Activity Report 2012

Section highlights of the Team

ABS Project-Team

2.2. Highlights of the Year

Three key achievements were obtained in 2012.

The first one deals with the problem of modeling high resolution protein complexes, a topic for which we came up with an original binding patch model [14]. Our model not only provides more accurate descriptors of key quantities (the binding affinity in particular), but also sheds new light on the flexibility of proteins upon docking. These developments will in particular be used to investigate complexes from the immune system in the future.

The second one deals with the problem of modeling large protein assemblies, involving up to hundreds of polypeptide chains. We finalized the application of our Toleranced Models framework to the nuclear pore complex [13], [19], and started to produce novel algorithms for mass-spectrometry data [18], an emerging technique to infer structural information on large molecular machines.

Finally, we have also made a steady progress on algorithmic foundations, in particular on the problem of developing a Morse theory for point cloud data, in the perspective of analyzing molecular dynamics data. Tests are currently on the way, so that this work will be advertised in 2013.

AMIB Project-Team (section vide)

BAMBOO Project-Team

2.1. Highlights of the Year

One highlight, both scientific and organisational, for 2012 concerns the setting up of a CNRS-UCBL-Inria Laboratoire International Associé (LIA) with the Laboratório Nacional de Computação Científica (LNCC), Petrópolis, Brazil. The LIA has for acronym LIRIO ("Laboratoire International de Recherche en BInformatique") and is coordinated by Ana Tereza Vasconcelos from the LNCC and Marie-France Sagot from BAMBOO. The LIA is created for 4 years, renewable once. A preliminary web page for the LIA LIRIO is available at this address: https://team.inria.fr/bamboo/en/cnrs-lia-laboratoire-international-associe-lirio/.

BEAGLE Team

2.2. Highlights of the Year

- We published at least three papers in high impact journals [16], [31], [23]: two in *PNAS* about the use of horizontal transfer in reconstructing and dating the history of bacterial diversification, and one in *Nature reviews microbiology* about the comparison between experimental and artificial evolution.

- Guillaume Beslon was nominated as a member of the CoNRS, section 06.

- 2012 has been fructuous in terms of collaborations between permanent members of the team, sometimes coming from different teams and backgrounds, as it is shown by a submitted article [43], gathering the different projects in the Computational Cell Biology part.

BEST PAPER AWARD :

[39] **Artificial Life XIII**. D. MISEVIC, A. FRÉNOY, D. P. PARSONS, F. TADDEI.

BONSAI Project-Team (section vide)

DYLISS Team

2.1. Highlights of the Year

- François Coste was the co-chair of the French conference in bioinformatics (JOBIM) which was organized in Rennes in July 2012.

- Matthias Gallé, a former PhD in the team, won the accessit thesis prize from AFIA. This work followed by F. Coste has been achieved in the framework of a cooperation with Universidad Nacional de Cordoba, thanks to a MinCYT-Inria program [14].

- Santiago Videla won a best paper award at the conference CMSB [19] [1]. This work implies a cooperation with EBI (UK) together with universities of Heidelberg, Potsdam and Padova.

BEST PAPERS AWARDS :

[19] **CMSB - 10th Computational Methods in Systems Biology 2012**. S. VIDELA, C. GUZIOLOWSKI, F. EDUATI, S. THIELE, N. GRABE, J. SAEZ-RODRIGUEZ, A. SIEGEL.

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[1]http://sites.brunel.ac.uk/cmsb2012

GENSCALE Team

2.2. Highlights of the Year

- GenScale organized **JOBIM 2012**, the French conference on computational biology wich gathered 375 participants in Rennes. [web site: http://jobim2012.inria.fr/].

- GenScale and CWI proposed the first web server for comparison of protein structure alignments (**CSA**). [web site: http://csa.project.cwi.nl]

- KLAST software released by Korilog. KLAST is an improved version of the PLAST technology developed by GenScale for bank-to-bank sequence similarity search. [Korilog promotion]

IBIS Project-Team

2.2. Highlights of the Year

Three students defended their PhD thesis this year: Guillaume Baptist [1], Sara Berthoumieux [2], and Jérôme Izard [3]. One of the papers derived from the work of Sara Berthoumieux was accepted for *Molecular Systems Biology* [7].

The collaborative project RESET was accepted in the Bioinformatics call of the Investissements d'Avenir program. RESET joins seven partners, including the company Metabolic Explorer SA, and runs until 2016. RESET studies the gene expression machinery in bacteria, by means of models and experiments, and develops biotechnological applications based on the control of the gene expression machinery.

Former IBIS member Caroline Ranquet and Johannes Geiselmann created, with Marie-Gabrielle Jouan (Floralis, Université Joseph Fourier), the start-up company BGene, active in the field of DNA engineering.

MAGNOME Project-Team (section vide)

MORPHEME Team

2.2. Highlights of the Year

- Laure Blanc Féraud has obtained the "grade de chevalier dans l'Ordre National du Mérite".

SERPICO Team (section vide)

ASCLEPIOS Project-Team

2.2. Highlights of the Year

- N. Ayache, H. Delingette, X. Pennec, M. Sermesant, G. Malandain, I. Strobant, A. Cortell were largely involved in the organization of the MICCAI 2012 conference (Medical Imaging Computing and Computer Assisted Interventions). The conference gathered together 1200 from more than 40 countries between October 1 to October 5, 2012 in Nice Acropolis.

- The ERC Advanced Grant MedYMA on Biophysical Modeling and Analysis of Dynamic Medical Images has started in April 2012 for a period of 5 years.

- **Stéphanie Marchesseau** received the Young Investigator award at the MICCAI 2012 conference held in Nice (Oct. 2012) for her paper [42] .

- **Hervé Lombaert** won the MCV 2012 best paper award at the MICCAI workshop on Medical Computer Vision (Oct. 2012) for his paper [38] .

- **Hervé Lombaert** has received a prize from the research fund of Québec FRQ (http://www.frq.gouv.qc.ca) as the "star research student" of the month January 2013 for his paper [] .

BEST PAPERS AWARDS :

[42] **Proceedings of Medical Image Computing and Computer Assisted Intervention 2012 (MICCAI)**. S. MARCHESSEAU, H. DELINGETTE, M. SERMESANT, K. RHODE, S. DUCKETT, C. ALDO. RINALDI, R. RAZAVI, N. AYACHE.

[38] **Medical Computer Vision (MCV'12) MICCAI workshop**. H. LOMBAERT, L. GRADY, X. PENNEC, J.-M. PEYRAT, N. AYACHE, F. CHERIET.

[] **IEEE Trans. on Medical Imaging**. H. LOMBAERT, J.-M. PEYRAT, P. CROISILLE, S. RAPACCHI, L. FANTON, F. CHERIET, P. CLARYSSE, I. MAGNIN, H. DELINGETTE, N. AYACHE.

ATHENA Project-Team (section vide)

CORTEX Project-Team

2.2. Highlights of the Year

We designed a computational model of the primary somatosensory cortex that is able to develop topographic maps, maintain and reorganize them in the face of lesions. We used neural fields as a mathematical and computational framework and focused on area 3b innervated by hand mechanoreceptors. The combination of such neural field with a simple Hebbian/anti-Hebbian like learning rule advocates for an unsupervised, distributed, robust and biologically plausible model of a (simplified) somatosensory cortical model where thalamocortical connections are the main sites of plasticity. The major finding of our model is that a topographic map can emerge as a consequence of the interaction between thalamus and cortical excitatory afferent connections. These results were recently published in PLoS ONE [6].

DEMAR Project-Team

2.2. Highlights of the Year

- David Andreu received the 1rst Price 2012 of the FIEEC-OSEO on Applied Research, for his research and innovation transfer with Vivaltis company.

GALEN 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 9$^{\text{th}}$ and July 14$^{\text{th}}$, 2012 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.

- **China Research Council Award**: Chaohui Wang was the recipient of the Chinese Government Award for Outstanding (self-financed) PhD. In 2012, a total of 495 awards were given worldwide in all disciplines, with 17 Chinese students in France receiving awards.

- **CVPR Participation**: GALEN has participated in the 2012 annual IEEE Conference in Computer Vision and Pattern Recognition (CVPR'12) conference, the leading event in the field of computer vision with five papers (double blind full submissions, acceptance rate %25).

- **EU FP7 Success**: GALEN has secured cutting edge research funding from the European Union through the highly competitive 2012 "Cognitive Vision and Robotics" FP7-ICT-9 call (5% acceptance) through two accepted grants (out of 12 for the entire call): MOBOT (Intelligent Active MObility Assistance RoBOT integrating Multimodal Sensory Processing, Proactive Autonomy and Adaptive Interaction) and RECONFIG (Cognitive, Decentralized Coordination of Heterogeneous Multi-Robot Systems).

- **MICCAI Participation**: GALEN has participated in the 2012 annual Medical Image Computing and Computer Assisted Intervention (MICCAI'12) conference one of the leading events in the field of medical image analysis with four papers (double blind full submissions, acceptance rate %30) and two invited talks in the associated workshops.

MNEMOSYNE Team

2.2. Highlights of the Year

As a good illustration of our thematic shift from models of visuomotor functions to applications to neurodegenerative diseases, this recent publication in PNAS [1] proposes that the Degus, a rodent from Chile used for the design of models of the retina, is also an animal model for the Alzheimer disease.

NEUROMATHCOMP Project-Team

2.2. Highlights of the Year

1. **Organisation of the Workshop on Biological and Computer Vision Interfaces in Firenze October 12, 2012, held in conjunction with ECCV 2012.** This workshop was organised by Olivier Faugeras and Pierre Kornprobst. This workshop was a one-day event with prestigious invited speakers discussing several aspects of biological and computer vision interfaces, namely biological vision, mathematical and computational paradigms for biological and human vision, computational and hardware models of the visual brain and bio-inspired methods for computer vision. More information is available at http://www-sop.inria.fr/manifestations/wbcvi2012/index.shtml

2. **Organisation of the workshop NeuroComp/KEOpS'12, Bordeaux, 10-11 October 2012.** This workshop was joinly organized by F. Alexandre and T. Viéville (Mnemosyne), B. Cessac (Neuromathcomp), A. Palacios and M.J. Escobar (CN Valparaiso). It addressed the following issues (i) neural population dynamics and coding; (ii) architecture (and information flow) at the retinal and the brain level. The workshop was a two days event involving speakers in the field of vision and cognition, robotics, retina healthcare and prosthesis, and dynamical systems modeling. More information is available at http://neurocomp.risc.cnrs.fr/neurocomp-2012/index.php?page=1.

3. **European Union project "MATHEMACS" accepted.** The MATHEMACS project aims to develop a mathematical theory of complex multi-level systems and their dynamics. This is done through a general formulation based on the mathematical tools of information and dynamical systems theories. To ensure that the theoretical framework is at the same time practically applicable, three key application areas are represented within the project, namely neurobiology, human communication, and economics. These areas not only provide some of the best-known epitomes of complex multi-level systems, but also constitute a challenging test bed for validating the generality of the theory since they span a vast range of spatial and temporal scales. Furthermore, they have an important common aspect; namely, their complexity and self-organizational character is partly due to the anticipatory and predictive actions of their constituent units. The MATHEMACS project contends that the concepts of anticipation and prediction are particularly relevant for multi-level systems since they often involve different levels. Thus, as a further unique feature, the project includes the mathematical representation and modeling of anticipation in its agenda for understanding complex multi-level systems.

4. **European Union project "RENVISION" accepted.** RENVISION's goal is twofold: i) to achieve a comprehensive understanding of how the retina encodes visual information through the different cellular layers; ii) to use such insights to develop a retina-inspired computational approach to high-level computer vision tasks. By exploiting the integration of recent advances in high-resolution light microscopy, 3D imaging and high-density multielectrode array technologies, RENVISION will be in an unprecedented position to investigate pan-retinal signal processing at high spatiotemporal resolution, allowing simultaneous recording from the entire population of ganglion cells and functional imaging of inner retinal layers at near-cellular resolution, combined with 3D structural imaging of the whole inner retina. The combined analysis of these complex datasets will require the development of novel multimodal analysis methods. Resting on these neuroscientific and computational grounds, RENVISION will generate new knowledge on retinal processing. It will provide advanced pattern recognition and machine learning technologies to ICTs by shedding a new light on how the output of retinal processing (natural, modelled) solves complex vision tasks such as automated scene categorization and action recognition.

PARIETAL Project-Team

2.1. Highlights of the Year

Fabian Pedregosa, PhD candidate at the Parietal team won the best poster award at the EuroScipy 2012 conference. The poster, Memory Profiler: monitor memory usage of Python code describes the Python package memory_profiler, a tool to monitor memory usage from within the Python language. Among other features, the package is able to perform line-by-line analysis of the memory usage program and to insert breakpoints on excessive memory consumption.

SHACRA Project-Team

2.3. Highlights of the Year

2.3.1. *Two full papers at MICCAI'2012 in Nice*

Two full papers have been accepted in the International Conference on Medical Imaging Computing and Computer Assisted Intervention (MICCAI, ERA's Ranking A).

2.3.2. *IHU Mix-Surg and Haystack Project*

The team is involved in the creation of the IHU Mix-Surg in Strasbourg, a new institute dedicated to minimally invasive therapies, guided by image and simulation. It involves interdisciplinary expertise of medical groups, academic partners and strong industry partnerships. IHU has provided financial support for a project named Haystack (image guided surgery for brachyterapy).

2.3.3. *HelpMeSee Project*

The team has been involved on a project funded by the non-governmental organization *HelpMeSee*[1]. HelpMe-See aims at providing ways to treat cataract surgery in third world countries. Their main objective is to develop a simulator to train surgeons. Shacra has been involved for its expertise in real-time simulation of soft anatomical structures.

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[1]http://www.helpmesee.org

VISAGES Project-Team

2.2. Highlights of the Year

Aymeric Stamm received the Magna Cum Laude Merit Award from the ISMRM organisation for [42] .
BEST PAPERS AWARDS :
[42] **Proc. Intl. Soc. Mag. Reson. Med.**. A. STAMM, P. PEREZ, C. BARILLOT.

CLIME Project-Team (section vide)

FLUMINANCE Project-Team (section vide)

MAGIQUE-3D Project-Team (section vide)

MOISE Project-Team

2.2. Highlights of the Year

François-Xavier Le Dimet has been nominated Fellow of the American Meteorological Society. He received this distinction in New Orleans on the January, 22, 2012 during the annual General Assembly of the Association. He is the second French scientist to get this award. See http://www.ujf-grenoble.fr/universite/medias-et-communication/actualities/francois-xavier-le-dimet-elu-fellow-of-the-american-meteorological-society-244259.htm?RH=UJF

The paper *"Variational algorithms for analysis and assimilation of meteorological observations."* by F.-X. Le Dimet and O. Talagrand [86] has received more than 1 000 citations.

POMDAPI Project-Team (section vide)

SAGE Project-Team

2.2. Highlights of the Year

The results of the year are focused on numerical models and simulations for flow in porous fractured media. For this subject only, the team published three papers in journals, gave an invited plenary talk and two invited talks in minisymposia. Societal and economical issues concern environment and energy, such as groundwater resources, prevention and remediation of pollution, geothermy, etc.

<div align="center">**STEEP Exploratory Action**</div>

2.3. Highlights of the Year

A highlight of our young team has been the successful submission of a multi-disciplinary ANR project coordinated by us (CITiES project, see further below). It is our first significant grant and creates a formal framework for our already existing collaborations with various partners throughout France.

Amaël Delaunoy has been the recipient of the annual PhD thesis award of AFRIF (Association Française pour la Reconnaissance et l'Interprétation des Formes), for his thesis *Modélisation 3D à partir d'images : contributions en reconstruction photométrique à l'aide de maillages déformables*, supervised by E. Prados and P. Sturm.

BANG Project-Team

2.2. Highlights of the Year

The ERC Starting Grant allocated to M. Doumic-Jauffret in 2012 will sustain a long term programme in mathematical biology. The many faces of the subject imply modelling of biopolymer size repartition, applications to prion (and other neurodegenerative) diseases, inverse problems, numerical simulations in biology and a strong interaction with biologists.

BIGS Project-Team

2.2. Highlights of the Year

For 2012 we stress the following noticeable events:

- HdR defense of Céline Lacaux, 12/6 (see [1]).

- Cybernano, an incubating start-up specialized in nano-cancerology created by Thierry Bastogne, has received the "emergence" award in 2012 from the French Research ministry for the creation of start-up based on innovative technology.

BIOCORE Project-Team

2.2. Highlights of the Year

- A model was developed in order to determine how to mix resistant and sensitive plants to vector-borne plant pathogens in order to best protect the crop. The model includes a process that would allow for the resistance breakdown through adaptation of the virus population and the wintering of the virus in the environment. The best mixing rate was then proposed in order to either maximize the production over a 15 year period or prevent the resistance breakdown [16]. This work is done with Frédéric Fabre and Benoît Moury of INRA Avignon.

- Green Stars, Institute of Excellence for Decarbonated Energy, was created this year, supported by a *Projet d'Investissement d'Avenir* funding. Recent Biocore developments in microalgae modeling strongly support the Green Stars Institute: including the temperature effect [14], [28], representing fast time scales of photosynthesis [37], coupling with hydrodynamics [13], representing N_2 fixation [89], modeling metabolism of microalgae [67], modeling anaerobic digestion of microalgae [20], developing observers [21] [101] and optimal strategies to produce biomass [90], [109].

BEST PAPER AWARD :

[36] **10th Conference on Computational Methods in Systems Biology**. A. CARTA, M. CHAVES, J.-L. GOUZÉ.

CARMEN Team

2.2. Highlights of the Year

- S. Labarthe was awarded the poster price for the theoretical and applied aspects of his work on atrial modeling by to distinct communities:

    – poster award by the medical community after at the « printemps de la cardiologie 2012 »;

    – poster award by the applied mathematics community at the CANUM 2012.

- N. Zemzemi: best poster presentation award at the international conference Computing in Cardiology 2012 (CINC'2012), [25].

DRACULA Project-Team (section vide)

MACS Project-Team

2.2. Highlights of the Year

The team has relocated from Rocquencourt to the Saclay Ile-de-France Inria research center in June 2012. This change was motivated by the very strong potential of this rapidly-evolving environment in terms of multi-disciplinary collaborations, with the actors already in place as well as those to come, in particular with the creation of the ambitious new Paris-Saclay University. We are already part of a local initiative entitled "Mechanics and living systems" in association with various components of the two mechanics laboratories of Ecole Polytechnique, and which encompasses fundamental, experimental and numerical aspects in biomechanics. This environment is also foreseen as most favorable to the launching of our successor-team, since 2012 was the last year of the Macs team itself, indeed.

MASAIE Project-Team

2.4. Highlights of the Year

Malaria infection is characterized by the fact that only the peripheral infected red blood cells (young parasites), also called circulating, can be observed (can be seen on peripheral blood smears) and the other ones (sequestered), hidden in some organs like brain and heart, can not be observed. There is no clinical method of measuring those sequestered infected cells. We have developed a simple tool to estimate the sequestered parasites and hence the total parasite burden for *Plasmodium falciparum* malaria patients [14].

MODEMIC Project-Team

2.6. Highlights of the Year

- *The characterization of interconnections of chemostats that provide a global stability of bioprocesses with inhibition, mentioned in Section 6.1.1 , has led to a patent application by INRA [59].*

- *Anaerobic membrane bioreactors (AnMBR) have a great potential for treating wastewater since they allow energy recovery (the biogas produced is mostly composed of methane) while guaranteeing a total separation of the treated water and of the microbial content of the process. However, their main drawback is the fouling of the membrane. In order to control the process while limiting the risk of clogging, we have developed a new model for AnMBR in coupling a two-step anaerobic model (called the "AM2" or the "AMOCO" model) with a model describing fouling dynamics [16].*

- *We have proposed hybrid models (deterministic/stochastic and continuous/discrete) of population dynamics as alternatives to conventional models based on ordinary differential equations. The later models are generally accepted as a good approximation of the former ones in large population asymptotic, but even in very large population size the two groups of models present drastically different behavior, notably in terms of persistence properties [15], see Section 6.1.5 .*

NUMED Project-Team (section vide)

REO Project-Team

2.2. Highlights of the Year

- Marc Thiriet et al. were awarded the "JBSE Paper of the Year 2010" for their article [6].
- New european project (FP7-PEOPLE Marie-Curie Action: "Initial Training Networks") REVAM-MAD about Retinal Modeling, Measurement and Diagnosis (Jean-Frédéric Gerbeau, Working Package leader)
- New ANR project EXIFSI (ANR JCJC) about fluid-structure interaction (Miguel Fernández, Principal Investigator)

SISYPHE Project-Team

2.2. Highlights of the Year

The feedback scheme for quantum systems proposed by Mazyar Mirrahimi and his co-authors have been very successful in some important physical experiments. After the preparation and stabilization of a small number of photons in a cavity in 2011 with the group of Serge Haroche, Nobel Prize for Physics (2012) at ENS Paris ([9], [8], [17], some new results have been obtained by Mazyar and his PhD student, Zaki Leghtas with the groups of Robert Schoelkopf and Michel Devoret at Yale University [74], [75], [77], [78]. In particular, they have proposed a new method to autonomously correct for errors of a logical qubit induced by energy relaxation. This proposal directly addresses the task of building a hardware-efficient and technically realizable quantum memory.

VIRTUAL PLANTS Project-Team

2.2. Highlights of the Year

- **Move of the team to a new campus to join other Inria teams.** Until this year, the team was located at the Cirad Lavalette campus in Montpellier. In May 2012, it moved to the *Maison de la Modélisation pour le vivant et l'environnement* in Montpellier close to the campus of Computer Science research (LIRMM). This move is intended to strengthen the presence of Inria in Montpellier by gathering several Inria teams at the same place, fostering interactions between them and consequently augment the visibility of Inria in the region. It is also meant to support the creation of the *Computational Biology Institute of Montpellier*, IBC, that succeeded to the national call on *investissements d'avenir* of ANR, and in which both Zenith and Virtual Plants Inria teams are strongly involved.

- **Acceptation of the Inria Large Scale Initiative Morphogenetics.** The Inria *action d'envergure* Morphognetics was evaluated by Inria and accepted. The project gathers 3 Inria teams (Imagine, Morpheme and Virtual Plants) from 2 Inria centers (Rhône-Alpes and Sophia-Antipolis-Méditerranée) and 2 Inra teams (RDP and RFD) from Lyon an Grenoble respectively to address the problem of flower development at early stages. The kick-off meeting of the project was held in November in Montpellier. The project will last 4 years and will focus in particular on the modelling of meristem mechanics during the early phases of organogenesis and how it is related to genes.

- **First paper on L-Py published.** The first paper describing our simulation system language *L-Py* has been published in Frontiers in Plant Science. The maturity and the diffusion of this software module increases and is now the basis of the work of several groups worldwide. Several training sessions have been organized by the team in the last two years and will be at the core of the future training program proposed by the Virtual Plants team on plant modeling.

- **Completion of a series of papers on tree development analysis using various types of stochastic processes.** Understanding tree development over several years has been the object of active research since about 10 years. This has generated the development of integrative models for analyzing tree growth components (ontogeny, climate and local environment influence) and patterns, in particular models combining latent state variables, tree response variables and environmental explanatory variables but also individual and population parameters [39] [2]. This approach has been applied to forest and fruit trees, to tropical and temperate species growing in various conditions (orchard, managed forest stand and unmanaged forest understory) [7] [49], [16].