



RESEARCH CENTER
Saclay - Île-de-France

FIELD

Activity Report 2014

Section Highlights of the Team

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COMETE Project-Team

6.1. Highlights of the Year

- Prix de thèse de l'Ecole Polytechnique 2014 for the thesis "The Epistemic View of Concurrency Theory" by Sophia Knight (Defended 20 September, 2013).
- Catuscia Palamidessi has been invited keynote speaker at the joint conferences CONCUR 2014 and TGC 2014. Rome, September 2014.

GEOMETRICA Project-Team

6.1. Highlights of the Year

[10] was elected among the notable articles of 2013 by ACM and Computing Reviews (see http://computingreviews.com/recommend/bestof/notableitems_2013.cfm).

GRACE Project-Team

6.1. Highlights of the Year

- F. Morain and A. Guillevic (with their co-authors R. Barbulescu and P. Gaudry) broke the discrete logarithm world record for finite fields of the form $GF(p^2)$ with a prime p of 80 decimal digits. The new techniques form the preprint [31].
- D. Augot and M. Finiasz received the best paper award at FSE 2014 [17]. FSE is the most important conference devoted to symmetric cryptography. Grace contribution is to propose a mathematical construction which enables direct construction of so-called diffusion layers in block ciphers.
- A. Zeh, former Grace PhD student, received the special Prize of the Université Franco-Allemande (UFA) Jury 2014 at the French Embassy in Berlin, on November 21st.

BEST PAPER AWARD :

[17] **21st International Workshop on Fast Software Encryption, FSE 2014.** D. AUGOT, M. FINIASZ.

MEXICO Project-Team

6.1. Highlights of the Year

6.1.1. Active Diagnosis for Probabilistic Systems

Diagnosis fits well with probabilistic systems since it is natural to model the uncertainty about the behaviour of a partially observed system by distributions. We had previously revisited the active diagnosis (which aims at controlling the system to make it diagnosable) in discrete event systems designing optimal decision and synthesis procedures [7]. This year, we have considered active diagnosis for probabilistic discrete event systems, obtaining again optimal procedures [26]. Furthermore we have refined the notion of active diagnosis by introducing the *safe active diagnosis* which ensures that after the control is applied, there is a positive probability that a fault never occurs. Interestingly this problem is undecidable but for finite memory controller we have shown that the problem becomes again decidable and we have designed optimal decision and synthesis procedures. Our approach has raised an issue that has not been observed by previous researchers: while in discrete event system, most variants of diagnosis are in fact equivalent, this is no more the case for probabilistic systems. So in [26], we have undertaken the task of classifying the different versions obtaining a complete landscape of the notions both in terms of relations and complexity. Furthermore we have proposed a new notion of diagnosis, the *prediagnosis* that combines the advantages of diagnosis and prediction.

6.1.2. Weighted automata and weighted logics

Weighted automata are a conservative quantitative extension of finite automata that enjoys applications, e.g., in language processing and speech recognition. Their expressive power, however, appears to be limited, especially when they are applied to more general structures than words, such as graphs. To address this drawback, we have introduced weighted pebble walking automata, which allow to navigate freely in the graph and may use pebbles to mark some positions.

In [20], we have shown with examples from natural language modeling and quantitative model-checking that weighted expressions and automata with pebbles are more expressive and allow much more natural and intuitive specifications than classical ones. We have extended Kleene-Schützenberger theorem showing that weighted expressions and automata with pebbles have the same expressive power. We focussed on an efficient translation from expressions to automata. We also proved that the evaluation problem for weighted automata can be done very efficiently if the number of reusable pebbles is low.

In [18], we have studied the expressive power of these automata on words. We have proved that two-way pebble weighted automata, one-way pebble weighted automata, and our weighted logic with transitive closure are expressively equivalent. We also gave new logical characterizations of standard recognizable series.

In [30], we addressed the more general case of graphs such as nested words, trees, pictures, Mazurkiewicz traces, ... We established that weighted pebble walking automata have the same expressive power as weighted first order logic with transitive closure logic, lifting a similar result by Engelfriet and Hoozeboom from the Boolean case to a quantitative setting.

6.1.3. Verification of concurrent recursive programs

Distributed systems form a crucially important but particularly challenging domain. Designing correct distributed systems is demanding, and verifying its correctness is even more so. The main cause of difficulty here is concurrency and interaction (or communication) between various distributed components. Hence it is important to provide a framework that makes easy the design of systems as well as their analysis. There are two schools of thought on reasoning about distributed systems: one following the interleaving based semantics, and one following the visual partial-order/graph based semantics. In [23], we compare these two approaches and argue in favour of the latter. An introductory treatment of the split-width technique is also provided.

In [34], we develop a general technique based on split-width for the verification of networks of multi-threaded recursive programs communicating via reliable FIFO channels. We extend the approach of [6] to this setting. Split-width offers an intuitive visual technique to decompose our behaviour graphs such as MSCs and nested words. The decomposition is mainly a divide-and-conquer technique which naturally results in a tree decomposition. Every behaviour can now be interpreted over its decomposition tree. Properties over the behaviour naturally transfer into properties over the decomposition tree. This allows us to use tree-automata techniques to obtain decision procedures for a range of problems such as reachability, model checking against logical formalisms etc. In this way, we obtain simple, uniform and optimal decision procedures for various verification problems parametrised by split-width. Furthermore, the simple visual mechanism of split-width is as powerful as yardstick graph measures such as tree-width or clique-width. Hence it captures any class of distributed behaviours with a decidable MSO theory.

Multi-threaded recursive programs communicating via channels are turing powerful, hence their verification has focussed on under-approximation techniques. Any error detected in the under-approximation implies an error in the system. However the successful verification of the under-approximation is not as useful if the system exhibits unverified behaviours. In [24], we study controllers that observe/restrict the system so that it stays within the verified under-approximation. We identify some important properties that a good controller should satisfy. We consider an extensive under-approximation class, construct a distributed controller with the desired properties and also establish the decidability of verification problems for this class.

6.1.4. Regulation in Systems Biology

6.1.4.1. Rare events in Signalling Cascades

The visit in 2013 of Professor Monika Heiner from Cottbus University has led to a fruitful collaboration related to statistical model checking of rare events in signalling cascades (a regulatory biological system) [25]. This work has received one of the five top paper awards of the conference. In addition, we have improved the statistical methods used in our tool Cosmos.

6.1.4.2. Characterization of Reachable Attractors Using Petri Net Unfoldings

Attractors of network dynamics represent the long-term behaviours of the modelled system. Their characterization is therefore crucial for understanding the response and differentiation capabilities of a dynamical biological system. In the scope of qualitative models of interaction networks, the computation of attractors reachable from a given state of the network faces combinatorial issues due to the state space explosion.

In [33], we have presented a new algorithm that exploits the concurrency between transitions of parallel acting components in order to reduce the search space. The algorithm relies on Petri net unfoldings that can be used to compute a compact representation of the dynamics. We have illustrated the applicability of the algorithm with Petri net models of cell signalling and regulation networks, boolean and multi-valued. The proposed approach aims at being complementary to existing methods for deriving the attractors of Boolean models, while being generic since it applies to any safe Petri net.

PARSIFAL Project-Team

6.1. Highlights of the Year

Dale Miller's 1994 LICS paper titled "A Multiple-Conclusion Meta-Logic" [67] was a co-recipient of the LICS Test of Time Award.

POSTALE Team

5.1. Highlights of the Year

CovTrack: Agile multi-target multi-threaded realtime tracker We have developed and highly optimized a multi-target tracking system based on covariance tracking algorithm. The complexity of the algorithm – connected to the number of features – can be tuned to fit the processor computation power (with/without SIMD). Moreover the features can be also selected from a large set of features to adapt the algorithm to the scene and the nature of tracking (indoor/outdoor, pedestrian/car,). Some software and algorithmic transforms have been also applied to accelerate the code for scalar/SIMD processors. [20]

The Light Speed Labeling (LSL) algorithm is still the world fastest connected component labeling (CCL) algorithm. We have proposed a new benchmark that performs fair comparisons for such a data-dependent algorithm (that involves Union-Find algorithm optimization combined with memory and control flow optimization). We show that thanks to its run-based approach and its line-relative labeling, LSL is intrinsically more efficient than all State-of-the-Art pixel-based algorithms, whatever the memory management.[23]

SPECFUN Project-Team

6.1. Highlights of the Year

Two results are particularly important this year, our computer-checked proof [11] of irrationality of $\zeta(3)$ and our new algorithm [19] for the integration of multiple integrals. The former is our first success in the merger between computer algebra and formal methods, and stimulates further research in this direction around special functions and creative telescoping. The latter has made a large class of integrals possible in practice, thus allowing us to compute a challenging list of integrals related to famous Calabi–Yau varieties; it has also received attention by physicists.

TOCCATA Project-Team

6.1. Highlights of the Year

- The ACM Software System Award 2013 was given, during a ceremony in June 2014 in San Francisco, to the Coq proof assistant (http://awards.acm.org/software_system/). The prestigious ACM price was previously awarded to the LLVM compiler infrastructure (2012) and to the Eclipse IDE (2011). Among the 9 recipients of the 2013 award are Christine Paulin and Jean-Christophe Filliâtre, from the Toccata team.
- The *Concours Castor informatique* (<http://castor-informatique.fr/>) had an even larger success than in the previous years. In November 2014, more than 228,000 teenagers from over 1500 schools participated and solved the interactive tasks of the contest. Arthur Charguéraud and Sylvie Boldo, from the Toccata team, significantly contributed to the preparation of the tasks and to the organization of the contest.

COMMANDS Project-Team

6.1. Highlights of the Year

6.1.1. Optimization of running strategies based on anaerobic energy and variations of velocity

Participant: Frédéric Bonnans.

The paper [10] about running strategies proves Keller's conjecture. It was highlighted in SIAM Connect, see <http://connect.siam.org/insightful-mathematics-for-an-optimal-run/>

6.1.2. Research and transfer collaboration in aeronautics with the startup Safety Line

Participants: Frédéric Bonnans, Daphné Giorgi, Stéphan Maindrault, Pierre Martinon.

Following the meeting with the startup Safety Line at Imatch "Optimisation and Control" in october 2013, we conducted a first collaboration of six months on optimizing the fuel consumption of civil airliners. This first step successfully established the proof of concept and was validated by actual test flights in June 2014, leading to a shared patent and the development of a specific module of our software 'Bocop', included in the tool 'OptiClimb' developed at Safety Line. Future prospects include improving the numerical robustness of the current tool, as well as expanding the optimization to the cruise flight in addition to the climb phase.

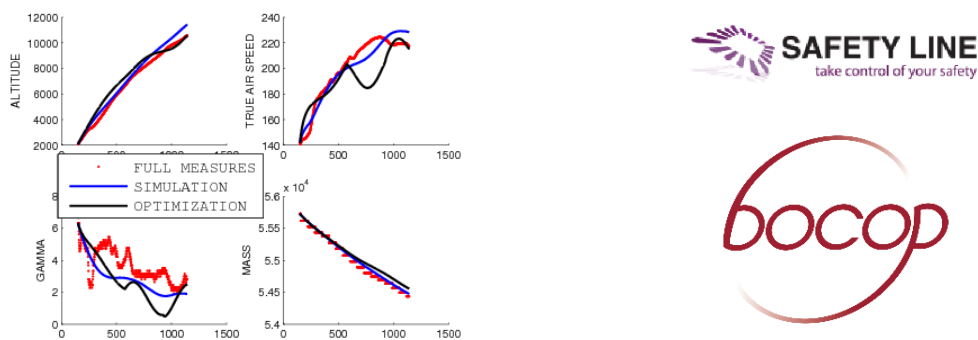


Figure 2. Plane climb phase (Boeing 737)

DEFI Project-Team (section vide)

DISCO Project-Team (section vide)

GECO Project-Team

6.1. Highlights of the Year

We organized a thematic trimester on “Geometry, analysis and dynamics on sub-Riemannian manifolds” at the Institut Henri Poincaré (IHP), including 4 workshops, 4 research courses, 8 thematic days, several seminars. We also organized an associated school at CIRM with 4 introductory courses. The web pages of the events are:

<http://www.cmap.polytechnique.fr/subriemannian/>

<http://www.cmap.polytechnique.fr/subriemannian/cirm/>

Maxplus Project-Team

6.1. Highlights of the Year

Nous avons donné un contre exemple inattendu à l'analogie continue de la conjecture de Hirsch, proposé par Deza, Terlaky et Zinchenko, voir Section 6.4.4 .

English version

We gave a somehow unexpected counter example to the continuous analogue of the Hirsch conjecture proposed by Deza, Terlaky and Zinchenko, see Section 6.4.4 .

POEMS Project-Team (section vide)

REGULARITY Project-Team

6.1. Highlights of the Year

The article "Christiane's Hair" by Jacques Lévy-Véhel and Franklin Mendivil has received the Paul R. Halmos - Lester R. Ford award of the Mathematical Association of America.

SELECT Project-Team (section vide)

TAO Project-Team

6.1. Highlights of the Year

- The European commission has chosen Crystal-Supergrids (<http://www.artelys.com/news/120/90/Energy-The-European-Commission-Chooses-Artelys-Crystal>) for energy modeling and planning in Europe. Crystal-Supergrids is based on the Post project, an ADEME project between Artelys and Inria-TAO.
- The HiggsML challenge was the all-time most popular challenge organized by Kaggle. Cécile Germain-Renaud, Balázs Kégl and Marc Schoenauer were part of the organizing committee.
- Creation of the Center for Data Science, an interdisciplinary institute of the Université Paris-Saclay. Co-chaired by Balázs Kégl, with more than 250 permanent researchers in 35 laboratories, the CDS organizes continued cross-fertilization of machine learning and domain sciences.
- Best Paper Award at PPSN .

BEST PAPERS AWARDS :

[36] **13th International Conference on Parallel Problem Solving from Nature**. I. LOSHCHILOV, M. SCHOENAUER, M. SEBAG, N. HANSEN.

AMIB Project-Team (section vide)

GALEN Project-Team

6.1. Highlights of the Year

- Handbook of Biomedical Imaging: Methodologies and Clinical Research [38] - co-edited from Nikos Paragios, James Duncan and Nicholas Ayache - has been published from Springer Publishing house.
- Nikos Paragios was admitted as a senior fellow at the Insitut Universitaire de France and has been awarded an IBM Faculty award. He has also been one of the plenary invited lecturers at the IARP International Conference in Pattern Recognition (ICPR'2015, Stockholm).

BEST PAPER AWARD :

[26] **Sparsity Techniques in Medical Imaging (STMI)**. M. MISYRLIS, A. KONOVA, M. BLASCHKO, J. HONORIO, N. ALIA-KLEIN, R. GOLDSTEIN, D. SAMARAS.

M3DISIM Team

6.1. Highlights of the Year

- Radomir Chabiniok recruited in starting research position (start Febr 2015);
- PhD Defense of Annabelle Collin;
- “Usine Nouvelle” article.

PARIETAL Project-Team

6.1. Highlights of the Year

- Congratulations also to Alex and Daniel Strohmeier for their best paper award at the PRNI 2014 conference: “Improved MEG/EEG source localization with reweighted mixed-norms“.
- Elvis Dohmatob got a honorable mention for the student paper award at PRNI 2014 for the work “Benchmarking solvers for TV-l1 least-squares and logistic regression in brain imaging”

POPIX Team

6.1. Highlights of the Year

Marc Lavielle published the book, *Mixed Effects Models for the Population Approach: Models, Tasks, Methods and Tools* (Chapman & Hall/CRC), which presents a rigorous framework for describing, implementing, and using mixed effects models. With these models, readers can perform parameter estimation and modeling across a whole population of individuals at the same time.

INFINE Team

6.1. Highlights of the Year

- We proved a conjecture made in 2011 about the feasibility of non-trivial community detection just above a threshold below which it was known that only trivial detection could be done, see [13]. This was published in ACM STOC'14 and well-received, as the proof required the invention of new techniques to control the spectral properties of random matrices.
- The official opening of IoT-LAB of all sites through the "Workshop Internet Of Things/Equipex FIT IoT-LAB" held in Grenoble (on 6 and 6 november 2014), has been a major event for our team: it concludes several years of preparation of the IoT-LAB site located in Rocquencourt, currently managed by C. Adjih, E. Baccelli and I. Amdouni, which was itself opened the same month <https://www.iot-lab.info/opening-of-the-paris-rocquencourt-site/>.

AVIZ Project-Team

6.1. Highlights of the Year

We had a number of highlights this year:

- Jean-Daniel Fekete was General Chair of the **IEEE VIS 2014** conference, organized for the first time ever outside of the USA, in Paris, with a record attendance.
- Aviz presented 7 articles at the IEEE VIS 2014 conference, and co-organized 3 workshops.
- Five PhD students defended this year.
- Benjamin Bach was awarded the second price in the IEEE VGTC Doctoral Dissertation Competition for his thesis "Connections, Changes, Cubes: Unfolding Dynamic Networks for Visual Exploration" [10].
- Yvonne Jansen was awarded the second price for the Gilles Kahn dissertation award for her thesis "Physical and Tangible Information Visualization" [11].
- Samuel Huron received the best paper honorable mention award at DIS 2014 for the paper "Constructive Visualization" [28].

DAHU Project-Team

6.1. Highlights of the Year

Victor Vianu was elected member of Academia Europaea.

BEST PAPER AWARD :

[21] Joint 25th International Conference on Rewriting Techniques and Applications and 12th International Conference on Typed Lambda Calculi and Applications. S. SCHMITZ.

IN-SITU Project-Team

6.1. Highlights of the Year

Wendy Mackay received the *ACM SIGCHI Lifetime Service Award*.

BEST PAPERS AWARDS :

[22] **CHI '14**. C. LIU, O. CHAPUIS, M. BEAUDOUIN-LAFON, É. LECOLINET, W. E. MACKAY.

OAK Project-Team

6.1. Highlights of the Year

The year has allowed reaching important results in four research areas of the group: query-based why-not provenance with explanations , minimal query reformulations under constraints [14], Linked Open Data analytics , and RDF data management in the cloud .

BEST PAPERS AWARDS :

[6] **Extending Database Technology (EDBT)**. N. BIDOIT, M. HERSHEL, K. TZOMPANAKI.

[10] **23rd International World Wide Web Conference**. D. COLAZZO, F. GOASDOUÉ, I. MANOLESCU, A. ROATIS.

[], [23] **The International Journal on Very Large Databases**. Z. KAUDI, I. MANOLESCU.