



RESEARCH CENTER

FIELD

Digital Health, Biology and Earth

Activity Report 2013

Section highlights of the Team

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ABS Project-Team (section vide)

AMIB Project-Team

2.2. Highlights of the Year

Michael Levitt, our international collaborator of the ITSNAP Associated team, was awarded the Nobel Prize in Chemistry *for the development of multiscale models for complex chemical systems*. The Nobel lecture is available at http://www.nobelprize.org/nobel_prizes/chemistry/laureates/2013/levitt-lecture.html.

The *Best application paper* at EGC 2013 was awarded to [34].

BAMBOO Project-Team

2.1. Highlights of the Year

BAMBOO is proposing the creation of a new Inria project team, ERABLE, that would replace BAMBOO. ERABLE would be a European Inria project team gathering the current members of BAMBOO, together with four researchers in Italy under the banner of the University of Rome La Sapienza (Alberto Marchetti-Spaccamela from La Sapienza, Pierluigi Crescenzi from the University of Florence, Roberto Grossi and Nadia Pisanti from the University of Pisa), and two researchers in the Netherlands under the banner of the CWI (Leen Stougie from the Free University of Amsterdam and the CWI, Gunnar Klau from the CWI). This proposal is currently being evaluated.

BEAGLE Project-Team

2.2. Highlights of the Year

- The Beagle Team has been granted an FP7 project (FET Proactive “Evolving Living Technologies” call). The EvoEvo (“Evolution of Evolution”) project connects five european teams working in evolutionary biology (D. Schneider, UJF, France; S. Elena, CSIC, Spain; Beagle, Inria, France), computational biology (P. Hogeweg, Utrecht University, Nederland; Beagle, Inria, France) and unconventional computing (S. Stepney, University of York, UK; Beagle, Inria, France). EvoEvo has been launched at the initiative of the Beagle Team who leads the project. Total amount funded: 2.6 Million euros. Amount funded for Inria : 800.000 euros.
- We organized the international conference “RECOMB Comparative Genomics” in October 2013, in Lyon and the international conference “Models and Algorithms for Genome Evolution” in August 2013 in Montreal, Canada. Following the latter conference, we co-edited a book published in the “Computational biology” series of Springer [37].
- Our long-lasting collaboration with the BM2A team of the CGphyMC (Centre de Génétique et de Physiologie Moléculaire et Cellulaire) is based on co-development of experimental work in the “wet lab” of the CGphyMC and computational experiments in the “dry lab” of Beagle. By using this approach to investigate the molecular basis of the stochasticity of gene expression in higher eukaryotic cells, we have been able to show that this stochasticity is due to intermittent transcription events with very long periods of quiet states. These results have been published in a high impact biological journal in February 2013 [12].
- Our work on the signalling pathways implicated in synaptic plasticity, initiated in 2012 [34] and carried out in collaboration with the experimental neurobiology lab led by L. Venance at Collège de France, Paris, became a major project for Beagle in 2013, with the recruitment of I. Prokin (PhD, Inria grant) and the extension of the collaboration to the group of A. Blackwell (Georges Mason University, USA). Respective publications and funded projects are expected for 2014.
- The project related to the study of intracellular reaction-diffusion dynamics of signalling pathways started to develop in 2013 a more mathematical direction. This is carried out with Beagle and S. Fedotov (School Mathematics, Univ. Manchester, UK), V. Calvez (Inria Numed, Lyon), T. Lepoutre (Inria Dracula, Lyon) and Master student A. Mateos-Gonzalez (ENS Lyon, Mathematics).

BIGS Project-Team (section vide)

BONSAI Project-Team (section vide)

DYLISS Project-Team

2.2. Highlights of the Year

The collaboration with Universidad de Chile was strengthened by the organization of a workshop in Chile gathering Chilean, French and German partners about the modeling of biological systems [[website](#)], the defense of a co-supervised Ph-D thesis [[13](#)], and a graduate-level course given by a Dyliss member in Chile.

GENSCALE Project-Team

2.2. Highlights of the Year

- Creation of KoriScale, an Inria Innovation Laboratory (I-LAB) to promote technology transfers between GenScale and the Korilog Company. The research thematic is focusing on intensive genomic sequence comparison. It covers innovative string algorithm aspects together with multi-level parallelism implementation. [\[Letter in Emergences\]](#)
- For the 2nd consecutive year the GenScale team won the best poster award from the annual Jobim conference. We demonstrate the efficiency of our low memory footprint NGS assembly tools to assemble the *C. Elegans* genome on the Raspberry Pi board, a very low cost computer (< \$ 50) equipped with limited memory resources (512 MB). [\[42\]](#) [\[Letter in Emergences\]](#)

IBIS Project-Team

2.2. Highlights of the Year

A paper based on the PhD thesis of Sara Berthoumieux was accepted for *Molecular Systems Biology* this year [4] and selected as an Editor's choice in *Science* (<http://ibis.inrialpes.fr/article1040.html>).

The start-up company BGene, created by Johannes Geiselmann and former IBIS member Caroline Ranquet, together with Marie-Gabrielle Jouan (Floralis, Université Joseph Fourier), obtained an Emergence award in the 2013 Oséo Concours d'entreprises innovantes (<http://www.grain-incubation.com/oseo-start-ups-laureates-categorie-emergence/>). BGene is active in the field of DNA engineering (Section 6.2).

MAGNOME Project-Team (section vide)

MORPHEME Project-Team

2.2. Highlights of the Year

- Laure Blanc Féraud has obtained the "prix Montbonnot Inria" from the Academy of Science.

SERPICO Project-Team

2.6. Highlights of the Year

- Serpico is an Inria Team-Project from July 2013.
- New computing (7 nodes with 2 CPU x 8 cores, 64 GigaBytes and 128 GigaBytes of RAM including in the IGRIDA computing grid) and storage (207 TeraBytes controlled by a server with 2 CPU x 6 cores, 32 GigaBytes of RAM) facilities dedicated to calculations and algorithm runs.
- Finalist for Best Student Paper Award [16]: D. Fortun et al. Aggregation of patch-based estimations for illumination-invariant optical flow in live cell imaging. IEEE Int. Symp. Biomedical Imaging (ISBI'13), San-Francisco CA, April 2013.

VIRTUAL PLANTS Project-Team

2.2. Highlights of the Year

- Participation to the Functional-Structural Plant Model (FSPM) international conference. The FSPM conference is an important event for the plant modeling community. At this occasion, the team made several oral presentations:
 - reconstruction methods of branching systems and foliage from laser scanner data [30], [29], or of root systems from images [33]),
 - analysis methods for Mango tree phenology [32], ramification of apple trees [40], [34] or environmental effect on growth of forest trees[38])
 - simulation (disease propagation on crops [36], [35] or fruit physiology [31]).
- Publication of a joint work with RDP at ENS-Lyon in the journal 'Nature'. In December 2013, a joint work on phyllotaxy with the RDP lab from ENS-Lyon was published online in the journal Nature [13]. Based on the analysis of phyllotaxis perturbations in mutants, this study sheds a new light on our interpretation of phyllotaxis, revisiting the standard model and suggesting that several fields based on auxin and cytokinin with different properties are required to provide robustness to phyllotaxis.

CORTEX Team (section vide)

ARAMIS Team

2.2. Highlights of the Year

Olivier Colliot was invited to give a lecture at the National Academy of Medicine in October 2013.

Stanley Durlleman was invited to give a presentation at the Rank Prize Funds symposium "Medical Imaging meets Computer Vision" in March 2013.

ASCLEPIOS Project-Team

2.2. Highlights of the Year

- Nicholas Ayache the received MICCAI 2013 “Enduring Impact Award” for his scientific contributions since the inception of the conference in 1998.
- Nicholas Ayache was elected by the Collège de France to the Chair “Informatics and Computational Sciences” for the academic year 2013-2014.
- The company Therapixel, spin-off of the Inria project teams Asclepios (Olivier Clatz) and Parietal (Pierre Fillard), received an OSEO award in the category "Creation-Development" of start-up companies.

ATHENA Project-Team

2.2. Highlights of the Year

Rachid Deriche was awarded the 2013 French Academy of Sciences Grand Prize of the EADS CORPORATE FOUNDATION in Computer Science. This award recognizes the achievement of a scientist in a French laboratory who has made exceptional contributions to the vitality and influence of computer-science research while building outstanding cooperation with industry. It has been officially awarded at the Institut de France on October 15th, 2013.

Demian Wassermann has been recruited as junior research scientist (CR2 Inria). He joined the ATHENA project-team by the end of Decembre 2013.

4 PhD students have been recruited : Brahim Belaoucha, Kai Dang, Rutger Fick and Marco Pizzolato.

2 PhD students defended their thesis at Nice Sophia Antipolis University : Sylvain Merlet (Sept. 11) and Anne-Charlotte Philippe (Dec. 19).

2 ANR projects have been accepted : ANR Mosifah and ANR Vibrations (see the dedicated part in this report).

DEMAR Project-Team (section vide)

GALEN Project-Team

2.2. Highlights of the Year

- **BIOMED Summer School:** Galen has organized the Biomedical Image Analysis Summer School : Modalities, Methodologies & Clinical Research at Paris between July 8th and July 12th, 2013 involving international leaders/contributors in the field of biomedical image analysis as instructors where approx 100 participants were selected from an outstanding number of applications.
- **Coursera:** Pawan Kumar Mudigonda & Nikos Paragios introduced a new course on discrete inference and learning in artificial vision on the Coursera platform with approx 15,000 student enrollments.
- **Editor in Chief:** Nikos Paragios was named editor in chief of the Computer Vision and Image Understanding Journal (CVIU). CVIU is published by Elsevier Publishing House and is one of the oldest and leading journals in the field of computer vision and image understanding. In 2009, it was named one of the top 20 journals in computer science by Times Higher Education.

MNEMOSYNE Team (section vide)

NEUROMATHCOMP Project-Team

2.2. Highlights of the Year

Our PhD student H. Nasser has obtained an award and some financial support from Nice University to create a start up to develop a software (DataSpot) based on the methods developed in Enas.

NEUROSYS Team

2.2. Highlights of the Year

In the last years we have been working on models of anaesthetic action on neural populations based on published experiments of other research groups. This year we have been able to participate in the analysis of experimental animal data measured under anaesthesia by the University of North Carolina-Chape Hill [9]. The corresponding common publication with this experimental laboratory is a perfect basis for a future international cooperation.

PARIETAL Project-Team

2.1. Highlights of the Year

- The **Therapixel** start-up was created by Pierre Fillard (effective on July 1st, 2013) <http://www.therapixel.com/company/>. Therapixel is designing a device to look at and interact with images without any contact to a screen or a keyboard. This technical solution is very handy for surgeons who have to avoid any contact while in the operating room, and yet need pre-operative images. The technologies developed at Therapixel are based on those of the medInria software. Therapixel got an OSEO 2013 grant.
- The **Human Brain Project** European flagship project has been accepted in 2013 for a ten years duration (see section 7.3.1). Parietal is part of it and took part to the kick-off in October 2013.

Popix Team

2.2. Highlights of the Year

The Inria Innovation Lab *Lollipop* was created. This i-Lab brings together POPIX and the start-up Lixoft. It aims to boost the transfer of new statistical methods developed by POPIX to new tools developed by Lixoft.

We have built a comprehensive online wiki (WikiPopix, <https://wiki.inria.fr/popix>) for the population approach with mixed-effects models. This wiki aims to be an invaluable resource for all pharmacometricians, statisticians, teachers, graduate and undergraduate students in academia, industry and regulatory agencies. It is freely available online for all these communities.

Bertrand Maury published the book, *The Respiratory System in Equations* (Springer), which gives an introduction to the mathematical modeling of the respiratory system. The book starts with detailed introduction to physiological aspects, and then different levels of description are proposed, from lumped models with a small number of parameters (ordinary differential equations), up to infinite dimensional models based on partial differential equations.

SHACRA Project-Team

2.3. Highlights of the Year

2.3.1. Scientific exhibition for the french government

The intergovernmental seminar on digital sciences was held in february at the University of Cergy-Pontoise. Within this context, the team has exhibited a demonstration of a cataract surgery simulator which is dedicated to train surgeons to a new cost-effective cataract surgery procedure MSICS (*manual small incision cataract surgery*). This simulator was developed at Inria and has been transferred to the start-up InSimo.



Figure 2. Demonstration of a cataract surgery simulator during the intergovernmental seminar on digital sciences.

2.3.2. Best Papers

We received the runner-up best paper award for the paper published in ISMAR 2013, the leading conference in Augmented and Mixed Reality.

BEST PAPERS AWARDS :

[22] **ISMAR - IEEE International Symposium on Mixed and Augmented Reality 2013**. N. HAOUCHINE, J. DEQUIDT, I. PETERLIK, E. KERRIEN, M.-O. BERGER, S. COTIN.

VISAGES Project-Team

2.2. Highlights of the Year

- The VISAGES team was awarded by the Brittany INPI Trophee for research and innovation in the *research structure* category (<http://www.bretagne-innovation.tm.fr/Temoignages/Laureats-Trophees-INPI-Bretagne-2013-Laboratoire-VisAGeS-Video>).
- H. Raoult received a Magna Cum Laude Merit Award at the 21th Annual ISMRM 2013

ANGE Team

2.2. Highlights of the Year

On the one hand, the ERC Consolidator Grant allocated to Anne Mangeney will enable cross-disciplinary works for the modelling of processes governing landslides. In the same spirit, the first Albert Tarantola workshop managed by A. Mangeney and J. Sainte-Marie held on September and aimed at promoting collaborations between mathematicians and geophysicists.

On the other hand, 2013 was dedicated to “Mathematics for Planet Earth” under the patronage of UNESCO. This international initiative consisted in highlighting the role played by mathematics in the modelling of processes that occur on earth including geophysics, biology and human sciences. The ANGE team got involved into this dynamic through the ARP “MathInTerre” from the French agency for research (ANR): scientific committee, organisation of dedicated workshops,...

BANG Project-Team

2.2. Highlights of the Year

Benoît Perthame was head of the team until January 2013 when he became head of the Laboratoire Jacques-Louis Lions of UPMC (Univ. Paris VI), a laboratory with around 200 members: University, CNRS or Inria permanent members, plus many non-permanents (PhD students, postdocs and engineers). Since then, Marie Doumic has been acting as the BANG team head and now heads the new team MAMBA.

CASTOR Team (section vide)

CLIME Project-Team (section vide)

COFFEE Project-Team (section vide)

FLUMINANCE Project-Team (section vide)

MAGIQUE-3D Project-Team (section vide)

MOISE Project-Team

2.2. Highlights of the Year

MOISE was a main contributor of the success of the MPT2013 event in France. Maëlle Nodet and Antoine Rousseau were co-authors of a movie that was presented at the MPT launch, at UNESCO. In addition, Maëlle and Antoine strongly participated to the initiative *Un jour, une brève*¹ in which Antoine was both executive editor and webmaster. This website - dedicated to scientific outreach - was visited by more than 1000 unique visitors each and every day of 2013. On the research side of MPT2013, several team members were in the main board of *Maths In Terre*²

¹See <http://mpt2013.fr>

²A French national program that was built to propose ANR a national strategy regarding applied mathematics and environmental sciences, see <http://mathsinterre.fr>.

POMDAPI Project-Team (section vide)

SAGE Project-Team

2.2. Highlights of the Year

Year 2013 was declared Mathematics of the Planet Earth by UNESCO. In relation with this domain, the team Sage participated in the prospective think tank "MATHématiqueS en INTERactions pour la TERRE" (ANR project) and in various popularization actions:

- the french blog "un jour une brève". See <http://mpt2013.fr/>.
- the TDC journal "les mathématiques de la terre" (no 1062, october 2013),
- papers on the website Interstices. See <http://www.interstices.info>.
- panels and conferences for scholars.

STEPP Team (section vide)

BIOCORE Project-Team

2.2. Highlights of the Year

- Based on simple microalgae models, optimal operating conditions were theroretically identified for the biomass productivity under day/night cycles using Pontryagin's maximum principle [25]. This results paves the way for the theoretical and numerical development of (near)-optimal control laws for lipid production based on more complex models.
- The dynamical behaviour of biological networks can often be qualitatively described by piecewise affine systems. We developped a probabilistic approach for describing the trajectories and predicting periodic orbits in such models. In the state transition graph, a *transition probability* between two nodes can be defined in terms of model parameters [22]. This approach could be used for design or control of genetic networks.

CARMEN Team

2.2. Highlights of the Year

- Simon Labarthe was awarded the « prix de THESAQT », during the « Forum NOVAQT » on innovation organized by the region Aquitaine. The price was awarded for his scientific achievements during his PhD.

DRACULA Project-Team (section vide)

M3DISIM Team

2.1. Highlights of the Year

- Hiring of one new permanent researcher: Sébastien Imperiale (CR2);
- New European project named VP2HF, see [7.2.1.2](#) ;
- First paper with experimental validations of our cardiac model, see [\[13\]](#).

MASAIE Project-Team

2.4. Highlights of the Year

The estimation of sequestered parasite population has been a challenge for the biologist and modeler, with many authors having studied this problem. The difficulty is that the infected erythrocyte leaves the circulating peripheral blood and binds to the endothelium in the microvasculature of various organs. A measurement of *Plasmodium falciparum* parasitaemia taken from a blood smear therefore samples young parasites only and there is no clinical methods to measure the sequestered parasites. We have developed a simple tool to estimate the sequestered parasites and hence the total parasite burden for *Plasmodium falciparum* malaria patients. We have also given a method to estimate a crucial parameter in the model of infection. This parameter β can be thought as the "transmission/invading" factor between merozoites and erythrocytes. This work [11] will be published in "Mathematical Biosciences and Engineering".

MODEMIC Project-Team

2.4. Highlights of the Year

A lectures program submitted by the team and R. Arditi (AgroParis Tech) entitled “Mathematics, Computer sciences and Theoretical Ecology” has been accepted by the “Centre Interfacultaire Bernoulli” at EPFL (Lausanne, Switzerland) for a semester in 2014 (see Section 7.4.3.2).

A patent has been deposited jointly with Moise/Lemon Inria project-team concerning an algorithm for “intelligent” pumps, that provides an efficient treatment of natural water resources [69].

NUMED Project-Team (section vide)

REO Project-Team

2.2. Highlights of the Year

- Cristóbal Bertoglio was awarded
 - the best thesis **Gamni prize** by SMAI.
 - the **“Best Thesis in Mathematics and their interactions” prize** by the EADS/Airbus Foundation

for his PhD thesis entitled “Direct and inverse problems in fluid-structure interaction. Application to hemodynamics”, under the supervision of Jean-Frédéric Gerbeau and Miguel Àngel Fernández Varela.

- Justine Fouchet-Incaux, supervised by Céline Grandmont and Bertrand Maury, was awarded the best poster prize by the Société de Physiologie at the 8th congress of "Physiologie, Pharmacologie et Thérapeutique", Anger 2013.

SISYPHE Project-Team

2.2. Highlights of the Year

Results in control of quantum systems obtained by Mazyar Mirrahimi and his former PhD student Zaki Leghtas in close collaboration with the teams of Michel Devoret and Robert Schoelkopf (Department of Applied Physics of Yale University) have been published in *Nature* ([49], [57]) ; *Science* ([47], [60]) ; *Physical Review Letters* ([46], [53]).