



RESEARCH CENTER

FIELD

**Applied Mathematics, Computation
and Simulation**

Activity Report 2012

Section highlights of the Team

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BACCHUS Team

2.2. Highlights of the Year

- Many achievements in rocket science have been made since Apollo, but prediction of the heat flux to the surface of spacecraft remains an imperfect science, and inaccuracies in these predictions can be fatal for the crew or the success of robotic missions. Predicting an accurate heat flux is a particularly complex task, regarding uncertainty on the complex multi-physics phenomena involved in hypersonic flows models as well as on atmospheric properties such as density and temperature. Hence, it is difficult to establish “error bars” on the heat flux prediction. We succeeded the first call for project from ESA concerning uncertainty quantification for aerospace applications. In this project, we are the main investigator concerning the set-up of efficient numerical techniques for UQ.
- In June and July, we joined the NASA Center for Turbulence Research (CTR) Summer Program at Stanford University. We developed a novel method to solve stochastic partial differential equations, in particular hyperbolic equations.
- We have developed an algorithm for the robust construction of curved simplicial meshes in two and three dimensions. Starting from a classical (straight) mesh, we are able to curve the boundary elements then the volumic ones in keeping as much as possible the structure of the initial mesh. In particular, this algorithm does not destroy the boundary layer structures, even for meshes designed for turbulent simulations.
- We have succeeded in having Residual Distribution schemes that are *uniformly* accurate whatever the Peclet number for scalar advection diffusion problems. The schemes have been extended to turbulent flow simulations.
- The native scheduler of the PaStiX solver can be replaced with generic runtimes to address sparse direct factorizations on heterogeneous architectures (clusters of multicore/multigpu). Our results on heterogeneous architectures show we can easily improve the factorization time on a personal computer (1 GPU and several cores), and we have identified leads, both on algorithms and on schedulers, to optimize the performances on larger platforms.

CAD Team (section vide)

CAGIRE Team (section vide)

CALVI Project-Team

2.2. Highlights of the Year

January 2012 : Anaïs Crestetto and Philippe Helluy have been awarded the fourth prize of the international “OpenCL Innovation Challenge” organized by the AMD company. They have simulated the electron beam inside an X ray generator on GPU. See <http://developer.amd.com/community/events/amd-opencl-coding-competition-2/>

September 2012 : Eric Sonnendrücker has obtained a position at the Max Planck Institute in Garching.

October 2012 : Michel Mehrenberger has defended his ‘Habilitation à diriger des recherches’.

CASTOR Team (section vide)

COFFEE Project-Team (section vide)

CONCHA Project-Team (section vide)

DEFI Project-Team

2.2. Highlights of the Year

- Grégoire Allaire was elected as president of SMAI.

GAMMA3 Project-Team

2.2. Highlights of the Year

Paul-Louis George : Inria - Dassault Systèmes 2012 Innovation Award winner:

Team leader of the Gamma3 project team (Inria, Troyes University of Technology), Paul-Louis George is one of the inventors of the GHS3D volume mesh, a software used throughout the world by players in the industry, researchers and academics. Integrated in several software for 3D calculations by finished elements, GHS3D helps obtain simulations which are particularly reliable and high performing. A success based on teamwork undertaken over the long term and which is now being rewarded with the innovation award.

IPSO Project-Team

2.3. Highlights of the Year

- The team is part of the newly accepted Labex “Lebesgues Center” (see <http://www.lebesgue.fr/>).
The Lebesgue Center (Foundations, Interactions, Application and Training) has been selected as an excellence cluster in February 2012. The Center proposes to build a highly attractive and efficient Research Center and Graduate School in Western France that will coordinate the research in geometry, analysis, statistics and probabilities with strong interdisciplinary links to the socio-economic environment and its applications.
Coordinators : Vũ Ngọc San (Irmarr, Rennes 1) together with Arnaud Debussche (Irmarr, ENS Cachan, IPSO), Christoph Sorger and Laurent Guillopé (LMJL, Nantes).
- Two members of the team, Florian Méhats and Mohammed Lemou, published a paper in “*Inventiones Mathematicae*” (see [31])
- Erwan Faou published the book [34] in the series “Zurich Lectures in Advanced Mathematics. Zürich: European Mathematical Society (EMS)”.
- Arnaud Debussche has launched with Boris Rozovskii a new journal entitled “*Stochastic Partial Differential Equations: Analysis and Computations*”, edited by Springer.

MC2 Project-Team (section vide)

MICMAC Project-Team (section vide)

NACHOS Project-Team (section vide)

NANO-D Team

2.3. Highlights of the Year

Stephane Redon has received an ERC Starting Grant in 2012 for his ADAPT project (ADAPT: Theory and algorithms for Adaptive Particle Simulation). The grant is about 1.5 million euros over 5 years.

OPALE Project-Team

2.3. Highlights of the Year

Our activity in road traffic modeling is reinforced by the creation of the Associated Team ORESTE with UC Berkeley.

Our activity in pedestrian flow modeling is reinforced by the doctoral thesis of M. Mimault, started in October, and the enrollment of M. Twagorowska on a post-doctoral position.

POEMS Project-Team

2.2. Highlights of the Year

Among the significative scientific advances and successes of this year, we would like to emphasize:

- The habilitation of L. Bourgeois on various inverse problems governed by elliptic equations.
- The PhD thesis of J. Chabassier on the numerical simulation of a grand piano
- The PhD thesis of L. Chesnel on the analysis of dign changing transmission coefficients with applications to electromagnetic metamaterials.
- Three new ANR Projects : CHROME on electromagnetic wave propagation in fusion plasmas, SODDA on the non destructive testing of networks of electric cables and RAFFINE about a posteriori estimators for integral equations.

SCIPORT Team (section vide)

SIMPAF Project-Team (section vide)

APICS Project-Team (section vide)

BIPOP Project-Team (section vide)

COMMANDS Project-Team (section vide)

CORIDA Project-Team

2.2. Highlights of the Year

BEST PAPER AWARD :

[45] **2nd International Symposium on Environment-Friendly Energies and Applications, EFEA 2012.**
T. MANRIQUE-ESPINDOLA, H. MALAISE, M. FIACCHINI, T. CHAMBRION, G. MILLÉRIOUX.

DISCO Project-Team

2.2. Highlights of the Year

With Anja Korporal and Markus Rosenkranz, G. Regensburger got the *Distinguished software presentation* award at ISSAC 2012 (International Symposium on Symbolic and Algebraic Computation) for the MAPLE packages `IntDiffOp` and `IntDiffOperations` (see [17]).

GECO Team

2.1. Highlights of the Year

Emmanuel Trélat obtained the Felix Klein Prize at the 6th European Congress of Mathematics in Krakow.

Motivations by the prize committee: Emmanuel Trélat receives the Felix Klein Prize for combining truly impressive and beautiful contributions in fine fundamental mathematics to understand and solve new problems in control of PDE's and ODE's (continuous, discrete and mixed problems), and above all for his studies on singular trajectories, with remarkable numerical methods and algorithms able to provide solutions to many industrial problems in real time, with substantial impact especially in the area of astronautics.

MAXPLUS Project-Team (section vide)

MCTAO Team

2.2. Highlights of the Year

- The team started this year.
- Bernard Bonnard publishes, with Dominique Sugny from University of Bourgogne, a reference book on control applications to Quantum Dynamics and Space Dynamics [18].

NECS Project-Team

2.2. Highlights of the Year

The most relevant events for the NeCS team in 2012 are the following:

- Carlos Canudas de Wit has been elected as member of the Board of Governor (BoG) of the IEEE Control System Society (CSS)
- The team animated the In'Tech seminar on intelligent transportation systems in November 2012.

NON-A Project-Team

2.3. Highlights of the Year

- The survey paper on delay systems [126] is the ScienceDirect TOP 1 hottest article of Automatica since July 2009;
- HdR of Join C. "Une approche algébrique pour la pratique de l'estimation, du diagnostic, de la commande et de la finance" [12], Université de Lorraine, June 2012;
- HdR of Efimov D. "Analysis, control and estimation of nonlinear oscillations" [11], Inria, November 2012;
- Patent pending (FR11/51604) on the control of traffic flow.

CLASSIC Project-Team (section vide)

DOLPHIN Project-Team

2.2. Highlights of the Year

- Francois Clautiaux: Premier accessit for Prix Robert Faure 2012.
- Best paper award at conference ICORES'2012 1st International Conference on Operations Research and Enterprise Systems, Vilamora, Portugal, Feb 2012 [44] . Rita Macedo, Said Hanafi, Francois Clautiaux, Claudio Alves, José Valério de Carvalho, Generalized disaggregation algorithm for the vehicle routing problem with time windows and multiple routes.
- Best paper award at GECCO'2012 (Genetic and Evolutionary Computation Conference, EMO Track), Philadelphia, USA, July 2012 [37] . D. Brockhoff, T. Wagner, H. Trautmann, On the Properties of the R2 Indicator.

BEST PAPERS AWARDS :

[44] **ICORES 2012, 1st International Conference on Operations Research and Enterprise Systems, Vilamora, Portugal, 4-6 february, 2012.** R. MACEDO, S. HANAFI, F. CLAUTIAUX, C. ALVES, J. M. VALÉRIO DE CARVALHO.

[37] **GECCO'2012.** D. BROCKHOFF, T. WAGNER, H. TRAUTMANN.

GEOSTAT Project-Team (section vide)

MISTIS Project-Team

2.2. Highlights of the Year

Our paper [33] entitled *An Improved CUDA-Based Implementation of Differential Evolution on GPU* was nominated and finalist for the best paper award in the Digital Entertainment Technologies and Arts / Parallel Evolutionary Systems session of the Genetic and Evolutionary Computation Conference 2012 (Gecco 2012).

MODAL Project-Team

2.2. Highlights of the Year

- The team finished the development of the blockcluster R package, allowing to process efficient and parsimonious generative models on huge data sets for different kinds of variables (see Section 5.2).
- The team developed also a R package of MIXMOD and started to develop a new version for simultaneous mixed categorical and continuous data (see Section 5.1).

REALOPT Project-Team

2.2. Highlights of the Year

Our scientific output is marked by strong publications in prestigious journals such as *Discrete Mathematics*, *Mathematical Programming*, *EURO Journal on Computational Optimization*, *INFORMS Journal on Computing*, and *Operations Research*, for instance, with contributions ranging from theoretical and methodological to numerical and applied industrial problem solving. This is completed by conference invitations in China, Chili and Canada and proceedings in selective conferences.

Our methodology of combining an extended formulation approach with Dantzig-Wolfe decomposition and column generation, that is now published [21], is a great illustration of our team's threefold objective: it is a theoretically proved method, playing the complementary between exact optimization techniques, and leading to an computational edge in application solving. This methodology is a key tool for currently ongoing collaboration with EDF and Russian partners on railway applications.

The Samba project with our associated team in Brasil is picking up a new pace, with good progress on primal heuristics [27] [30] and stabilization techniques [23] [25] [29] [32]. In the coming year, short term visits will be completed by a one-month stay of Professor Uchoa, and a one-year-stay of his PhD student.

The composition of the team is going through rapid evolution: Gautier Stauffer, our Inria Chair, has been promoted as a Professor in Grenoble; Andrew Miller has returned to the US. Both positions have been re-published in our thematic. We are currently building tighter links with CEPAGE by building closer work relations with Olivier Beaumont, Lionel Eyraud-Dubois, and Paul Renaud-Goud who share our methodologies, while emphasizing our expertise in the application domain of cloud computing.

The team has been integrated in the LaBEX CPU. The complete team participates in the WP5 "Network and Service Optimization". At the same time, there is a participation in the WP6 "Codes, Cryptologie, Algorithmique Arithmétique" with the proper methodology of the team.

SELECT Project-Team (section vide)

SEQUEL Project-Team (section vide)

SIERRA Project-Team

2.2. Highlights of the Year

- Rodolphe Jenatton (former PhD student, graduated in 2011) received two thesis prizes (Fondation Hadamard and AFIA).
- Francis Bach received the Inria young researcher prize.
- Monograph published in the collection *Foundations and Trends in Machine Learning*: “Optimization with sparsity-inducing penalties”.

TAO Project-Team

2.3. Highlights of the Year

- Energy management is becoming one of the main focuses, and the most important applicative focus of TAO UCT-SIG. Underlying the various debates, ranging from climate change to nuclear power and integration of renewable energies in the grid (including transportation and storage), is a burning need for scenario simulation, evaluation and optimization. The scientific challenges concern the handling of continuous and discrete uncertainties (e.g. ecological impacts or emergence of future technologies) with a long term horizon. Our commitment is to provide principled studies of various investment scenarios in economical and ecological terms, including a rigorous handling of uncertainties. Specifically,
 - We actively worked to develop collaborations between European and Taiwanese experts of energy management (organization of a forum in Taiwan, <http://top.twman.org/2012frtw>, of meetings between French companies and Taiwanese academic visitors in Limoges and Paris <http://www.lri.fr/teytaud/france2012.html>).
 - We developed a Ilab (collaboration between Inria Saclay-IDF / Artelys) on energy, involving our common participation to the European project Citines <http://www.citines.com>, aimed at optimal energy management at the scale of a city or an industrial area. We also successfully applied for an ADEME project named POST, aimed at the long term (2050) optimization of the power grid in Europe and North Africa and raising hard stochastic stock management issues. Another critical issue concerns the representation of strategies enabling to combine the good long term properties of direct policy search, and the efficiency of combinatorial optimization tools for structured problems. Additionally, a collaboration with Inria-Chile is under discussion. We are also working on creating a company in Taiwan, working with tools from the French industry.
 - We also participated in several energy-related European meetings, including companies (section 8.5.1).
- Games remain a key and cool showcase to demonstrate the efficiency of our algorithms: Our meta-learning approach in Monte-Carlo Tree Search (MCTS) was illustrated by playing 12 games against professional players in even conditions in 7x7; it won 7 games (6/6 win with the easy side and 1/6 win with the difficult side). We achieved the best performances so far on small board minesweeper, demonstrating the efficiency of MCTS on one-player stochastic games. In collaboration with Olivier Buffet (Loria), we scaled up previous implementations to large boards, demonstrating the efficiency of Monte-Carlo Tree Search as a tool for improving existing heuristics. For illustrating the pedagogical properties of simulation-based approaches, we developed tools for generating nice test cases in games and automatically checking the opponent level. Besides, we realized experimental biological measurements (neuro-imagery, skin conductivity) on amateur and professional players, for further comparison and analysis.
- One of the main fundamental milestones on the TAO research agenda has been achieved by the OPT-SIG, bridging the gap between practice and theory in stochastic optimization through information-geometric optimization (IGO). IGO is devised as a canonical way to turn any smooth parametric family of probability distributions on an arbitrary, discrete or continuous search space X into a continuous-time black-box optimization method on X . Rooted on the Fisher metric, IGO shows invariance properties under various parameterizations of the distribution family [71], [19], [20]. IGO covers the state-of-art CMA-ES (invariant w.r.t. monotonous transformations of the objective function and linear transformations of the coordinate space) as a special case where the probability distribution is Gaussian.

This paper got the *excellent paper award* (international track) at TAAI conference (given to 3/55 papers).

BEST PAPER AWARD :

[36] TAAI. C.-W. CHOU, P.-C. CHOU, C.-S. LEE, D. LUPIEN SAINT-PIERRE, O. TEYTAUD, M.-H. WANG, L.-W. WU, S.-J. YEN.

ALEA Project-Team

2.2. Highlights of the Year

The book [33] presents a series of novel results on the design and analysis of new classes of mean field particle models in numerical finance, including particle sensitivity measures, calibration models, and particle option pricing algorithms.

ASPI Project-Team (section vide)

CQFD Project-Team

2.2. Highlights of the Year

CQFD made advances in the practical use of its algorithms with DCNS. In the particular case of submarine command, we have coupled an tracking algorithm with an optimization code in order to compute optimal trajectories using only signals issued from embedded sonars. These results will be developed in an operating simulator.

The CQFD team created in 2012 a new annual national conference for the users of the statistical software R. The "Premières Rencontres R" are conceived as a place to present and share ideas on using the R statistical software. This meeting is designed to be a nationwide event where various topics belong, such as graphical tools, applied statistics, biostatistics, bayesian statistics, bioinformatics, data analysis, modeling, machine learning, high performance computing, etc...

The Rencontres R contained 5 guest lectures, 32 regular talks, 12 Lightning Talks and 6 posters on the following topics :

- new advances in statistics and their implementation with R,
- new R packages,
- applications or original case studies involving the R software (genetics, bioinformatics, environment, psychometrics, social sciences, neuroscience, etc...),
- computer features about the R software (multithreading, graphical tools, binding with other softwares, etc...) ,
- topics about teaching methods with R.

This meeting was intended to everyone interested in R: researchers, teachers, people from industries, students, etc... It was built for both beginners and advanced R users, statisticians and informaticians, as well as wellwishers from every area where R can be useful. More than hundred participants attended this first edition of the conference.

I4S Team

2.2. Highlights of the Year

- + Prize : M. Döhler has received the Foundation of Rennes 1st Prize 2012 for his PhD.
- + The team was given the privilege to organize the next joint EWSHM and PHM conference in 2014 in Nantes together with IFSTTAR and Nantes University.

MATHRISK Team

2.6. Highlights of the Year

Creation of the Mathrisk Project Team.

REGULARITY Project-Team

2.2. Highlights of the Year

- Release of version 2.1 of the software toolbox FracLab.

BEST PAPER AWARD :

[39] **International Conference on Mass Data Analysis of Images and Signals (MDA'2012)**. J. LÉVY-VÉHEL, M. TESMER.

TOSCA Project-Team (section vide)