zaki Leghtas, Mazyar Mirrahimi, Pierre Rouchon, Michel Sorine.

The project EPOQ2 is an ANR "Young researcher" project led by Mazyar Mirrahimi (Sisyphe). It has for goal to address a class of inverse problems rising from either the emerging application domain of "quantum engineering" or from some classical applications where a natural quantization lead to quantum-like systems, as it is the case in particular for inverse scattering for transmission lines. This research is in collaboration with the Pierre Aigrain laboratory (LPA) at ENS Paris and the Quantronics Laboratory (Qlab) of Michel Devoret and the Rob Schoelkopf Lab at Yale University and Pierre Rouchon from Ecole Nationale Supérieure des Mines de Paris.

7.2.7. *Inria Large Scale Initiative Action REGATE*

REGATE (REgulation of the GonAdoTropE axis) is a 4-year Large Scale Initiative Action funded by Inria in May 2009 dedicated to the modeling, simulation and control of the gonadotrope axis.

The action is coordinated by Frédérique Clément. The Inria participants to this action are researchers of 2 Inria research teams, Contraintes and Sisyphe. There are also participants from INRA, Université Libre de Bruxelles (Unité de Chronobiologie théorique) and Université Paris 6 (Laboratoire Jacques-Louis Lions).

7.3. European Initiatives

7.3.1. *Collaborations in European Programs, except FP7*

7.3.1.1. ERNSI

The SISYPHE project-team is involved in the activities of the European Research Network on System Identification (ERNSI) federating major European research teams on system identification.

- Program: Funded as a SCIENCE project (1992 - 1995), HCM Project (1993-1996), TMR Project (1998 - 2003).
- Project acronym: ERNSI
- Project title: European Research Network System Identification
- Duration: 1992 —
- Coordinator: The network ERNSI is currently coordinated by Bo Wahlberg, Automatic Control, KTH SE 100 44 Stockholm, Sweden.
- Other partners: KTH (Sweden), Inria (France), TUD (Technische Universität Darmstadt), TUW (Vienna University of Technology), UCAM-DENG (University of Cambridge), ELEC (Vrije Universiteit Brussel), ULIN (Sweden), UNIPD (Italy).
- Abstract: Modeling of dynamical systems is fundamental in almost all disciplines of science and engineering, ranging from life science to process control. Engineering uses models for the design and analysis of complex technical systems. System identification concerns the construction, estimation and validation of mathematical models of dynamical physical or engineering phenomena from experimental data.

7.3.1.2. MODRIO
Participants: Abdouramane Moussa Ali, Qinghua Zhang.

The SISYPHE project-team, with two other Inria project-teams (PARKAS, S4) participates in the MODRIO project regrouping partners from 7 european countries.

- Program: ITEA 2.
- Project acronym: MODRIO.
- Project title: Model Driven Physical Systems Operation.
- Duration: 2012 – 2015
- Coordinator: Daniel Bouskela, EDF, France.

- Other partners: ABB (Sweden AB), ABB AG (Germany), AIT Austrian Institute Of Technology (Austria), Ampère Laboratory-CNRS-University of Lyon (France), Bielefeld University of Applied Sciences (Germany), Dassault Aviation (France), Deutsches Zentrum für Luft- und Raumfahrt (DLR) (Germany), Digital Product Simulation (DPS) (France), DS AB (Sweden), EADS (France), Enicon Eco-Energy-Consulting GmbH (Austria), Equa Simulation AB (Sweden), IFP Energies nouvelles (France), Ilmenau University of Technology (Germany), Inria (France), ITI (Germany), Katholieke Universiteit Leuven (Belgium), Knorr-Bremse (Germany), Linkping University (Sweden), LMS Imagine (France), LMS International (Belgium), MathCore Engineering AB (Sweden), Modelon AB (Sweden), Pöyry Finland Oy (Finland), Qtronic (Germany), Scania (Sweden), Semantum Oy (Finland), Sherpa Engineering (France), Siemens AG (Germany), Siemens Industrial Turbomachinery AB Industrial Turbomachinery A.B. (Sweden), Simpack AG (Germany), Supmeca (France), Triphase (Belgium), University of Calabria (Italy), Vattenfall (Sweden), VTT Technical Research Centre of Finland Tec (Finland), Wapice Ltd (Finland).

- Abstract: To meet the evermore stringent safety and environmental regulations for power plants and transportation vehicles, system operators need new techniques to improve system diagnosis and operation. Open standards are necessary for different teams to cooperate by sharing compatible information and data. The objective of the MODRIO project is to extend modeling and simulation tools based on open standards from system design to system diagnosis and operation. This project joined by partners from Austria, Belgium, Finland, France, Germany, Italy and Sweden has been selected by the board of Information Technology for European Advancement (ITEA 2). The involved Inria project-teams are PARKAS, S4 and SISYPHE.

7.4. International Initiatives

7.4.1. Inria International Partners

Mazyar Mirrahimi closely collaborates with the Quantronics Laboratory (Qlab) of Michel Devoret and the Rob Schoelkopf Lab at Yale University.

7.5. International Research Visitors

7.5.1. Visits of International Scientists

7.5.1.1. Internships

Patrick FLETCHER (two months: February and July 2012)

Subject: Regulation of hormone production by the frequency of a periodic stimulating signal

Institution: Florida State University (United States)

7.5.2. Visits to International Teams

Mazyar Mirrahimi spent one year in the Quantronics Laboratory (Qlab) of Michel Devoret and the Rob Schoelkopf Lab at Yale University.

Qingua Zhang visited the Laboratory of Industrial Process Monitoring and Optimization of Peking University, in the framework of the ANR EBONSI project.

<p style="text-align:center; color:red;">**VIRTUAL PLANTS Project-Team**</p>

6. Partnerships and Cooperations

6.1. Regional Initiatives

6.1.1. *OpenAlea*

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

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

The aim of this project is to foster the development and the national and international diffusion of the platform OpenAlea. This opensource platform provides an easy-to-use environment for plant modelers through a visual programming interface to efficiently use and combine models or computational methods from different scientific fields in order to represent, analyze and simulate complex plant systems at different scales, from meristems to plant canopy. OpenAlea makes it possible to assemble highly reusable, heterogeneous components. The central point of its architecture is to allow to integrate existing components or modules developed by different teams without rewriting them. These components are developed in multi-languages like C, C++, Fortran or Java as well as Python. Work comprises development of standard data structures, deployment tools, documentation, training, software engineering, user interface, ...

6.1.2. *Fruit3D*

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

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

The aim of this project is to develop a virtual tomato that contains the geometrical description of a growing fruit, physiological models (for sugar and hormone transfers) and mechanical model. The project gathers the competences of plant modelers, physicists and ecophysiologists. Physical and biological laws involved in tissue differentiation and cell growth, in relation to fruit growth and compartmentalization, and a number of related traits of quality (e.g. size, composition and texture) are modeled and integrated within the virtual tomato. Magnetic Resonance Imaging (MRI) techniques are used to provide an in vivo validation of the model by non invasive measurements.

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

6.1.3. *PlantScan3D*

Participants: Frédéric Boudon, Chakkrit Preuksakarn, Jean-Baptiste Durand, Christophe Godin, Christian Fournier.

Funding: Agropolis foundation (Contractor for Virtual Plants: CIRAD, From 2009 to 2012)

Automatic acquisition of plant phenotypes, and in particular of architecture phenotypes, constitutes a major bottleneck of the construction of quantitative models of plant development. Recently, 3D Laser scanners have made it possible to acquire 3D images on which each pixel has an associated depth corresponding to distance between camera and the pinpointed surface of the object. The objective of this project is to develop the use of laser scanner for plant geometry reconstruction. For this, we develop methodologies for the automation of numerical 3D acquisition of vegetal structures of different sizes, and new methods for the reconstruction of parsimonious geometrical and structural models usable in agronomic and biological contexts.

Partners: AFEF Team, UMR AGAP, UMR LEPSE (Montpellier), UMR PIAF (INRA Clermont Ferrand), UMR URP3F (Inra Lusignan), EPI Galaad (Inria Sophia Antipolis), EPI Imagine (Inria Grenoble). University of Helsinki, Finland.

6.1.4. *Agropolis computational plant seminar*

Participants: Yann Guédon, Christine Granier [INRA, LEPSE], Soazig Guyomarc'h [Montpellier 2 University, DIADE].

Funding: Agropolis foundation (Contractor for Virtual Plants: CIRAD. From 2008 to 2012)

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

6.1.5. *Rhizopolis*

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

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

Rhizopolis is a multidisciplinary project on the biology and ecology of the plant root that addresses the broad roles of this organ in mineral nutrient and water acquisition. The consortium addresses central issues of root development, that are operationally divided into 3 work packages.

- WP A: Integration of membrane transport activity and structure-function relationships in roots and root symbioses.
- WP B: Key tools for imaging root development: (i) a world unique platform for 4D root imaging of root cell division and root primordia formation, and (ii) an innovative image analysis software for high-throughput phenotyping of root system architecture. These tools will be used to identify mechanisms and traits associated with root system efficiency and plasticity
- WP C: Integrating root-soil interactions in the rhizosphere at the whole root system level – application to water and nutrient acquisition by plants.

Virtual Plants is mainly involved in WP B and in particular in the development of a tool to automatically reconstruct root systems from 2D imaging.

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

6.2. National Initiatives

6.2.1. *ANR*

6.2.1.1. *Morpholeaf*

Participants: Christophe Godin, Etienne Farcot.

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. The leaf is the main photosynthetic organ of the plant and its margin can show diverse levels of dissections ranging from no (entire margin), mild (serration) to strong (lobes) incisions. The leaf itself can be either simple or dissected into units called leaflets. The CUC genes are part of a network involving negative regulation by a miRNA, miR164 and possible response of the signalling molecule auxin. However, the interplay between the three actors of this network (CUC, miR164 and auxin) is not understood yet. Nor are known the cellular effects of the expression of the CUC genes and their link with differential growth of the leaf margin leading to serration. 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. By combining biological observations and manipulations, quantitative measurements and modeling, 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. We will, stepwise, build, test and validate a model of leaf margin development integrating a regulatory network, cellular behaviour and morphogenesis.

Partners: RDP ENS-Lyon; INRA Versailles.

6.2.1.2. HydroRoot

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

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

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

6.2.2. Other national grants

6.2.2.1. OpenAlea 2.0

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

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

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

Partners: EPI Zenith

6.2.2.2. 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. This is a demonstration project focusing on the wheat septoria system, but the modeling approach is generic and intended to apply to other pathosystems. The originality of the project is based on: (i) the plant material used, consisting of innovative wheat varieties selected for their ability to produce contrasting architectures, (ii) the development of an integrative modeling tool coupling the canopy development, the fate of fungicides and the dynamics of the pathogen, and (iii) a proposed approach to multicriteria evaluation of protection strategies including estimation of yields, assessments of environmental impact of pesticides and erosion of efficacy. The project focuses on the development of a modeling tool. This tool is organized around three components: (1) the effect of the architecture of crops on epidemics, (2) the effect of fungicides on infection cycles and (3) the effect of canopy architecture on the fate of fungicides after application. The integration of the three components are performed within the OpenAlea platform that will allow the multicriteria evaluation of various scenarios (climate / varieties / architecture / fungicides) and help design new practices. Field experiments allow testing of treatment strategies associated with a variety of architectures. Data will be used to validate the modeling tool developed. Thanks to the integrated model various scenarios combining climate architecture x fungicide treatment will be simulated to identify and propose efficient strategies for pesticide applications.

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

6.2.2.3. Morphogenetics

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

Funding: Inria Action d'Envergure(From 2011 to 2015)

Morphogenetics is an Inria transversal project gathering 3 Inria teams and two Inra teams. It is aimed at understanding how flower shape and architecture are controlled by genes during development. To do so, we study the spatio-temporal relationship between genetic regulation and flower shape utilizing recently developed imaging techniques together with molecular genetics and computational modeling. The project addresses flower development at different scales using the Arabidopsis flower, currently one of the best-characterised plant systems. The workplan is divided into three major parts:

- Through 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. In particular, by using induced gene disruption together with careful live-imaging analysis, we will obtain dynamic, quantitative and causal data that link gene expression and molecular interactions to morphogenesis at a higher scale.

- We will integrate the results generated from these experiments in a specially designed database called a 3D Atlas.

- We will use these detailed, multidimensional data as direct input to new predictive computational models for morphogenesis and gene regulation that will then be further tested through subsequent rounds of experimental perturbation and analysis. A particular emphasis will be put on the modeling of mechanics in tissues for which different approaches will be developed.

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

6.2.2.4. Rose

Participants: Christophe Godin, Frédéric Boudon, Christophe Pradal.

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

Lateral bud outgrowth of aerial stems in plants is known to regulated by hormonal signals such as auxin and cytokinin.Recently detailed modeling approaches have been successfully developed to explain such regulation. However, it is known that on many species the sugar status of the plant also plays a role in shoot branching. In this project we want to quantify this role and to understand how sugars interfere with hormonal signals to regulate bud outgrowth. For this, 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. As a result, it is expected that main branching habits can be reproduced with the model and that experiments can be designed in order to test model predictions.

Partners: UMR SAGAH, Angers

6.3. International Bilateral Relations

6.3.1. ERASysBio+ iSAM

Participants: Christophe Godin, Etienne Farcot, Jan Traas, Teva Vernoux, James A.H. Murray [Univ. Cardiff, UK], Yrjö Helariutta [Univ. Helsinki, Finland].

(Contractor for Virtual Plants: Inria. From September 2008 to September 2011)

This project essentially aims at improving our knowledge of shoot apical meristem, and more specifically the combined action of auxin and cytokinin, using a systems biology approach. It is part of a wider program, the ERASysBio initiative, a consortium of European funding bodies, ministries and project management agencies. The purpose of this consortium is to develop fundamental and strategic collaboration in the funding of systems approaches to biological research. The iSAM project is one of the 16 transnational consortia that have been selected out of 51 proposals; in total they comprise 85 working groups from 14 countries. Four partners are involved in iSAM: the group of J. Murray will focus on mutants of cell cycle regulation, the group of Y. Helariutta is specialized in several aspects of cytokinin regulation, while the group of J. Traas in Lyon provides input regarding auxin regulation and transport, and Virtual Plants is in charge of the modeling aspects, in synergy with the three other groups.

More information on the project can be found at http://www.erasysbio.net/index.php?index=277.

6.3.2. *Other bilateral relations*

Yann Guédon is working with Claudia Negron (PhD student) and Ted DeJong (University of California, Davis) on the influence of water stress and pruning practices on the branching and axillary flowering structures of almond shoots.

6.4. International Initiatives

6.4.1. *Inria 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. In this context, both groups have regular meetings and visio conference to progress jointly on the definition of the platform. In particular, C. Godin, M. Walker and E. Farcot went to a 1-week meeting on tissue data-structure definition and several researchers from CPIB came to Montpellier to continue this work and start implementation.

The team of Pr. Prusinkiewicz at the University of Calgary (Canada) has been an *associated team* of *Virtual Plants* from 2009 to 2011. see http://www-sop.inria.fr/virtualplants/wiki/doku.php?id=projects:eqass-vp-uc. In 2012 the collaboration continued and a major paper the L-Py language for modeling plants was published in the context of this collaboration.

6.5. International Research Visitors

6.5.1. *Visits of International Scientists*

The team received several visitors from exterior research groups in 2012:
- Farah Ben Naoum, from Sidi Bel Abbes University, Algeria, visited the team last spring for 1 month. She worked with C. Godin on combinatorial algorithms to compress trees.
- Risto Sievanen, from University of Helsinki, visisted the team for 3 months sabbatical leave in spring. He worked in particular with C. Pradal and C. Godin to integrate the model Lignum developed in his group within OpenAlea.
- Philip Benfey, from the University of Duke, USA, visited the group for 1 day at spring. Contacts have been established to exchange students/researchers between the labs for short periods. Julien Diener, working on automated methods for 2D root reconstruction from 2D images, should pay a visit to their lab in 2013.
- Xavier Sirault, from CSIRO and the High Resolution Plant Phenomics Centre in Canberra, Australia, visited the team during one day. It was decided during this visit to launch a project for coupling the phenotyping platform developed in Australia, a similar one developed in Montpellier by the group of F. Tardieu, and OpenAlea. The objective of this project will be to develop an integrated pipeline allowing the thorough analysis of a large number of genotypes, in particular assessment of growths of individual organs, of plant geometry, and of derived variables such as light interception. There is a strong complementarity between the three teams and the combination of expertise brought in the project by the different groups can result in a reference pipeline of model-assisted image analysis for plant phenotyping.

6.5.2. *Visits to International Teams*

Yann Guédon was invited by Miroslava Rakocevic (IAPAR, Londrina, Parana state) in Brazil during two weeks in september. This visit was funded by an Embrapa project. He visited three research centers: (i) EPAGRI, Caçador, Santa Catarina state; IAPAR, Londrina, Parana state; Embrapa, Campinas, Sao Paulo state. He gave a 8h course about plant architecture analysis at Londrina and gave a talk at Campinas.

Christophe Godin was invited at the Sainsbury Lab in Cambridge. A first collaboration with Henrik Jonsson based on the joint supervision of a post-doc fellow coming from Virtual Plants to Sainsbury was assessed. Other collaboration projects about meristem modeling and imaging were discussed.