Activity Report 2011

Section Contracts and Grants with Industry

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6. Contracts and Grants with Industry

6.1. Genostar

**Participant:** François Rechenmann.

Genostar, an INRIA start-up created in 2004, is a company developing software and solutions for the management and analysis of genomic and post-genomic data. The software has been developed, from 1999 to 2004, by the Genostar consortium (INRIA, Institut Pasteur, and the two biotech companies Genome Express and Hybrigenics) and by the HELIX project-team. It includes several modules originally developed by HELIX, notably GenoAnnot, GenoLink, GenoBool and GenoExpertBacteria. The modules have been integrated in the Iogma bioinformatics environment, which also includes the modeling and simulation tool GNA developed by members of IBIS (Section 4.1). François Rechenmann is scientific consultant of the company. For more information, see [http://www.genostar.com](http://www.genostar.com).
7. Contracts and Grants with Industry

7.1. Contracts with Industry

SARCO, the research subsidiary of the Laffort group, has entered into a contract with MAGNOME to develop comparative genomics tools for selecting wine starters. This contract will permit SARCO to take a decisive step in the understanding of oenological microorganisms by obtaining and exploiting the sequences of their genomes. Comparison of the genomes of these strains has become absolutely necessary for learning the genetic origin of the phenotypic variations of oenological yeasts and bacteria. This knowledge will permit SARCO to optimize and accelerate the process of selection of the highest-performing natural strains. With the help of MAGNOME members and their rich experience in comparative analysis of related genomes, SARCO will acquire competence in biological analysis of genomic sequences. At the same time, MAGNOME members will acquire further experience with the genomes of winemaking microorganisms, which will help us define new tools and methods better adapted to this kind of industrial cell factory.

7.2. Grants with Industry

The French Petroleum Institute (Institut français de pétrole-énergies nouvelles) is coordinating a 6 M-Euro contract with the Civil Aviation Directorate (Direction Générale de l’Aviation Civile) on behalf of a large consortium of industrial (EADS, Dassault, Snecma, Turbomeca, Airbus, Air France, Total) and academic (CNRS, INRA, Inria) partners to explore different technologies for alternative fuels for aviation. The CAER project studies both biofuel products and production, improved jet engine design, and the impact of aircraft. Within CAER MAGNOME via CNRS, works with partners from Grignon and Toulouse on the genomics of highly-performant oleaginous yeasts.
7. Contracts and Grants with Industry

7.1. Contracts with Industry

J. Boulanger, C. Kervrann, P. Bouthemy. Commercial software license agreement with Photometrics company: “Software for denoising n-dimensional images”.
SYMBIOSE Project-Team

7. Contracts and Grants with Industry

7.1. Contracts with Industry

GASSST-GQ is an industrial contract with the GenomeQuest Company for tuning the GASSST software with industrial requirements. It is coordinated by D. Lavenier (EPI Symbiose) and JJ. Codani (GenomeQuest). In 2011, the GASSST software has been transferred to GenomeQuest. [Genome Quest web announcement] [Inria web announcement]

7.2. Grants with Industry

KoriPLAST is a project with the Korilog company aiming to transfer the PLAST software developed in the Symbiose Team. It is funded by the Brittany region. [Inria web announcement]

The Peapol project is funded by Sofiproteol company whose mission is to develop the French vegetable oil and protein industry, open up new markets, and ensure an equal distribution of value among its members. The Peapol project counts two collaborators, Biogemma, and INRA, the latter working in collaboration with the Symbiose team, in charge of algorithmic research in the context of the project. This collaboration enabled to hire in the Symbiose team Raluca Uricaru for 18 months on an INRA post doctoral position.
6. Contracts and Grants with Industry

6.1. CIFRE PhD Fellowships

6.1.1. Dosisoft
The work of Liliane Ramus, *Digital anatomical atlases for radiotherapy planning*, is supported by a PhD fellowship from the Dosisoft company.

6.1.2. Mauna Kea Technologies
The work of Barbara André, *Smart Atlas for the Early Diagnosis of Gastrointestinal Cancers from Optical Biopsy Images*, is supported by a PhD fellowship from the Mauna Kea Technologies company.

6.2. Other contracts
The contracts Cancéropôle PACA CPER Telius, Maestro®, Miniara, Philips, and Siemens are described in our previous activity reports.

6 http://www.maestro-research.org/
ATHENA Project-Team (section vide)
CORTEX Project-Team (section vide)
7. Contracts and Grants with Industry

7.1. Contracts with Industry

- An industrial technological transfer contract is ongoing with the MXM company that develops cochlear implant and artificial lens implant. MXM can perform also Ethylene Oxyde sterilization necessary for all our experimental setups used during surgery. Two DSU prototypes (named Stim’3D and Stim’nD), one miniaturized DSU (named USR24*1000) and an external controller have been developed within this frame. The associated programming environment (SENIS Manager, cf. section 5.1.2) has also been developed in this context.

- The contract with Vivaltis company that is specialized in the development of external stimulators, has been completed. We jointly developed a new advanced external FES system dedicated to clinical rehabilitation; this first wireless external stimulation architecture is now marketed by Vivaltis.
GALEN Team

7. Contracts and Grants with Industry

7.1. Contracts with Industry

- **Intrasene**: spatio-temporal modeling of low gliomas brain tumors [PhD thesis S. Parisot: 2010-2013]

- **General Electric HealthCare**


NEUROMATHCOMP Project-Team (section vide)
7. Contracts and Grants with Industry

7.1. Grants with Industry: Abrain project

Participants: Bertrand Thirion [Correspondant], Jean-Baptiste Poline.

Joint acquisition of neuroimaging and genetic data on large cohorts of subjects is a new approach used to assess and understand the variability that exists between individuals, and that has remained poorly understood so far. As both neuroimaging- and genetic-domain observations represent a huge amount of variables (of the order of $10^6$), performing statistically rigorous analyses on such amounts of data represents a computational challenge that cannot be addressed with conventional computational techniques. In this project, we plan to introduce grid and cloud computing techniques to address the computational challenge using cloud computing tools developed at INRIA (Kerdata team) and the Microsoft Azure cloud computing environment.

The ABrain project (2010-2013), funded by INRIA-Microsoft common lab.
7. Contracts and Grants with Industry

7.1. Contracts with Industry

7.1.1. Digital Trainers

The company Digital Trainers has signed a two year contract and a two year license with our group for the transfer of our suture simulation technology. The contract aims at improving the simulation by using an adaptive model for the suture thread and continuous constraints for the interaction with the soft tissues. Haptic feedback will also be investigated.

7.1.2. Collin

We have started a collaboration with INSERM - UMR-S 867 (robot based minimally invasive otologic surgery) Faculté de Médecine Paris Diderot Paris 7 and with the company Collin which is developing some activities in the domain of the head and neck (implants, surgery instruments, surgical navigation, ..). The objective of this project is to obtain a simulation tool applied to the ear surgery for both training and planning of middle ear surgery. Guillaume Kazmicheff is doing his phD in the context of this collaboration: he is paid by a CIFRE contract with Collin, he is mainly working with the INSERM team but the design of the simulation is done in collaboration with our group and he is enrolled in the university of Lille 1.
7. Contracts and Grants with Industry

7.1. Contracts with Industry

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

In the context of the Neurinfo imaging platform, a partnership between Siemens SAS - Healthcare and University of Rennes 1 was signed in October 2011 for 5 years. This contract defines the terms of the collaboration between Siemens and the Neurinfo platform. The Neurinfo platform is now granted access to source code and/or object code of selected MRI sequences. This a major advance in the collaboration since it will enable the development of MRI sequences on site. Besides, the Arterial Spin Labeling (ASL) was grounded as a key research activity by both parties and will be the object of a strong collaboration, particularly on the sequence development side.
7. Contracts and Grants with Industry

7.1. INERIS

Clime is partner with INERIS (National Institute for Environmental and Industrial Risks) in a joint cooperation devoted to air quality forecast. This includes research topics in uncertainty estimation, data assimilation and ensemble modeling.

Clime also provides support to INERIS in order to operate the Polyphemus system for ensemble forecasting, uncertainty estimations and operational data assimilation at continental scale.

7.2. IRSN

Clime is partner with IRSN, the French national institute for radioprotection and nuclear safety, for inverse modeling of emission sources and uncertainty estimation of dispersion simulations. The collaboration aims at better estimating emission sources, at improving operational forecasts for crisis situations and at estimating the reliability of the forecasts. The work is derived at large scale (continental scale) and small scale (a few kilometers around a nuclear power plant).

7.3. NUMTECH

Clime takes part to a joint Ilab with the group SETH (Numtech). The objective is to (1) transfer Clime work in data assimilation, ensemble forecasting and uncertainty estimation, with application to urban air quality, (2) identify the specific problems encountered at urban scale in order to determine new research directions. The first study addresses the application of data assimilation at urban scale.
4. Contracts and Grants with Industry

4.1. Contracts with Industry

(EdF) A. Chiche is preparing a PhD thesis (Cifre EdF-Inria, direction J. Ch. Gilbert) on decomposition-coordination methods for the middle-term optimization of the electricity production. The case where uncertainties are present is also considered, using scenario trees, which leads to even larger deterministic optimization problems. Improvements have been brought

- on the solution to infeasible convex quadratic optimization problems using the augmented Lagrangian approach [8] and
- on the solution to the optimization of the electricity production under uncertainties, using the progressive hedging algorithm.

(Andra) Estime takes part in 2 projects in the framework of the Andra–Inria research agreement;

- Ph. Hoang–Thi–THao is preparing a PhD (supervised by J. E. Roberts, C. Japhet and M. Kern) on space–time domain decomposition methods for modeling transport in porous media. At the end of the first year, a Matlab prototype has been developed, that enables comparing different domain decomposition methods.
- M. Kern is advising Andra in the choice of high performance linear algebra solvers for the heterogeneous problems encountered in flow simulations. The numerical properties and expected parallel performance have been analyzed.
FLUMINANCE Project-Team (section vide)
7. Contracts and Grants with Industry

7.1. Contracts with TOTAL

- Depth Imaging Partnership (DIP)
  Period: 2010 January - 2012 December, Management: INRIA Bordeaux Sud-Ouest, Amount: 3600000 euros. 50 000 euros have been devoted to hire an associate engineer (from Oct. 2010 to Sept. 2011).

- Optimisation de codes pour la migration terrestre d’ondes élastiques.

- Schémas en temps d’ordre élevé pour la simulation d’ondes élastiques en milieux fortement hétérogènes par des méthodes DG.

- Propagateurs d’ondes élastiques en milieux anisotropes

7.2. Contract with CSUN

In the context of the Associate Team MAGIC.
Period: 2009 January - 2011 December, Total Amount: 15000 USD
7. Contracts and Grants with Industry

7.1. Contracts with Industry

- A 4-year contract named ReDICE (Re Deep Inside Computer Experiments) with EDF, CEA, IRSN, RENAULT, IFP on the thematic computer experiments
- A 3-year contract with EDF: project MeCSiCo (coupling methods for the simulation of river flows): see 4.4
- A 3-year contract with ADEME on the thematic "Stochastic Downscaling Method": see 6.9
- A 1-year contract with IFREMER on the thematic “Optimization of the parallel performance of the AGRIF software”: see 5.1
7. Contracts and Grants with Industry

7.1. ANDRA: Numerical methods for reactive transport

Participants: Jocelyne Erhel, Souhila Sabit.

Contract with ANDRA
Time: three years from October 2010.
Title: Numerical methods for reactive transport.
See sections 6.4.3, 4.2, 8.1.1.

7.2. competitive cluster LUTB: CINEMAS2 project

Participants: Denis Billon, Jocelyne Erhel, Désiré Nuentsa Wakam.

Contract with Région Rhône Alpes.
Time: three years from May 2007, extended until October 2011.
Title: Conception Interactive par simulation Numérique des Ecoulements couplées à des Méthodes d’optimisation par Algorithmes Spécifiques.
Coordinator: Ecole Centrale de Lyon.
Partners: INSA Lyon, University of Lyon, Plastic Omnium, Valeo, Renault Trucks.
See sections 6.1, 5.7 and grant LIBRAERO, section 8.1.3.
6. Contracts and Grants with Industry

6.1. Contracts with Industry

6. Contracts and Grants with Industry

6.1. Contracts with Industry

The society CardioInsight Inc. is developing a new technology for a non-invasive cardiac electrical mapping in close collaboration with the IHU Liryc. Measuring the surface potential on the torso it provides a map of the potential on the epicardium by solving an ill-posed inverse problem. The research on improvement of the inversion method is an objective of the thesis of Alejandro Lopez Rincon. Preliminary discussion with CardioInsight were done to collaborate on the project.
6. Contracts and Grants with Industry

6.1. Grants with Industry

Grant EDF-LNHE  Grant with EDF-LNHE (2010-2011) “Modélisation hydraulique des milieux naturels.”
Simulation of free surface stratified flows (the density stratification being due to temperature and/or salinity),
effect of the wind, upwellings.
Comparison of the variable density multilayer code developed at Inria and the rigid lid hydrostatic Navier-
Stokes code (Ophélie) of EDF.
7. Contracts and Grants with Industry

7.1. Contracts with Industry

Start-up project by T. Bastogne:

Industrial partner: CyberBio (Biocybernetics for Cancerology & Nanomedicine).
Status: in incubation.

7.2. Grants with Industry

CIFRE PhD grant supervised by P. Vallois:

Industrial partner: Caisse Mutuelle du Crédit Agricole.
Title: Claim reserving for insurance.
PhD thesis of M. Geoffray Nichil.

PEPS project (Mathematics-Industry Interactions) led by A. Muller:

Industrial partner: Sport4Spirit (start-up).
Title: Computation of profit probabilities in sports gambling.
Two Internships involved.
7. Contracts and Grants with Industry

7.1. Microalgae for biofuel production

A contract between BIOCORE, Alpha Biotech, EADS and PSA Peugeot Citroen has been signed for assessment of microalgal biofuel productivity.
CARMEN Team (section vide)
DIGIPLANTE Team (section vide)
7. Contracts and Grants with Industry

7.1. Contracts with Industry

Two contracts have been written with the industry:


7.2. Grants with Industry

- We got a grant with Merial (10 keuros), it allowed us to pay an internship for 4.5 months (Adour Mikirditsian).

- We are actually working on an application to a FUI (Fonds Unique Interministériel) contract, involving Merial; The application occurred in november, and we still have no answer.

- We also applied to the IRT program, with Merial and Sanofi-Pasteur, decisions are expected in the first semester of 2012.
MACS Project-Team (section vide)
6. Contracts and Grants with Industry

6.1. Contract with IAEA

Anopheles arabiensis is the target of a sterile insect technique (SIT) program in Sudan. Success will depend in part upon reasonable estimates of the adult population in order to plan the sizes of releases. It is difficult to obtain good estimates of adult population sizes for this mosquito because of the low density of the populations and also because the temporal and spatial distribution of Anopheles arabiensis is very dynamic. We have developed a compartmental model capable of predicting the range of adult populations of Anopheles arabiensis in two study sites in the North of Sudan. We have provided a software that is “user friendly” and that is able to give an estimate of the whole male and female population for the two geographical areas. A screenshot of the soft user interface is presented in Figure 5.

![Figure 5. Anopheles estimator: screenshot of the soft user interface](image)
7. Contracts and Grants with Industry

7.1. BioInh

Participants: Jérôme Harmand, Alain Rapaport, Tewfik Sari.

The project BioInh (Modelling and optimization of bio-conversion of plant materials in inhomogeneous media) proposed by the UMR IATE (Ingénierie des Agropolymères et Technologies Emergentes, Montpellier) and the team MODEMIC is funded by the Agropolis foundation (Montpellier) for two years since 2009. The project aims at studying inhomogeneity effects in enzymatic reactors with the help of models of cascade of reactors. The presence of inhibition in the growth function may lead to unstabilities and drive the system toward several possible equilibria, one of them only being interesting in terms of yield and productivity. First experiments have been run but have not been finished due the interruption of our former postdoc for health reasons.

7.2. CAFE

Participants: Jérôme Harmand, José Fernandez, Alain Rapaport.

The objective of the CAFE European project is to provide new paradigms for the smart control of food processes, on the basis of four typical processes in the areas of bioconversion, separation, preservation and structuring. The novelty of the project lies in the capacity of combining PAT (Process Analytical Technology) and sensing devices with models and simulation environment with the following objectives:

1- to extract as much as possible information from the process/plant in the form of precise estimations of unmeasured variables defining, in particular, product quality, and of physical parameters changing as the process dynamics does or difficult to know beforehand;

2- to save and encode the information in a reliable and usable way, basically via physical/deterministic models;

3- to develop control methods to keep uniform quality and production, despite the variability in the raw material and/or to respond to sudden changes in the demand.

MODEMIC is involved in the wine making optimization part of the project which constitutes the PhD thesis of José Fernandez (see Sections 6.1.10 and 6.2.2).

7.3. DIMIMOS

Participants: Jérôme Harmand, Alain Rapaport.

This fundamental research project aims at better understanding the functional microbial soil ecosystems with respect to the turnover of soil organic matter (SOM). More specifically, we aim at evaluating the role of the microbial diversity in transforming SOM, in order to better manage the carbon in its biochemical global cycle within agro-ecosystems. This project must deliver new insights for managing agricultural productivity (allow better agricultural practices) while maintaining a high quality of soil over the long term.

The results obtained within the E-MICRAM project turn out to be of direct interest for the DIMIMOS project (see Section 7.6).

7.4. DISCO

Participants: Fabien Campillo, Chloé Deygout, Bart Haegeman, Jérôme Harmand, Claude Lobry, Alain Rapaport, Tewfik Sari.
DISCO (Multi-scale modelling bioDIversity Structure COupling in biofilms) is a three years project funded by the ANR SYSCOMM since the end of 2009, that aims at developing and studying computational and mathematical models of biofilm dynamics, taking into account the biodiversity (distribution of bacteria species) and spatial structure.

In 2010, C. Deygout has been hired as a postdoctoral fellow. She is developing a double modelling approach of the formation of single species biofilms in tubular bioreactors. One approach is based on an IBM model with a large number of individuals, while the second one is a system of PDE at the macroscopic level (see Section 6.1.7 ). We aim at understanding the links between the characteristics of the random events (consumption, growth, death, movement) at individual level with the functional expressions of growth, detachment and attachment at the population level.

In 2011, C. Deygout has spent most of her time at HBAN Cemagref to contribute to experiments in tubular plug-flow reactors, the biofilm being observed with the help of confocal microscopy. At that time, the set-up has not allowed yet a fair comparison between model simulations and experimental data.

A new collaboration has been launched with the HBAN team at Cemagref Antony, within this project, about the modelling of cellulose degradation. Cellulose is typically available in small balls (but ten times larger than the average size of microorganisms) that are first converted by enzymatic activity into carbon substrate that can then be assimilated by the microorganisms. Some of the microorganisms are attached to these balls, creating a particular aggregates structure.

7.5. MODECOL
Participants: Fabien Campillo, Ihab Haidar.

The ANR SYSCOMM Project MODECOL (2009-2011) involves three INRIA project-teams (MODEMIC, MAESTRO and TOSCA) with the UMR Ecobio (Rennes, France), the University of La Rochelle and the Universities of Houston and Berkeley. The aim of the MODEMIC component is to propose individual-based models for terrestrial prairial plant communities’ dynamics in the context of water purifying from nitrate and pesticides. This year the INRIA team proposed a new model [ 26 ], its analysis and the development of a simulation software. The project-team was also involved in the organization of a session at the 54th Symposium of the International Association for Vegetation Science (IAVS) in Lyon (20-24 June 2011). This work has been presented in three international conferences [ 36 ] [ 35 ] [ 26 ].

7.6. E-MICRAM
Participants: Florent Dayle, Jérôme Harmand, Alain Rapaport.

E-MICRAM is a project supported within the framework of the French RNSC (Réseau National des Systèmes Complexes). It aims at investigating whether the performance of a microbial ecosystem is related to its diversity or not.

With researchers of UMR Eco & Sols (Montpellier) and Bioemco (Paris-Grignon), we are investigating the influence of the size of samples on the probability of obtaining a “positive” reconstituted ecosystem, on the basis of experimental data (MSc subject of F. Dayle).

7.7. VITELBIO
Participants: Fadia Gafsi, Ihab Haidar, Jérôme Harmand, Mouna Jraou, Alain Rapaport.

The former ARC VITELBIO (VIrtual TELluric BIOreactors) gathers biologists, agronomist, micro-biologists, soil physicists and mathematicians about the modelling of heterogeneity in soil, and its role on microbiological functions. An important activity of the project has consisted in the development of a user friendly software for designing networks, simulating the dynamics and exploiting the results, with the help of ITK Company (see Section 5.1 ).
The software has allowed to explore the yield properties of several configurations of interconnections (serial, parallel, diffusive, dead zone and more sophisticated ones). Part of them has then being analytically studied in the PhD work of H. Haidar.

The VITELBIO project has been also financed by INRA for the purchase of four experimental chemostats settled at the LBE Narbonne. The training period of F. Gafsi and M. Jraou at the LBE and then in Montpellier have aimed to compare numerical predictions with real experiments.
6. Contracts and Grants with Industry

6.1. Etoile Projet

Participants: Benjamin Ribba, Branka Bernard.

Etoile is a research consortium on hadrontherapy. B. Ribba is responsible for the modeling part and focuses on the study tumor growth models.

6.2. Vaccine design

Participants: Vincent Calvez, Benjamin Ribba, Emmanuel Grenier.

One year industrial contract with Sanofi, on vaccine design.

6.3. ANR Modpol "cell polarization modeling"

Participants: Vincent Calvez, Paul Vigneaux.

Three years ANR young researcher contract, on the modeling of cellular polarization, with T. Lepoutre (INRIA Dracula), N. Meunier (Paris 5), M. Piel (Institut Curie) and R. Voituriez (Paris 6).

6.4. ANR "Bimbo"

Participants: Marie-Aimée Dronne, Thierry Dumont, Emmanuel Grenier.

The "Bimbo" ANR project (head: F. Gueyffier, Lyon I) is devoted to the study or atheroma. Numed members has the task to help to parametrize the various models which will emerge from this project.

6.5. ANR "Sechelles"

Participants: Violaine Louvet, Thierry Dumont.

The "Sechelles" ANR project (head: S. Descombes, Nice) is devoted to new numerical methods and scheme for stiff reaction diffusions equations, in particular strokes simulation. Numed members has the task to develop the associated software in order to have efficient tools (in particular, parallel software) for this simulations.

6.6. Weizmann Institute

Participants: Benjamin Ribba, Floriane Lignet.

B. Ribba is involved in the PhD direction of Floriane Lignet (MSc) on the modeling of in vivo tumor growth data from the Weizmann Institute of Science (on-going collaboration with Prof. Yossi Yarden, dept Biological Regulation).
REO Project-Team (section vide)
6. Contracts and Grants with Industry

6.1. LK2 contract: Tight glycemic control for Intensive Care Units

Participants: Alexandre Guerrini, Michel Sorine.

Collaboration with the Intensive Care Unit (ICU) of Chartres Hospital headed by Dr Pierre Kalfon. This work on tight glycaemic control (TGC) for ICU started in September 2008. It is done in the framework of the CIFRE contract of Alexandre Guerrini with the small medtech company LK2 (Tours, France). For the medical context of this study, see [69]. Blood glucose has become a key biological parameter in critical care since publication of the study conducted by van den Berghe and colleagues [85], who demonstrated decreased mortality in surgical intensive care patients in association with TGC, based on intensive insulin therapy. However, two negative studies were recently reported, which were interrupted early because of high rates of severe hypoglycaemia, namely the VISEP study [65] and the Glucontrol trial.

After having studied a possible origin of the failure of the recent study NICE-SUGAR, we have worked on more robust control algorithms based on a database of representative “virtual patients” [66].

In this study, we have developed efficient monitoring and control tools, now marketed by LK2 that will help clinicians and nursing staff to control blood glucose levels in ICU patients, in particular to avoid hyperglycaemia superior to 10 mmol/l and hypoglycaemia episodes. Our first controller has been assessed in the study CGAO-REA (see 4.3) with more than 3500 included patients. The controller determines the insulin infusion rate on the basis of the standard available glycaemia measurements despite their irregular sampling rate.

6.2. CARMAT SAS contract: Modeling and control of a Total Artificial Heart

Participants: Julien Bernard, Michel Sorine.

This is a cooperation with CARMAT SAS (Suresnes, France) on the development of a Total Artificial Heart. This fully implantable artificial heart is designed to replace the two ventricles, possibly as an alternative to heart transplant from donors. In a first time, it will be used as an end-of-life treatment for patients waiting for a transplant. The first patients may receive this artificial organ in less than three years.

Compared with the mechanical hearts used up today, that are mainly LVAD (left ventricular assist devices) or with its main concurrent, the Abiocor implantable replacement heart system (Abiomed), the present artificial heart is designed to be highly reliable and with a low thromboembolism rate. It will allow longer waiting periods for heart transplants and even, in a next future, may be an alternative to these transplants.

The prosthesis uses two controlled pumps that are not in direct contact with the blood, eliminating hemolysis risk and is equipped with miniature sensors in order to have a full control of the heart rate and arterial blood pressure. Our objective is to improve the control strategies by mimicking the physiological feedback loops (Starling effect, baroreflex loop, ...) to allowing patients to live as normally as possible. In a first step, this year we have modeled the prosthesis with its present controller and its testbed, a “mock circulation system” (MCS). This year we have tried some control algorithms with the MCS.

6.3. ANR project DMASC: Scaling Invariance of Cardiac Signals, Dynamical Systems and Multifractal Analysis

Participants: Julien Barral, Patrick Loiseau, 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). An article has been submitted [54].

6.4. Modeling for diagnosis and prognosis (Paris Region ASTech project)

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 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.

6.5. 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 block-oriented nonlinear models with hysteresis blocks and bilinear blocks, and to relax some traditional restrictions on nonlinearity structures and on experimental conditions. The two extensions with hysteresis blocks and bilinear blocks have been motivated by their importance in process control. Through these extensions, it is expected to considerably increase the applicability of block-oriented nonlinear system identification to industrial systems. This is an international project jointly funded by the French Agence Nationale de la Recherche (ANR) and the Chinese National Natural Science Foundation (NSFC). Its duration is 3 years starting from March 2011. 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.

6.6. 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 faisceaux 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) for three years from 2009. The involved partners are CEA LIST (project leader), Renault Trucks, Freescale, PSA, Delphi, Supelec LGEP and INRIA. A prototype of a reflectometry-based diagnosis tool is under development in this project.

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

Participants: Leila Djaziri, Michel Sorine, Huaibin Tang, 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 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 for three years 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.

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

Participants: Hadis Amini, Zaki Leghtas, Ram Somaraju, Mazyar Mirrahimi, Pierre Rouchon, Michel Sorine, Filippo Visco Comandini.

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. The partners of INRIA are Emmanuelle Crépeau-Jaisson (University of Versailles - Saint Quentin), Hideo Mabuchi (Stanford University), Herschel Rabitz and Ramon Van Handel (Princeton University), Pierre Rouchon (Mines de Paris). See EPOQ2.

6.9. Renault contract: Modeling, Control, Monitoring and Diagnosis of Depollution Systems

Participants: Pierre-Alexandre Bliman, David Marie-Luce, Michel Sorine.

This work is done in cooperation with Renault in the framework of a CIFRE contract. The issue of depollution has become a central preoccupation for the automotive industry, and the increased severity of the emission norms necessitates tight modeling and control solutions. We have worked on simple models for two devices, namely the NOx-trap and the SCR (Selective catalytic reduction). Observers have been obtained and tested against real-world data. See [25].
VIRTUAL PLANTS Project-Team (section vide)