



RESEARCH CENTER  
**Bordeaux - Sud-Ouest**

FIELD

Activity Report 2015

# Section Highlights of the Team

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## CAGIRE Team

# 5. Highlights of the Year

## 5.1. Highlights of the Year

### First DNS simulation of a turbulent flow with AeroSol

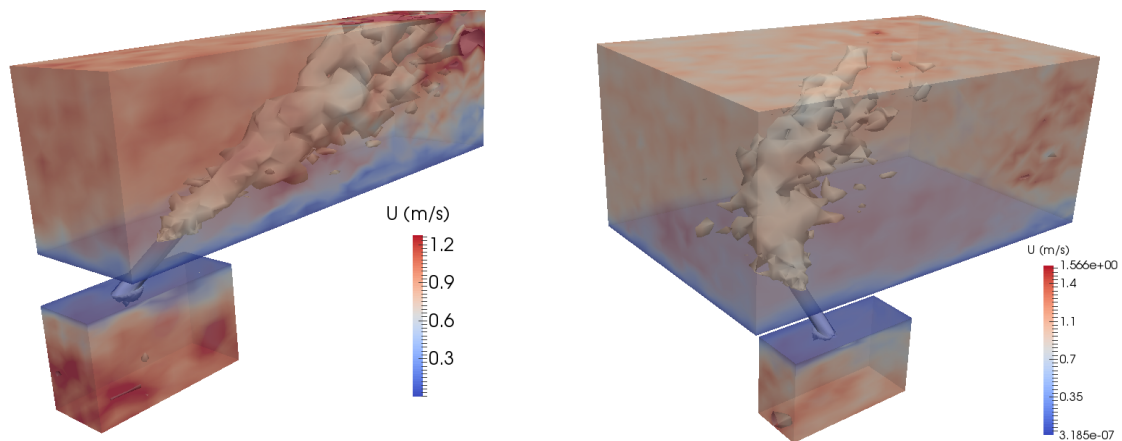


Figure 3. DNS of jets in crossflow (AeroSol-DG2): Examples of snapshots of instantaneous surfaces of the velocity norm. Left - With a 0-degree jet skidding (MAVERIC configuration). Right - With a 90-degree jet skidding.

In 2015, the first DNS of the configuration of a jet in turbulent crossflow have been carried out with the AeroSol library. Qualitativeley speaking, this represents the completion of the initial objective that the team was targeting in 2011 when it was created ! These computations were done within the IMPACT-AE project. The runs were using 1024 cores of the BlueGene /Q cluster Turing at IDRIS thanks to a 4400000-hour computing grant obtained in 2015. Examples of results obtained for the two flow configurations considered are presented in Fig. 3 .

### Implementation of the EB-RSM model into StarCCM+

In close collaboration with the R&D team of Adapco, the company that develops and sells the commercial CFD package StarCCM+, the EB-RSM model has been implemented in this code, starting from release 10.02. This constitutes a significant achievement that our models are made widely available to the engineering community.

## CARDAMOM Team

# 5. Highlights of the Year

## 5.1. Highlights of the Year

- A whole new release of the mesh adaptation platform MMG is available, with a brand new looking website : <http://www.mmgttools.org/> ;
- We have solved the conflict between the conservation of either mass and steady equilibria relevant in applications (lake at rest state) when performing mesh-adaptive computations of shallow water flows. This algorithm will be embedded in the FMG adaptation library which will be part of the MMG tools ;
- We have shown the potential of Boussinesq-type depth averaged codes for the simulation of Wave Energy Converters [97], [98]. This result paves the way to the construction of new medium fidelity models to be used in the optimization of converters. This will be achieved in the framework of the MIDWEST project funded this year (EU OCEANErnet call) ;
- We have finally proven that fully discrete asymptotic approaches allow to construct new discretizations of depth averaged weakly nonlinear Boussinesq models with greatly improved phase and linear shoaling. We are now working on the construction of improved genuinely nonlinear models ;

## CARMEN Team

# 5. Highlights of the Year

## 5.1. Highlights of the Year

A large part of the newly-constructed LIRYC building, hosting researchers' offices, has been taken in use. The extra space greatly facilitates collaboration between Carmen and LIRYC researchers.

The *service de cardiologie-électrophysiologie et stimulation cardiaque* of the CHU Haut-Leveque, the clinical partner in LIRYC, was ranked first in the classification 2015–2016 of Hospitals and Clinics published by the news magazine *L'Express*, while its director, professor M. Haissaguerre, has been awarded the Gold Medal of the European Society of Cardiology.

M. Potse published a high-profile paper with a group of internationally renowned researchers on terminology and criteria for the diagnosis of a rare but potentially fatal ECG abnormality named Early repolarisation syndrome [37].

In silico assessment of drugs effects on human embryonic stem cells derived cardiomyocytes electrical activity Computational modeling and simulation is extensively used to investigate diseases in cardiac electrophysiological activity and also drug effects, side effects and interactions. Human embryonic stem cell-derived cardiomyocytes (hESC-CMs) have been recently considered as a promising tool in regenerative medicine: their major role in repairing damaged tissue is due to pluripotency and ability to differentiate. These pluripotent cells are also used in early stages of drugs development. Pharmaceutical companies use the MultiElectrode Array (MEA) device in order to perform many in vitro experiments on hESC-CMs. The goal of our study is to derive a mathematical model and to simulate these in vitro experiments. Sensitivity of the Electrocardiography Inverse Solution to the Torso Conductivity Uncertainties Electrocardiography imaging (ECGI) is a new non invasive technology used for heart diagnosis. It allows to construct the electrical potential on the heart surface only from measurement on the body surface and some geometrical informations of the torso. The purpose of this work is twofold: First, we propose a new formulation to calculate the distribution of the electric potential on the heart, from measurements on the torso surface. Second, we study the influence of the errors and uncertainties on the conductivity parameters, on the ECGI solution. We use an optimal control formulation for the mathematical formulation of the problem with a stochastic diffusion equation as a constraint. The discretization is done using stochastic Galerkin method allowing to separate random and deterministic variables. The optimal control problem is solved using a conjugate gradient method where the gradient of the cost function is computed with an ad-joint technique. The efficiency of this approach to solve the inverse problem and the usability to quantify the effect of conductivity uncertainties in the torso are demonstrated through a number of numerical simulations on a 2D geometrical model. Our results show that adding  $\pm 50$  alter the inverse solution, whereas adding  $\pm 50$  lung conductivity affects the reconstructed heart potential by almost 50

Inverse Localization of Ischemia in a 3D Realistic Geometry: A Level Set Approach The reconstruction of cardiac ischemic regions from body surface potential measurements (BSPMs) is usually performed at a single time instant which corresponds to the plateau or resting phase of the cardiac action potential. Using a different approach, we previously proposed a level set formulation that incorporates the knowledge of the cardiac excitation process in the inverse procedure, thus exploiting the spatio-temporal correlations contained in the BSPMs. In this study, we extend our inverse level-set formulation for the reconstruction of ischemic regions to 3D realistic geometries, and analyze its performance in different noisy scenarios. Our method is benchmarked against zero-order Tikhonov regularization. The inverse reconstruction of the ischemic region is evaluated using the correlation coefficient (CC), the sensitive error ratio (SN), and the specificity error ratio (SP). Our algorithm outperforms zero-order Tikhonov regularization, specially in highly noisy scenarios.

Inverse problem in electrocardiography via the factorization method of boundary value problems We present a new mathematical approach for solving the inverse problem in electrocardiography. This approach is based on the factorization of boundary value problems method. In this paper we derive the mathematical equations and test this method on synthetical data generated on realistic heart and torso geometries using the state-of-the-art bidomain model in the heart coupled to the Laplace equation in the torso. We measure the accuracy of the inverse solution using spatial Relative Error (RE) and Correlation Coefficient (CC).

It is now possible for all Carmen members to go to the IHU LIRYC since the construction of the new building. This aims for the Carmen teams to follow doctors and researchers at Xavier Arnoz hospital.

## CQFD Project-Team

### 5. Highlights of the Year

#### 5.1. Highlights of the Year

Publication of the book: *Numerical methods for simulation and optimization of piecewise deterministic Markov processes* written by Benoîte De Saporta; Francois Dufour and Huilong Zhang in Mathematics & Statistics, Wiley, 298 pages, 2015.



## FLOWERS Project-Team

# 5. Highlights of the Year

## 5.1. Highlights of the Year

### Scientific Awards

Jonathan Grizou obtained the "Prix Le Monde de la recherche universitaire" for his thesis ([91]) and work on "Learning from unlabeled interaction" [30] [92]. This work allowed in particular to develop new algorithms for Brain-Computer Interfaces that remove the need for a phase of calibration and allow users to achieve sequential tasks. This work was achieved in collaboration with I. Iturrate and L. Montesano (Univ. Zaragoza, Spain), and the PhD was co-supervised by M. Lopes and PY. Oudeyer.

Matthieu Lapeyre obtained the "Second prix de thèse du GDR Robotique" for his thesis on the development of the open-source 3D printed Poppy Humanoid platform [102], now in use in various scientific, educational and artistic projects worldwide <http://www.poppy-project.org>. This work was achieved in collaboration with P. Rouanet and the PhD was supervised by PY Oudeyer.

### Dissemination and transfer

In the context of the Poppy project, a contract was signed between Inria and the company Generation Robots agreeing on the worldwide reselling and distribution of the Poppy robotic kits, and in particular the Poppy Humanoid and Poppy Torso kits: <http://www.generationrobots.com/>.

The Flowers team made major achievements in diffusing science and technology towards the general public. The team developed the IniRobot pedagogical kit, for the discovery of computer science and robotics in primary schools. The kit was first developed and evaluated in schools, in collaboration with a group of teachers, and then in 2015 saw a large national dissemination, as it has been used by 8000 school children in 35 towns. A dedicated web site has been created, allowing all users and contributors to share their experiences with the kit: <https://dm1r.inria.fr/c/kits-pedagogiques/inirobot>. Also, in 2015 the team began a large scale transfer project called Poppy Education (Féder/Region Aquitaine/Inria co-finding) targeting to develop, evaluate and disseminate robotic pedagogical kits for teaching ICT in high-schools and university level courses.

## **GEOSTAT Project-Team**

### **5. Highlights of the Year**

#### **5.1. Highlights of the Year**

- Article published on Inria web site: [link to page](#) on Nicolas Brodu's *Nature Communications* paper: *Spanning the scales of granular materials through microscopic force imaging*, [17].

## **HIEPACS Project-Team**

# **5. Highlights of the Year**

## **5.1. Highlights of the Year**

### **5.1.1. Awards**

The paper entitled “Task-based multi frontal QR solver for GPU-accelerated multicore architectures” by Emmanuel Agullo (Inria, France); Alfredo Buttari (CNRS - IRIT Toulouse, France); Abdou Guermouche (Université de Bordeaux, France); Florent Lopez (Université Paul Sabatier, France) received the best paper award at HiPC 2015 .

BEST PAPERS AWARDS :

[28] **High Performance Computing-HiPC**. E. AGULLO, A. BUTTARI, A. GUERMOUCHE, F. LOPEZ.

## LFANT Project-Team

### 4. Highlights of the Year

#### 4.1. Highlights of the Year

The team has been evaluated in 2015, and our scientific project for the next four years has been validated by the external reviewers.

Fredrik Johansson, who was already a postdoc last year, has been recruited as a full time researcher.

The team has organised the Atelier Pari/GP in January 2015 and the ECC 2015 international conference (with a summer school) in September 2015.

Athanasios Angelakis has defended his PhD thesis on *Universal Adelic Groups for Imaginary Quadratic Number Fields and Elliptic Curves* in September 2015.

Julio Brau has defended his PhD thesis on *Galois representations of elliptic curves and abelian entanglements* in December 2015.

Enea Milio has defended his PhD thesis on *Computing modular polynomials in dimension 2* [11] in December 2015.

The European H2020 project OpenDreamKit, in which the team participates, has been accepted.

**MAGIQUE-3D Project-Team (section vide)**

## MANAO Project-Team

# 5. Highlights of the Year

## 5.1. Highlights of the Year

Our search of a better understanding of appearance have reached some great milestones this year. First, our studies have shown that Bidirectional Reflection Distribution Functions (BRDFs) exhibits some meaningful statistics [21]. They help designing intuitively MatCaps (a shorthand for "Material Capture") that are often used by artists as a simple and efficient way to design appearance [23]. Our studies have also shown that current BRDF models are limited [17]. We are exploring new models and parameterizations [20], [24]. It is worth noting that we are integrating all these researches into a common library named ALTA (<http://alta.gforge.inria.fr/>).

### 5.1.1. Awards

"Notable article in computing in 2014", from ACM ThinkLoud Computing Reviews <http://www.computingreviews.com/recommend/bestof/notableitems.cfm?bestYear=2014> for our article on The Revealing Flashlight [7].

## MEMPHIS Team

# 5. Highlights of the Year

## 5.1. Highlights of the Year

### Capsule reentry in high atmosphere

The atmosphere reentry of a capsule is simulated in high atmosphere via a fully parallel code running on massive multi-thread platforms. In these flow conditions, rarefied flow models have to be used. We present here a simulation of a capsule reentry: the focus of this example is on dynamic octree-grid refinement as the geometry and the flow change. Adaptation is based on the distance to the geometry and on the temperature gradient. The dynamics of the capsule is taken into account: according to the force exerted by the fluid on the capsule, the geometry rotates around its center of mass up to the stationary position. The simulation is six-dimensional: three space dimensions and three velocity directions. Without parallelism and grid adaptation the simulation would be out of reach.

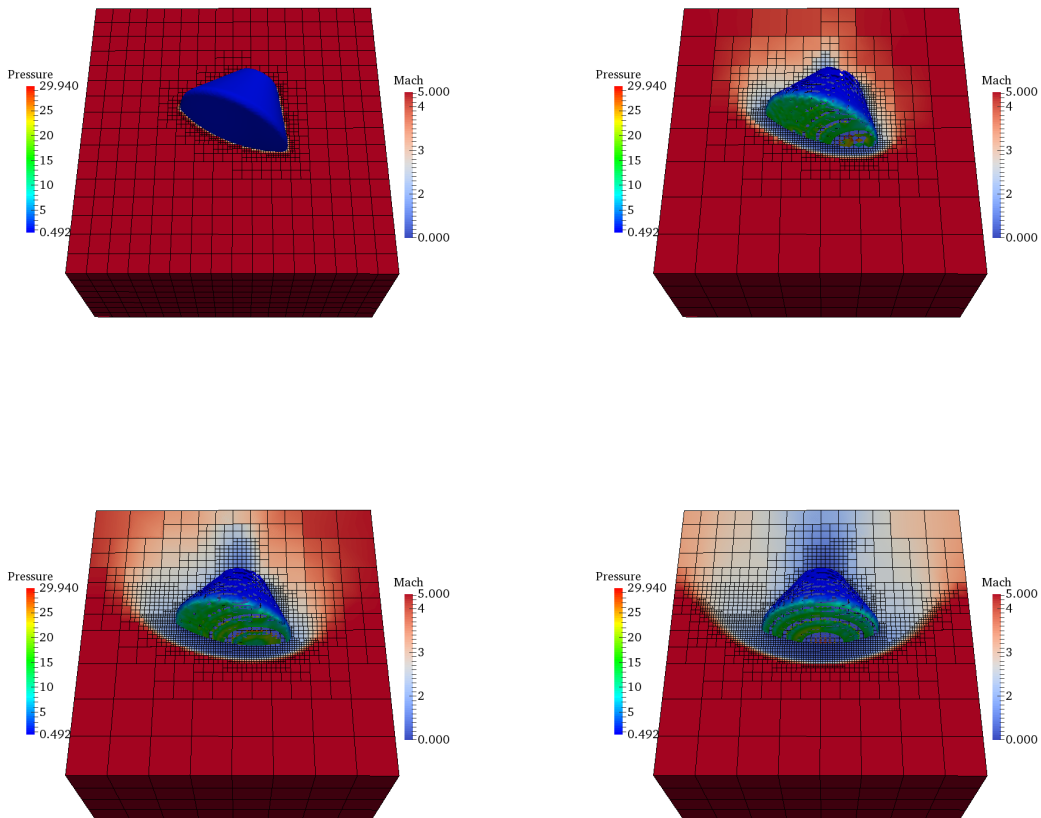


Figure 5. Capsule reentry dynamics in 3D. Rarefied flow and parallel adaptive grid refinement via Octrees.

## MNEMOSYNE Project-Team

# 5. Highlights of the Year

## 5.1. Highlights of the Year

### 5.1.1. *ReScience journal*

Nicolas Rougier has co-founded the ReScience journal (<http://rescience.github.io/>) with Konrad Hinsen and is one the Editor-in-chief. ReScience is a peer-reviewed journal that target computational research and encourage the explicit replication of already published research promoting new and open-source implementations in order to ensure the original research is replicable.

### 5.1.2. *Most viewed and downloaded article*

Our paper [4] is in the spotlight of the Frontiers blog (cf. <http://blog.frontiersin.org/2015/12/22/spotlight100/>): among the 100 articles the most viewed and downloaded among over 12,500 articles published by Frontiers in 2015.

### 5.1.3. *Awards*

Our paper was given the Best Paper Award at the 2015 International Conference on Neural Computation Theory and Applications, cf. <http://www.ncta.ijcci.org/PreviousAwards.aspx>

BEST PAPERS AWARDS :

[11] **International Joint Conference on Computational Intelligence.** R. KASSAB, F. ALEXANDRE.



## Monc Team

# 5. Highlights of the Year

## 5.1. Highlights of the Year

### Awards

Perrine Berment won the third price of *Ma thèse en 180 secondes* of the Aquitaine region.

## **PHOENIX Project-Team**

# **5. Highlights of the Year**

## **5.1. Highlights of the Year**

### **HomeAssist 500.**

We are launching a massive deployment of HomeAssist in the homes of 500 older adults. This experiment will take the form of a randomized controlled trial and will be done over a period of 12 months. More details are given in Section [8.1.2](#) .

**PLEIADE Team (section vide)**

## **POSET Team**

# **5. Highlights of the Year**

## **5.1. Highlights of the Year**

Two presentations, by D. Janin and S. Salvati, at ICALP 2013, a leading conference in the field of formal language theory and its applications to computer science, have eventually been selected among the 16 out of 120 papers for a complete version to appear this year in the associated special issue (see [15] and [16]).

## POTIOC Project-Team

# 5. Highlights of the Year

## 5.1. Highlights of the Year

- Fabien Lotte obtained the ANR project REBEL (JCJC, acceptance rate 9.7%). More details in Section [9.2](#)
- We have conceived a new system that aims at teaching Optics in an innovative way (Patent pending). This system mixes spatial augmented reality and tangible interaction. It is currently evaluated based on a panel of more than one hundred students. This work is conducted in collaboration with experts in Optics and Electronics (Univ. Bordeaux), and Education Sciences (Univ. Lorraine). More details in Section [7.6](#) .

### 5.1.1. Awards

IFRATH PhD Award, First Prize ex-aequo with J. Veytizou, Institut Fédératif de Recherche sur les Aides Techniques pour personnes Handicapées, June 2015 (Anke Brock)

BEST PAPERS AWARDS :

[39] **Colloque des Jeunes Chercheurs en Sciences Cognitives**. C. JEUNET.

[27] **PhyCS - International Conference on Physiological Computing Systems**. J. FREY.

## REALOPT Project-Team

### 5. Highlights of the Year

#### 5.1. Highlights of the Year

The international society in Mathematical Optimisation (MOS) has selected the bid of Realopt for the organization of the next triennial international congress of mathematical optimization. Hence, the 23rd International Symposium on Mathematical Programming (ISMP 2018) shall take place in Bordeaux. The web site is in construction <http://ismp2018.sciencesconf.org>. This symposium is the most prestigious scientific event in the field of optimization by the quality of its program and its size (it can gather close to 2000 participants). This event has received strong support from the University of Bordeaux, Inria and CNRS, along side national scientific societies: Roadeff and SMAI.

The team is tightening its links with industrial partners: our Inria Innovation Lab with Ertus-consulting has been launched; we have had two recruitments (a PhD and a Post-doc) this year on our production planning project with EDF; Saint Gobain is very enthusiastic about our progress in solving glass cutting problems, and Renault was quite happy with the challenge on logistic issues that we organized for them.

We are making progress on methodologic developments of algorithms for large scale optimization (convergence acceleration, filtering to reduce problem size, math heuristics, approximation algorithms) and their application (in cloud computing, scheduling, and planning). In particular, two of our papers were accepted at the prestigious conference IPDPS'16. Our research collaborations are being tightened in particular through the SAMBA associated team project: Ruslan Sadykov is spending a sabbatical year in Brasil in our associated team. We established a new partnership with KEDGE business school.

## SISTM Project-Team

# 5. Highlights of the Year

## 5.1. Highlights of the Year

### 5.1.1. Time-Course Gene Set Analysis for Longitudinal Gene Expression Data

A work in collaboration with J. Skinner has been published in *PLoS Computational Biology* : [10]

Gene set analysis methods, which consider predefined groups of genes in the analysis of genomic data, have been successfully applied for analyzing gene expression data in cross-sectional studies. The time-course gene set analysis (TcGSA) introduced here is an extension of gene set analysis to longitudinal data. The proposed method relies on random effects modeling with maximum likelihood estimates. It allows to use all available repeated measurements while dealing with unbalanced data due to missing at random (MAR) measurements. TcGSA is a hypothesis driven method that identifies a priori defined gene sets with significant expression variations over time, taking into account the potential heterogeneity of expression within gene sets. When biological conditions are compared, the method indicates if the time patterns of gene sets significantly differ according to these conditions. The interest of the method is illustrated by its application to two real life datasets: an HIV therapeutic vaccine trial (DALIA-1 trial), and data from a recent study on influenza and pneumococcal vaccines. In the DALIA-1 trial TcGSA revealed a significant change in gene expression over time within 69 gene sets during vaccination, while a standard univariate individual gene analysis corrected for multiple testing as well as a standard Gene Set Enrichment Analysis (GSEA) for time series both failed to detect any significant pattern change over time. When applied to the second illustrative data set, TcGSA allowed the identification of 4 gene sets finally found to be linked with the influenza vaccine too although they were found to be associated to the pneumococcal vaccine only in previous analyses. In our simulation study TcGSA exhibits good statistical properties, and an increased power compared to other approaches for analyzing time-course expression patterns of gene sets. The method is made available for the community through an R package.

### 5.1.2. Two new books

DC is co-editor and RT is co-author of the two following books :

- Daniel Commenges and H el ene Jacqmin-Gadda (2015), *Dynamical Biostatistical Models*, Chapman & Hall.
- Daniel Commenges and H el ene Jacqmin-Gadda (2015), *Mod eles biostatistiques pour l' pid miologie*. De Boeck.

## **STORM Team**

# **5. Highlights of the Year**

## **5.1. Highlights of the Year**

STORM received an H2020 FETHPC Grant for taking part in the INTERTWinE European project to be run from Oct. 2015 to Sep. 2018, to promote interoperability between multiple runtime systems and application support layers.



**TADAAM Team (section vide)**