Activity Report 2012

Section Contracts and Grants with Industry

ABS Project-Team (section vide)

AMIB Project-Team (section vide)

BAMBOO Project-Team (section vide)

BEAGLE Team (section vide)

BONSAI Project-Team (section vide)

DYLISS Team (section vide)

GENSCALE Team

7. Bilateral Contracts and Grants with Industry

7.1. Sequence Comparison, Korilog

Intensive bank-to-bank comparison with Korilog : this collaborative project between the Korilog company and the GenScale team aims to investigate new research directions in the bank-to-bank sequence comparison problem. Two research axes are followed : constrained exploration of the search space and adaptation of the ORIS algorithm, developed by D. Lavenier for fast DNA comparison, to the protein sequences. It is funded for 3 months (Nov. 2012 - Feb. 2013), including the visit of assistant professor Van-Hoa Nguyen from Vietnam.

KoriPlast: this project is a cooperation between GenScale and the Korilog company, it is funded by Région Bretagne from June 2011 to Nov. 2012. It aims to industrialize the PLAST software prototype, previously developed in GenScale, that performs intensive genomic bank-to-bank comparisons. The commercial version is now called KLAST http://www.korilog.com/index.php/KLAST-high-performance-sequence-similarity-search-tool.html

7.2. Peapol

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 Genscale team, in charge of algorithmic research in the context of the project. This collaboration enabled to hire in the Genscale team Raluca Uricaru for 18 months on an INRA post doctoral position, followed by Suzete Alves-Carvalho (engineer).

7.3. Rapsodyn

RAPSODYN is a long term project funded by the IA French program (Investissement d'Avenir) and several field seed companies, such as Biogemma, Limagrain and Euralis. The objective is the optimisation of the rapeseed oil content and yield under low nitrogen input. GenScale is involved in the bioinformatics workpackage, in collaboration with Biogemma's bioinformatics team, to elaborate advanced tools dedicated to polymorphism.

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

6. Bilateral Contracts and Grants with Industry

6.1. Genostar

Participant: François Rechenmann.

Genostar, an Inria start-up created in 2004, provides bioinformatics solutions for the comparative analysis of bacterial genomes, proteomes and metabolomes. Genostar's software suite performs the annotation of sets of genomic sequences, *i.e.*, the identification of the coding sequences and other features, followed by the prediction of the functions of the gene products. The modules which make up the software suite were originally developed within the Genostar consortium and the HELIX project team at Inria Grenoble - Rhône-Alpes. The software suite also includes the modeling and simulation tool GNA developed by members of IBIS (Section 4.1). Genostar offers a comprehensive service line-up that spans genome sequencing, read assembly, annotation, and comparison. Genostar thus works with trusted subcontractors, each specialized in state-of-the-art sequencing technologies. François Rechenmann is scientific consultant of the company. For more information, see http://www.genostar.com.

6.2. BGene

Participant: Johannes Geiselmann.

BGene is a start-up company of Université Joseph Fourier in the field of DNA engineering. BGene proposes efficient and custom-made modifications of bacterial genomes, leaving no scars or antibiotics resistance genes. The company has know-how and expertise at all stages of the development process, including the *in-silico* design of a desired construction, the choice of the right genetic tools, and the delivery of the finished product. Former IBIS-member Caroline Ranquet and Johannes Geiselmann are co-founders of BGene, together with Marie-Gabrielle Jouan (Floralis, Université Joseph Fourier).

MAGNOME Project-Team

7. Bilateral 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.

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

6. Bilateral Contracts and Grants with Industry

6.1. Bilateral Contracts with Industry

6.1.1. Galderma Sophia-Antipolis

Participants: Sylvain Prigent, Xavier Descombes.

Contribution of multi and hyperspectral imaging to skin pigmentation evaluation. Contract #4383.

In collaboration with Joisane Zerubia from Ayin team.

6.2. Bilateral Grants with Industry

6.2.1. CNES Toulouse and TAS Cannes

Participants: Mikael Carlavan, Laure Blanc-Féraud.

Optimization of the compression-restoration chain for satellite images.

SERPICO Team

7. Bilateral Contracts and Grants with Industry

7.1. Innopsys: Methods and algorithms for tissue microarrays image analysis

In collaboration with Magellium company and Institut Gustave Roussy, Innopsys plans to develop new image analysis software to be included in the INGRID platform developed by Megellium company. New statistical methods and algorithms will be investigated by SERPICO for:

- segmentation and detection of deformable cell contours and cell nuclei in 2D fluorescence tissue microarray images;
- deconvolution and superresolution of fluorescence microarray imaging.

The three-year contract supports the PhD thesis of Alice Bergonzoni (2013-2015).

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

6. Bilateral Contracts and Grants with Industry

6.1. Inria - Mauna Kea Technologies I-Lab SIWA

Participants: Nicholas Ayache, Xavier Pennec, Irina Vidal Migallon, Marzieh Kohandani Tafreshi, Barbara André [Mauna Kea technologies], Tom Vercauteren [Mauna Kea technologies], Julien Dauguet [Mauna Kea technologies].

The I-Lab SIWA (Stitching Images and Wisdom into the Atlas) aims at maturating two key image processing technologies into real products for confocal fibered-microscopy. The first axis on content-based image retrieval (CBIR) will develop efficient and friendly tools for helping the diagnosis and for user training. The second axis on image registration will develop near real-time and robust image registration tools for mosaicking, image stabilization and super-resolution.

The opening ceremony of the I-Lab SIWA took place on Friday, November 16, 2012 in the presence of Michel Cosnard (CEO of Inria) and Gérard Giraudon (head of Inria-SAM Center). Keynotes lectures by Asclepios members were given by Xavier Pennec and the two engineers dedicated to this project: Irina Vidal Migallon and Marzhieh Kohandani Tafreshi. For more information, visit: https://lisa.sophia.inria.fr/siwa-loasis-numerique-dinria-et-de-mauna-kea-706.html

6.2. CIFRE PhD Fellowships

6.2.1. *General Electric*

The work of Thomas Benseghir, *3D/2D Coronary Registration for Interventional Cardiology Guidance*, is supported by a PhD fellowship from the General Electric company.

6.3. Other contracts

The contracts Cancéropôle PACA, Philips, and Siemens are described in our previous activity reports.

6.4. National initiatives

6.4.1. *ANR KaraMetria*

Participants: Xavier Pennec [correspondant], Vikash Gupta, Marco Lorenzi.

KaraMetria is the concatenation of Kara ("head", "brain" in ancient Greek), and Metria ("measure"). This ANR-funded project (2010-2012, http://sites.google.com/site/karametria/) aims at: developing an extensible image registration framework able to map anatomical descriptors (such as sulcal lines or white matter fibers) of the brain shape from one subject to another : providing all necessary statistical tools to compare a subject with a group or compare groups of subjects based on the aforementioned registration framework ; and identifying biomarkers of certain brain pathologies and psychiatric disorders. In particular, we target the study of a population of depressive teenagers. This project is led in collaboration with the LNAO at CEA, the MAP5 laboratory from the University Paris Descartes, and the INSERM U797 unit.

6.4.2. *Consulting for Industry*

- Nicholas Ayache is scientific consultant for the company Mauna Kea Technologies (Paris).

6.4.3. *Collaboration with national hospitals*

Asclepios is collaborating with the following 3 IHU (University Hospital Institute) in France : the IHU-Strasburg (Pr J. Marescaux and L. Soler) on image-guided surgery, the IHU-Bordeaux (Pr M. Haïssaguere and Pr P. Jaïs) on cardiac imaging and modeling and the IHU-Pitié Salpétriére (Dr. O. Colliot and S. Durrleman) on neuroimaging.

We also have long term collaborations with the CHU Nice and Centre Antoine Lacassagne in Nice.

ATHENA Project-Team (section vide)

CORTEX Project-Team (section vide)

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

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral 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 controler 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 CE marked, and commercialized by Vivaltis.

  This work has been awarded by the 1st Prize 2012 of the FIEEC-OSEO on Applied Research.

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

7. Bilateral Contracts and Grants with Industry

7.1. General Electric HealthCare

- Compressed Sensing Digital Subtraction Rotational Angiography [PhD thesis H. Langet: 2009-2012]:
- Guide-wire Segmentation and Tracking of in interventional Imaging [PhD thesis N. Honnorat: 2008-2012]

7.2. Intrasene

Modeling, segmentation and registration of low gliomas brain tumors [PhD thesis S. Parisot: 2010-2013]

7.3. Siemens

Graph-based Knowledge-based Segmentation of the Human Skeletal Muscle in MR Imaging [PhD thesis P-Y. Baudin: 2009-2012]

MNEMOSYNE Team (section vide)

NEUROMATHCOMP Project-Team (section vide)

PARIETAL Project-Team (section vide)

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

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

7.1.1. *HelpMeSee and Sensegraphics*

The swedish company Sensegraphics and the NGO HelpMeSee have signed for 2 contracts for technology transfer. The contract focus on the design of a simulator to treat cataract surgery using the MSICS (Manual small incision cataract surgery) technique.

7.1.2. *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.

7.1.3. *Collin*

We have started a collaboration with INSERM - UMR-S 867 (minimal invasive and robotized otological 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 (middle ear implants, surgical 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 Kazmitcheff 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.

<div align="center" style="color:red">

VISAGES Project-Team

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7. Bilateral Contracts and Grants with Industry

7.1. Contracts with Industry

7.1.1. *Siemens*

duration: 5 years from 2011/10/26

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 has received work in progress (WIP) sequences from Siemens in the form of object code for evaluation in the context of clinical research. The Neurinfo platform has also received source code of selected MRI sequences. This a major advance in the collaboration since it will enable the development of MRI sequences on site.

7.1.1.1. *TransIRMf project*

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

duration : 24 months, from 01/10/2010

The objective of this project is to set up and validate acquisition and data processing pipelines for metabolic and functional MRI. Acquition techniques comprise innovative block design and event related paradigms based on various stimuli (visual, auditive) and use various MRI sequences (BOLD, ASL). Paradigms were selected to cover a large scope of potential applications. The protocol imaging namely includes a BOLD fMRI resting state paradigm, an n-back working memory paradigm for BOLD fMRI, as well as and for the first time, for functional ASL. An emotional prosody recognition task was implemented, also for the first time, in an event related BOLD fRMI context. Data were acquired on 30 healthy subjects. Processing of these data is in progress based on inhouse pipelines (e.g., template construction using DARTEL, PVE correction for ASL data). This grant was awarded in collaboration with Biotrial within the CRITT-Santé Bretagne program.

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

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

- 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.

- 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 forecasts. The work is derived at large scale (continental scale) and small scale (a few kilometers around a nuclear power plant).

- 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.

FLUMINANCE Project-Team (section vide)

MAGIQUE-3D Project-Team

7. Bilateral 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. 150 000 euros have been devoted to hire an associate engineer (from Oct. 2010 to Sept. 2012).

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

  Period: 2010 November - 2013 October, Management: Inria Bordeaux Sud-Ouest, Amount: 150000 euros.

- Propagateurs optimisés pour les ondes élastiques en milieux anisotropes

  Period: 20November - 2014 October, Management: Inria Bordeaux Sud-Ouest, Amount: 160000 euros.

- RTM en milieux hétérogènes par équations d'ondes élastiques

  Period: 2011 November - 2014 October, Management: Inria Bordeaux Sud-Ouest, Amount: 160000 euros.

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

7. Bilateral 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 CEA Cadarache related to Simon Nanty's PhD.
- 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 5.4 .

POMDAPI Project-Team

4. Bilateral Contracts and Grants with Industry

4.1. Bilateral Contracts with Industry

Agence Nationale pour la gestion des Déchets RAdioactifs (Andra) Pomdapi takes part in 2 projects in the framework of the Andra–Inria research agreement;

- Ph. Hoang–Thi–THao is preparing a PhD (surpervised by J. E. Roberts, C. Japhet and M. Kern) on space–time domain decomposition methods for modeling transport in porous media.
- M. Kern is advising Andra in the choice of high performance linear algebra solvers for the heterogeneous problems encountered in flow simulations.

4.2. Bilateral Grants with Industry

Martin Vohralík, conjointement avec Vivette Girault (Université Pierre et Marie Curie), dirigent le projet **ERT (Equipe de Recherche Technologique)** entre le Laboratoire Jacques-Louis Lions (LJLL) et l'Institut Français du Pétrole Energies Nouvelles (IFPEN) sur la *Récupération d'huile assistée et séquestration géologique du* CO_2*: adaptation de maillage, contrôle d'erreur a posteriori et autres techniques avancées*. Projet mené en partenariat avec des industriels afin de « lever des blocages technologiques ». 9 chercheurs du LJLL, 6 chercheurs de l'IFPEN, 2 doctorants, stagiaires.

<center>**SAGE Project-Team**</center>

7. Bilateral Contracts and Grants with Industry

7.1. ANDRA: Numerical methods for reactive transport

Participants: Édouard Canot, Jocelyne Erhel, Souhila Sabit.

Title: Numerical methods for reactive transport.
Time: three years from October 2010.
Partner: ANDRA Coordination: J. Erhel, with G. Pépin (ANDRA)

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

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

EADS Astrium   We have been sub-contractors of EADS Astrium in several national and international application-oriented projects. This activity is related to the previous research in computer vision of some team members.

7.2. Bilateral Grants with Industry

ARTELIA   We have agreed on a CIFRE scheme for a PhD on the topic: Material flow and environmental impact analyses at local scales, from labor pools to regions. We are currently waiting for the validation by ANRT.

BANG Project-Team (section vide)

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

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

Start-up project by T. Bastogne:

> Industrial partner: CyberBio (Biocybernetics for Cancerology & Nanomedicine).

> Status: in incubation.

> Comments: Cybernano is an incubating start-up specialized in nano-cancerology, which has received the "emergence" award in 2012 from the French Research ministry for the creation of start-up based on innovative technology. Cybernano proposes innovating products to reduce the cost and control the risk during the preclinical development of nanoparticles in oncology applications. The engineering approach used by this spin-off is strongly based on the use of suited mathematical models.

7.2. Bilateral 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.

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

7. Bilateral Contracts and Grants with Industry

7.1. Microalgae for biofuel production

Biocore takes part in a project for assessment of microalgal biofuel productivity whose other partners are Alpha Biotech, EADS and PSA Peugeot Citroen.

CARMEN Team (section vide)

DRACULA Project-Team

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

The MIREV project, on the "Modeling of the Immune Response to support Efficient Vaccine development", submitted in 2011 to the BioAster IRT, is still in the selection process. Partners include: Sanofi-Pasteur, Altrabio, Antagene, The Cosmo Company, INSERM-I2V and Dracula Team.

MACS Project-Team (section vide)

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

6. Bilateral 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 3 . This work is done in collaboration with Yves Dumont (AMAP, CIRAD).
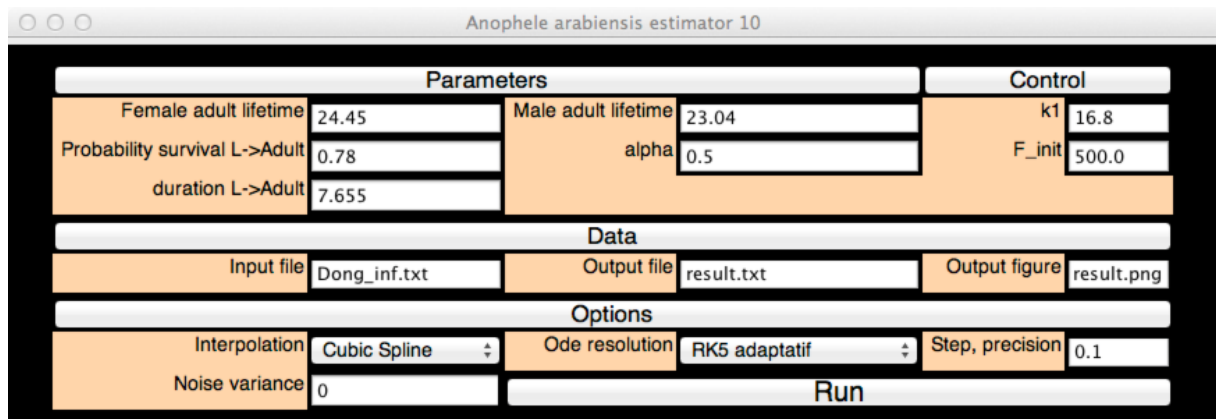

Figure 3. Anopheles estimator: screenshot of the soft user interface

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

7. Bilateral Contracts and Grants with Industry

7.1. CAFE

Participants: Céline Casenave, Jérôme Harmand, 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, see details in http://www.cafe-project.org. 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 supervision part (see Section 6.2.4) and in the ice cream crystallization control part (see Section 6.2.5).

7.2. DIMIMOS

Participants: Jérôme Harmand, Alain Rapaport.

DIMIMOS is an ANR SYSTERRA 2008 project of 4 years headed by the UMR Microbiologie du Sol et de l'Environnement (INRA Dijon).

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.

For the final stage of the project, the theoretical results obtained in Section 6.1.7 need to be confronted with the data provided by the partners.

7.3. DISCO

Participants: Fabien Campillo, Chloé Deygout, Bart Haegeman, Jérôme Harmand, Annick Lesne, 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; see details in https://sites.google.com/site/anrdisco/.

Several "go back" between simulation models and experiments in plug-flow reactors performed at IRSTEA Antony have been conducted during the two postdoctoral years of C. Deygout hired by the project. A first paper on the simulation of a multi-scale model has been published [17] and a second one on the confrontation with experiments is in preparation (see Section 6.2.2).

At a macro-scale, the team has studied several extensions of the chemostat model dedicated to microbial ecosystems with biofilm (see Section 6.1.1 and the publication [21]).

A new collaboration has been launched with the HBAN team at IRSTEA 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.

An IBM for the degradation of one cellulose bead (dozens of micrometers in diameter) by cellulolytic bacteria has been developed. Our aim is to determine the macroscopic degradation behavior. The initial stages of the degradation process may involve a very limited number of bacteria that cannot be properly modelled by classical models based on deterministic equations (see Section 6.2.3 and communications [44] and [43]).

The duration of the project has been extended by the ANR to May 2013, in order for the team to prepare a final restitution at Paris in spring 2013.

7.4. MODECOL

Participant: Fabien Campillo.

The ANR SYSCOMM Project MODECOL (January 2009/June 2012) involves three Inria project-teams (MODEMIC, MAESTRO and TOSCA) with the UMR Ecobio (Ecosystèmes, Biodiversité, Evolution, Rennes), the University of La Rochelle and the Universities of Houston and Berkeley. The aim of the Inria component is to propose individual-based models for terrestrial prairial plant communities' dynamics in the context of water purifying from nitrate and pesticides. The results of the Inria component have been published [13] This year was also dedicated to the edition of a special issue of Ecological Modelling on "Modelling clonal plant growth" [22]. See http://www-sop.inria.fr/members/Fabien.Campillo/software/ibm-clonal/ for more details.

NUMED Project-Team

7. Bilateral Contracts and Grants with Industry

7.1. Bilateral Contracts with Industry

SANOFI Pasteur: second contrat on vaccine degradation study.

7.2. Bilateral Contracts with Industry

SERVIER: four years frame contract.

REO Project-Team (section vide)

<div align="center">**SISYPHE Project-Team**</div>

6. Bilateral Contracts and Grants with Industry

6.1. 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 [16].

Based on the later, a control law has been obtained this year, for the control of the NOx-trap. This control law is defined by setting thresholds for the estimated NOx coverage fraction, to switch between storage mode and purge mode. These thresholds are optimal in stationary conditions, in the sense that they minimize the gas consumption under given pollutant emission constraint. Adequate moving window is fitted to define the switching values in non-stationary conditions. The algorithm has led to successful numerical tests.

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 a 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. LK2 contract: TIght glycemic control for Intensive Care Units

Participants: Alexandre Guerrini, Michel Sorine.

This work on tight glycaemic control (TGC) for ICU started in Septembrer 2008 in the framework of the CIFRE contract of Alexandre Guerrini with the small medtech company LK2 (Tours, France). It is in collaboration with the Intensive Care Unit (ICU) of Chartres Hospital headed by Dr Pierre Kalfon. For the medical context of this study, see [90].

Blood glucose has become a key biological parameter in critical care since publication of the study conducted by van den Berghe and colleagues [104], 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 [85] 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" [87].

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.

VIRTUAL PLANTS Project-Team (section vide)