RESEARCH CENTER

FIELD
Applied Mathematics, Computation and Simulation

Activity Report 2015

Section Highlights of the Team

Edition: 2016-03-21

ACUMES Team (section vide)

CAGIRE Team

5. Highlights of the Year

5.1. Highlights of the Year

First DNS simulation of a turbulent flow with AeroSol

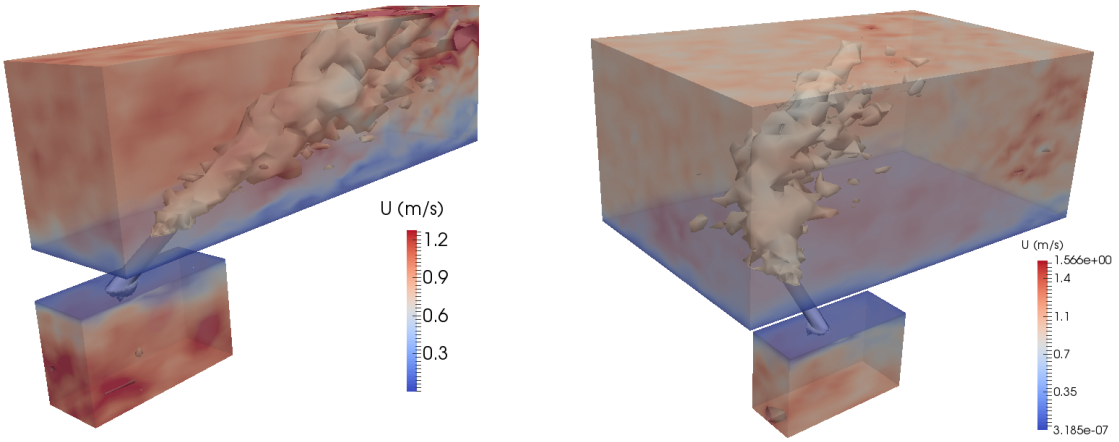

Figure 3. DNS of jets in crossflow (AeroSol-DG2): Examples of snapshots of instantaneous surfaces of the velocity norm. Left - With a 0-degree jet skidding (MAVERIC configuration). Right - With a 90-degree jet skidding.

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.mmgtools.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 OCEANEranet 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 ;

DEFI Project-Team (section vide)

ECUADOR Project-Team (section vide)

GAMMA3 Project-Team

3. Highlights of the Year

3.1. Highlights of the Year

3.1.1. Awards

BEST PAPERS AWARDS :
[] **Procedia Engineering**. A. LOSEILLE, V. MENIER, F. ALAUZET.

IPSO Project-Team

4. Highlights of the Year

4.1. Highlights of the Year

4.1.1. Awards

E. Faou received the SIAM Germund Dahlquist prize in september 2015.

MATHERIALS Project-Team (section vide)

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.

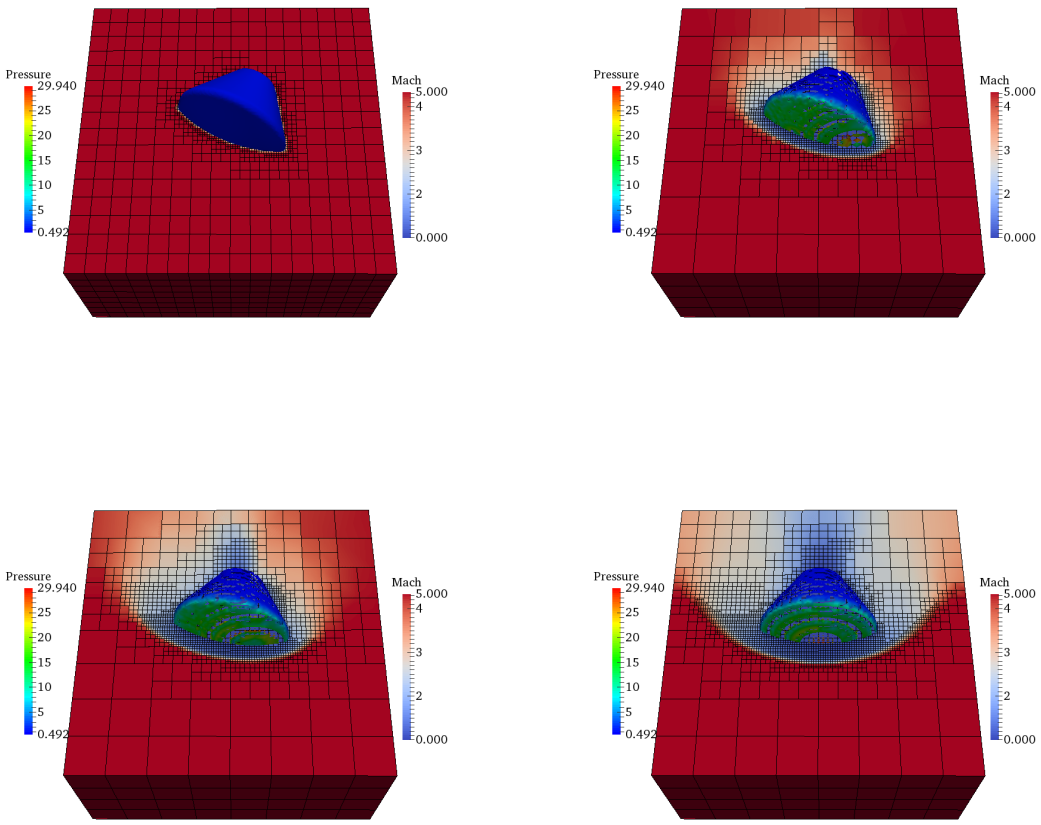

Figure 5. Capsule reentry dynamics in 3D. Rarefied flow and parallel adaptive grid refinement via Octrees.

MEPHYSTO Team

5. Highlights of the Year

5.1. Highlights of the Year

Scientific results

The team obtained two striking results in 2015.

- In collaboration with Felix Otto, Antoine Gloria obtained near-optimal estimates with optimal stochastic integrability in stochastic homogenization under a finite range of dependence assumption, cf. [35].
- In collaboration with physicists at PhLAM, Stephan De Bièvre and Guillaume Dujardin, proposed in [18] an analysis of the phenomenon of modulational instability in an optic fiber, induced by periodic modulation of the dispersion of the fiber. In particular, they characterized the frequencies at which the gain occurs and provided sharp estimates of that gain. Both numerical and physical experiments supported the analysis, cf. Figure 2 which displays the experimental gain (above) and the numerical gain (below).

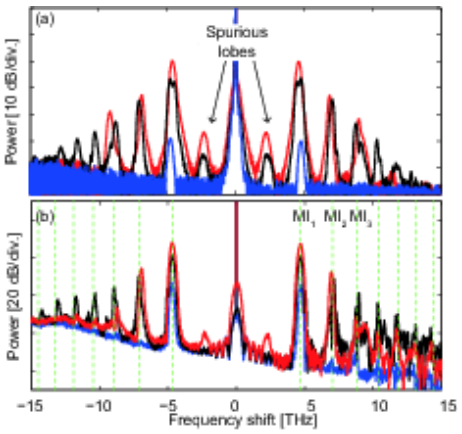

Figure 2. Experimental (above) and numerical (below) gain for the modulational instability in (periodic) optic fibers

Awards

Antoine Gloria was awarded the Agathon De Potter prize in mathematics from the Académie royale de Belgique.

MOKAPLAN Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

Fast entropic methods for optimal transport problems: In a series of papers [19] [34] [10] [15] , MOKAPLAN's team members derived a new class of algorithm to obtain efficient approximations of the solution to various problems related to OT (including barycenters, Euler equation, unbalanced problems, gradient flows). This method makes use of entropic regularization and first order optimization method for the Kullback-Leibler divergence. See Section 6.3 for details about the software output.

Relaxing the mass conservation constraints: Our team derived a new theoretical and numerical framework to deal with "unbalanced" optimal transport problems [38], [39]. This contribution is a breakthrough that will open the door to application in image processing and machine learning. See Section 7.6 for more details.

NACHOS Project-Team (section vide)

NANO-D Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

We have released the first version of the SAMSON software platform for computational nanoscience on the SAMSON Connect website (http://www.samson-connect.net). Using the SAMSON Connect website, users may download SAMSON and choose which SAMSON Elements (modules for SAMSON) to add to their configuration (e.g. a nanotube creator, for users interested in materials science). Developers may download the SAMSON Software Development Kit (SDK) to develop SAMSON Elements and upload them to the SAMSON Connect website. We are frequently releasing updates, on Windows, Linux, and Mac (Figure 3).

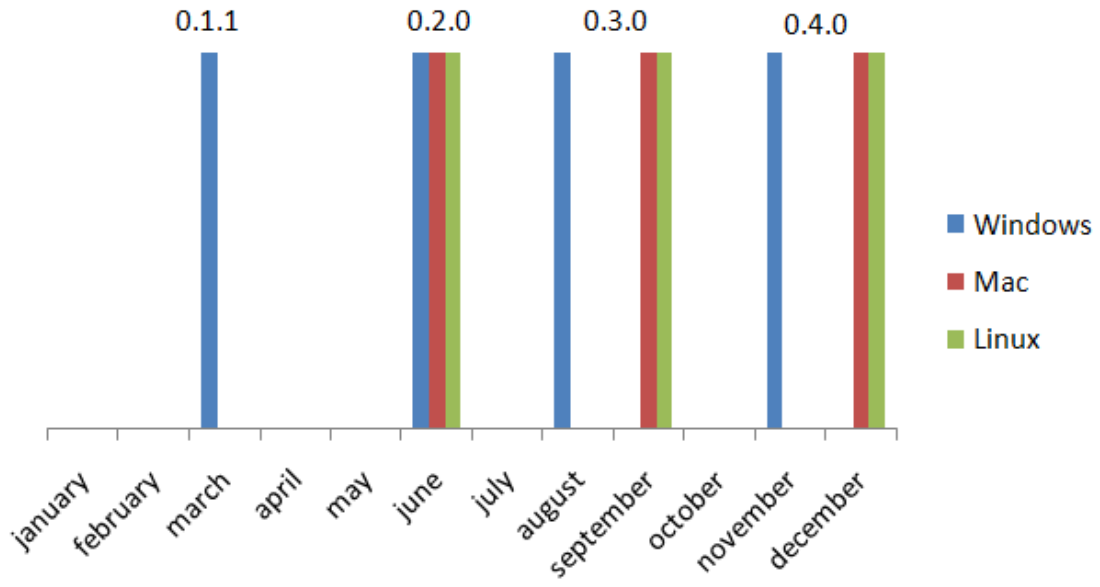

Figure 3. Release dates of the various versions of SAMSON

POEMS Project-Team (section vide)

RAPSODI Team

5. Highlights of the Year

5.1. Highlights of the Year

The research team RAPSODI was created on August 1, 2015.

A new nonlinear numerical method for solving possibly degenerate parabolic problems with gradient flow structure was proposed and analyzed by C. Cancès & C. Guichard in [35]. This method is second order accurate in space and preserves the variational structure of the continuous problem, ensuring by the way the decay of the physical entropy. Moreover, it is more robust with respect to strong anisotropy ratios than the method proposed in [15] that was only first order accurate in space.

APICS Project-Team (section vide)

BIPOP Project-Team (section vide)

COMMANDS Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

5.1.1. Awards

- B. Heymann received a Siebel Scholar fellowship from the Siebel foundation. These fellowships are given to top graduate students of partner institutions, namely here the Ecole Polytechnique. See the List of Siebel Scholars

DISCO Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

Dec. 2015 - Frédéric Mazenc is President of the "Commission Scientifique" Inria Saclay-Ile-de-France.

GECO Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

- GECO is one of one of the partners of the ANR SRGI, which has been funded in 2015. SRGI deals with sub-Riemannian geometry, hypoelliptic diffusion and geometric control.
- In the recent preprint [23] we answer an open problem proposed by J.P. Hespanha in 2003 in the volume "Unsolved Problems in Mathematical Systems & Control Theory". The problem deals with the characterization of the finiteness of the L_2-gain of a switched linear control systems, in dependence of the value of the minimal dwell-time of its switching laws.

I4S Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

Paper [30]. was nominated for best paper at IFAC SAFEPROCESS in 2015.

A. Nassiopoulos is launching the startup Ecotropy from December 2015.

Maxplus Team

5. Highlights of the Year

5.1. Highlights of the Year

5.1.1. Awards

- Pascal Benchimol obtained in June 2015 a prize of Ecole polytechnique for his PhD thesis [70].
- Best paper award for the paper presented by Nikolas Stott of EMSOFT'15.

BEST PAPERS AWARDS :
[29] **International Conference on Embedded Software (EMSOFT'2015)**. X. ALLAMIGEON, S. GAUBERT, E. GOUBAULT, S. PUTOT, N. STOTT.

MCTAO Project-Team (section vide)

NECS Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

- The publication of the book *Multisensor Data Fusion: From Algorithms and Architectural Design to Applications*, edited by Hassen Fourati
- Carlos Canudas de Wit was in the organizing committee of IPAM Long Program 'New Directions in Mathematical Approaches for Traffic Flow Management'
- Hassen Fourati was elected at CNU 61 and Alain Kibangou was elected at Conseil du pôle MSTIC, UGA

NON-A Project-Team

4. Highlights of the Year

4.1. Highlights of the Year

- Concepts of Homogenenty, Implicit Lyapunov Functions and Convergence in Finite/Fixed time are now extended to different classes of dynamic systems (e.g time delay systems [27], distributed parameters systems [67], time-varying systems [42], MIMO systems[38], [25], differential inclusions [37], multi agent systems [19],[23]). In this context, ANR Project Finite4SOS (cordinator: Wilfrid Perruquetti) is accepted for 2015-2020. It is aimed at development of different tools for non-asymptotic control and estimation for System of Systems.
- Living sensor is a biological organism, which can be utilized as a sensor of some enveronmental characteristics. In collaboration with Aquatic Ecotoxicology (EA) team from CNRS Lab "Environnements et Paleoenvironnements Oceaniques et Continentaux", University of Bordeaux 1, we developed innovative methods for monitoring the water quality using oysters as biological sensors [16], [51], [15]. The project ANR WAQMOS (coordinator: Denis Efimov) is supported for 2015-2020. It is aimed at creation of novel oyster-based living sensors (including hardware and software development).
- We provided a novel solution for motion control of wheeled mobile robots with obstacle avoidance (for single robot [32], [32] and a formation of robots [60]).
- From september 2015, model-free control [84],[7] is applied to control the traffic on A25 (access ramp « La Chapelle-d'Armentières »), users and DiRN are satified with results (http://www.lavoixdunord.fr/region/feu-intelligent-de-l-a25-quel-bilan-quatre-mois-apres-ia11b49733n3187841).

Awards

- Prize of "ABB AWARD: Best application/case study paper", IFAC Safeprocess, Paris, 2015, see [80].

QUANTIC Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

- First demonstration of Quantum Zeno Dynamics of light: this important experimental result offers a new scheme to control quantum systems based on light modes and was published in Science in 2015 [13].
- In a collaboration with the team of Michel H. Devoret at Yale university, we engineered a new form of quantum friction. By engineering a particular non-linear interaction between a quantum harmonic oscillator (a superconducting cavity mode) and a driven bath, we were able to stabilize a manifold of quantum states. This result which was published in Science in 2015 [18] should lead to a new direction of research in quantum information processing with driven dissipative systems.
- In a collaboration with the team of Robert J. Schoelkopf at Yale university, we were able to realize a version of Schrdoinger's cat thought experiment. We were able to entangle an artificial atom to a cat state of a quantum harmonic oscillator. We were able to characterize this entanglement using the Clauser-Horne-Shimony-Holt formulation of a Bell test. This result was published in Nature Communications [25].

SPHINX Team

5. Highlights of the Year

5.1. Highlights of the Year

In collaboration with Colin Guillarmou, Matti Lassas and Jérôme Le Rousseau, David Dos Santos Ferreira organized an IHP trimester on Inverse Problems hold in April-June 2015 (more than 100 participants).

DOLPHIN Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

5.1.1. Awards

- Best paper award at GECCO 2015 (ECOM track, Madrid, Spain, 2015) for the paper “Global vs local search on multi-objective NK-landscapes: contrasting the impact of problem features” , by F. Daolio, A. Liefooghe, S. Verel, H. Aguirre, K. Tanaka. This work is part of our collaboration with Shinshu University in Japan (Associate team s3-bbo and JSPS-MEXT project) on fitness landscape analysis and search performance. In this paper, we consider two prototypical multi-objective optimization algorithms and relate their performance on combinatorial optimization problems with tunable ruggedness, objective space dimension, and objective correlation. Our study departs from simple performance comparison by systematically analyzing the correlation between runtime and problem features, contrasting their association with search performance within and across problem classes. A mixed-model approach allows us to further generalize from the experimental design, supporting a sound assessment of the joint impact of problem features on the search performance.
- Best paper award of “11^{th} Intl. Conf. on Parallel Processing and Applied Mathematics" (PPAM’2015, Krakow, September 6-9). assigned to Jan Gmys, Mohand Mezmaz, Nouredine Melab and Daniel Tuyttens for their article entitled "IVM-based Work Stealing for Parallel Branch-and-Bound on GPU" . This work falls within the framework of the Ph.D thesis of Jan Gmys from University of Mons in cotutelle with Université Lille 1. The contribution consists in revisiting on GPU the parallel design and implementation (based on the Work Stealing paradigm) of the Branch-and-Bound algorithm applied to permutation problems. The raised challenge, which is the originality of the contribution, is to efficiently perform highly irregular exploration process entirely on the GPU having a SIMD architecture.
- Thesis Prize: 26th Nov 2015: Julie Jacques (Phd 2011) won the "Force Awards Nord de France" trophee in the category "thesis with an industrial". Her thesis work, in collaboration with the Dolphin team and the Alicante company, aimed at providing new datamining approaches in order to optimize inclusion in clinical trials.

BEST PAPERS AWARDS :
[31] **GECCO’15 - Proceedings of the 24th ACM Annual Conference on Genetic and Evolutionary Computation**. F. DAOLIO, A. LIEFOOGHE, S. VEREL, H. AGUIRRE, K. TANAKA.
[54] **11th Intl. Conf. on Parallel Processing and Applied Mathematics**. J. GMYS, M. MEZMAZ, N. MELAB, D. TUYTTENS.

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].

INOCS Team (section vide)

MISTIS Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

- Creation of the Pixyl startup (http://pixyl.io). Pixyl is a startup created in March 2015 by F. Forbes with M. Dojat (INSERM), a former post-doctoral fellow S. Doyle (CEO) and IT Translation. F. Forbes is a co-founder and a scientific advisor. Pixyl specializes in automatic pathological brain MRI segmentation. Pixyl delivers precise neuroimaging biomarker extraction for improved insight and decision-making in clinical studies. Our automatic neuroimaging solutions are designed for seamless integration into both web-based and locally deployed CRO platforms. Advanced algorithms are available for multiple sclerosis, chronic stroke, brain tumor and traumatic brain injury applications The technology transferred is based on the P-LOCUS software.
- Xerox Foundation University Affairs Committee (UAC) collaborative grant. F. Forbes was co-laureate (with R. Horaud) of this grant (90 k$) for a three year project (2014-2017) on Advanced and Scalable Graph Signal Processing Techniques. It was awarded in collaboration with Arijit Biswas and Anirban Mondal, research scientists at Xerox Research Center India (XRCI), Bangalore.

MODAL Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

MODAL was implicated at the first level (general chair) in the organization of the main annual French conference in statistics gathering more than 400 participants (JdS 2015, see Section 10.1.1.1. General chair, scientific chair). It is the first time this conference is held in Lille since about 30 years.

MixtComp is the first package for clustering data with full mixed data (continuous, categorical, counting, ordinal, rank) with possibly missing or partially missing (intervals) data (see Section 6.15. MixtComp).

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: Roadef 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 recruitements (a PhD and a Post-doc) this year on our production planning project with EDF; Saint Gobain is very enthousiastic 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, sheduling, 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.

SELECT Project-Team (section vide)

SEQUEL Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

- organization of the 32nd International Conference on Machine Learning (ICML), in Lille, from Jul 6th to Jul 11th, 2015.

  ICML is the leading international conference in Machine Learning. This is the first time of its history that France hosts ICML. This edition has been the largest of all the times, with 1690 registrants (the previous record was 1400 in Beijing, in 2014).
- as an outcome of a contract with this start-up, Nuukik has been awarded “best data analysis” during the “connected commerce night” - http://www.retail-network.fr", 1500 participants, 80 projects in competition.

5.1.1. Awards

- V. Gabillon and B. Piot both received an AFIA award for their respective PhD, defended in 2014. They were both ranked second in this competition.
- Olivier Pietquin, Fellow of the “Institut Universitaire de France”.
- A. Lazaric and M. Valko received best reviewer awards at ICML 2015.

SIERRA Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

F. Bach has served as a program co-chair for the International Conference in Machine Learning (ICML) held in Lille, France, 2015.

TAO Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

- **DataScienc@LHC** First of a series of workshops officially organized at CERN - TAO leader on the ML side.

5.1.1. Awards

- Best Paper Award in the Genetic Programming track at GECCO 2015 (Madrid, July 2015) for the paper [39].
- First place in the Taxonomy Induction task of SemEval 2015 (Denver, June 2015) [55].

BEST PAPERS AWARDS :

[39] **Genetic and Evolutionary Computation COnference (GECCO 2015)**. R. FFRANCON, M. SCHOENAUER.

ASPI Project-Team (section vide)

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.

MATHRISK Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

Conference in honor of Vlad Bally for his 60th birthday, Le Mans, October 6-9 2015 http://www.cmap.polytechnique.fr/~demarco/files/pageWebConfV/ConferenceVladBally.html

5.1.1. Awards

J. Reygner received the 2014 Jacques Neveu prize for his thesis entitled "Longtime behaviour of particle systems : applications in physics, finance and PDEs" co-supervised by B.Jourdain and L. Zambotti

TOSCA Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

5.1.1. Awards

- M. Deaconu, B. Dumortier and E. Vincent won a poster award price (http://www.ewea.org/annual2015/conference/programme/ and http://www.inria.fr/centre/nancy/actualites/ewea-2015-baldwin-dumortier-recoit-un-prix-d-honneur) for their work with the Venathec SAS on the acoustic control of wind farms.