RESEARCH CENTER
Nancy - Grand Est

FIELD

Activity Report 2015

Section Highlights of the Team

Edition: 2016-03-21

ALICE Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

Geometry Processing: New Algorithms / New Software

This year we developed a set of geometric algorithms to robustly manipulate 3D data and generate volumetric meshes from them, with a special focus on usability, efficiency and robustness. The pipeline that we developed includes a simple and scalable surface reconstruction algorithms, a compiler for generating C++ code for robust geometric predicates, an efficient implementation of 3D Delaunay triangulation, the first algorithm to compute optimal transport in 3D, and an algorithm to generate hexahedral-dominant meshes.

As a result of the VORPALINE ERC Proof of Concept project, we distribute most of these algorithms in our open-source low-level Geogram library and Graphite graphics user interface. Some algorithms are distributed in the commercial VORPALINE software (hex-dominant meshing), proposed to the sponsors of the GOCAD consortium. The Proof of Concept project made it possible to set up tools for software quality (continuous integration, non-regression testing, systematic Doxygen documentation of all classes/functions/parameters).

Fabrication

This year has seen some important advances regarding the objectives of the ERC ShapeForge, with the publications of two novel techniques for the synthesis of structures from examples [9], [12]. We have proposed to formulate a shape synthesis problem as an appearance synthesis problem under minimal rigidity constraints. This affords for the automatic synthesis of structurally sound objects under specific boundary conditions (attachments and loads), while producing objects that visually resemble an example pattern.

We have continued to include the results of our research into our additive manufacturing software IceSL, which has been augmented with a new user interface to make it more accessible.

This year we also gave a half-day course at ACM SIGGRAPH on fused filament deposition software in collaboration with Makerbot, one of the major manufacturer of consumer level 3D printers. The course is available online at http://webloria.loria.fr/~slefebvr/sig15fdm/.

BIGS Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

The composition of the team was changed this year : Bruno Scherrer (Inria researcher) and Anne Gégout-Petit (Pr) joined the team (resp in January and in May). Samy Tindel moved to Purdue University as full Professor and Céline Lacaux has been promoted full Professor at Avignon University. Anne Gégout-Petit is temporary team leader since September.

CAMUS Team

5. Highlights of the Year

5.1. Highlights of the Year

Aravind Sukumaran-Rajam has shown in his PhD work [13] that the polyhedral model, usually exclusively dedicated to advanced static analysis and optimization of linear loops, can also be applied to nonlinear loops. This noteworthy extension of the scope of polyhedral techniques has been made possible thanks to the speculative and dynamic parallelization strategy implemented in the Apollo framework. Significant parallel speed-ups can now be obtained automatically for loops and loop nest that could not be handled before by compilers. Aravind Sukumaran-Rajam and Philippe Clauss have published a paper on this topic in the ACM journal Transactions on Architecture and Code Optimization in 2015 [14].

CAPSID Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

Large ANR Grant – Investissements d'Avenirs

Marie-Dominique Devignes and Malika Smaïl-Tabbone (Orpailleur Team) coordinated a work-package on network-based science for the project "FIGHT_HF" (Fight Heart Failure) that was submitted by Nancy University Hospital's Federation "CARTAGE" (http://www.fhu-cartage.com/) to the ANR "Investissements d'Avenirs" programme. This project aims to discover novel mechanisms for heart failure and to propose decision support for precision medicine. The project has been granted € 9M.

Journal Front Cover

A figure from our article in the *Journal of Chemical Information and Modeling* [15] was used to illustrate the front cover of the August issue of the journal.

CARAMEL Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

5.1.1. Awards

The LOGJAM attack has received the best paper award at the conference ACM CCS 2015 (Conference on Computer and Communications Security). It has also received a Pwnie award [0] in the category *Most innovative research*.

The Tower NFS article was one of the two ASIACRYPT 2015 papers invited to submit a long version to Journal of Cryptology.

BEST PAPERS AWARDS :

[15] **ACM CCS 2015**. D. ADRIAN, K. BHARGAVAN, Z. DURUMERIC, P. GAUDRY, M. GREEN, J. A. HALDERMAN, N. HENINGER, D. SPRINGALL, E. THOMÉ, L. VALENTA, B. VANDERSLOOT, E. WUSTROW, S. ZANELLA-BÉGUELIN, P. ZIMMERMANN.

[17] **ASIACRYPT 2015**. R. BARBULESCU, P. GAUDRY, T. KLEINJUNG.

[0] http://pwnies.com/

CARTE Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

The paper [21] published at the International Conference on Functional Programming (ICFP 2015) has given a positive answer to an open problem, conjectured to be true for a long time: the question is to know whether inductive and coinductive data types can be added to light logic based systems without breaking the complexity of the system (i.e. staying within the class of polynomial time computable functions). This issue is analog to the issue of adding inductive and coinductive data types to system F without breaking normalization, which is known to hold for a long time. To tackle this challenging question, we have studied the problem of defining algebras and coalgebras in the Light Affine Lambda Calculus, a system characterizing the complexity class FPTIME. In this system, the principle of stratification limits the ways we can use parametric polymorphism, and in general the way we can write our programs. We have shown that while stratification poses some issues to the standard System F encodings, it still permits to encode some weak form of algebra and coalgebra. Using the algebra encoding one can define in the Light Affine Lambda Calculus the traditional inductive types. Unfortunately, the corresponding coalgebra encoding permits only a very limited form of coinductive data types. To extend this class, we have studied an extension of the Light Affine Lambda Calculus by distributive laws for the modality §.

5.1.1. Awards

Hugo Férée has received the Ackermann award for his PhD thesis “complexité d’ordre supérieur et analyse récursive”.

CASSIS Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

Véronique Cortier has obtained the prestigious Inria-French Académie des sciences Young Researcher Award.

Steve Kremer has been awarded an European Research Council (ERC) Consolidator Grant to fund his work on the specification and formal verification of new security properties.

Two junior permanent members have been hired: Vincent Cheval as CR Inria and Jannik Dreier as associate professor at Université de Lorraine.

COAST Project-Team (section vide)

LARSEN Team

5. Highlights of the Year

5.1. Highlights of the Year

Figure 1. Cover the Nature issue of the 28th of May, 2015, which features Larsen's work on trial-and-error learning for damage recovery (ResiBots project).

- Jean-Baptiste Mouret joined the team (CR1, HDR [8], on secondment from Pierre and Marie Curie University for 5 years);
- The ERC project ResiBots (PI: Jean-Baptiste Mouret) started on the 1st of May, 2015;
- The preliminary work on which the ERC project ResiBots is based made it to the cover of Nature (28th of May, 2015), see figure 1 . This work was covered by all the major media outlets and the associated videos total more than 400,000 views on YouTube.

MADYNES Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

The Madynes team got involved this year in some new funded collaborations:

- in HUMA, funded at the french national level (FUI)
- in Orange and Inria laboratory "<I/O Lab>"

The *Alérion* spin off is definitively on track (http://www.alerion.fr).

MAGRIT Project-Team (section vide)

MIMESIS Team

4. Highlights of the Year

4.1. Highlights of the Year

4.1.1. Translational Simulation: from pre-operative to intra-operative simulation

In recent years, an active development of novel technologies dealing with medical training, planning and guidance has become an increasingly important area of interest in both research and health-care manufacturing. With a combination of advanced physical models, realistic human-computer interaction and growing computational power, the MIMESIS team aims at bringing new solutions in order to help both medical students and experts to achieve a higher degree of accuracy and reliability in surgical interventions [26].

4.1.1.1. Pre-operative planning

In the context of cryoablation, planning the outcome of the procedure is key to ensure an optimal ablation. Cryotherapy is a rapidly growing minimally invasive technique for the treatment of certain tumors. It consists in destroying cancer cells by extreme cold delivered at the tip of a needle-like probe. As the resulting iceball is often smaller than the targeted tumor, a key to the success of cryotherapy is the planning of the position and orientation of the multiple probes required to treat a tumor, while avoiding any damage to the surrounding tissues. In order to provide such a planning tool, a number of challenges need to be addressed such as fast and accurate computation of the freezing process or interactive positioning of the virtual cryoprobes in the pre-operative image volume. To address these challenges, we developed a thermal model using the finite-element method and implemented on GPU. Our thermal model was intensively validated and specific solvers were built. From these simulations, we developed a prototype for cryotherapy planning.

4.1.1.2. Towards intra-operative guidance

Not only does the simulation bring a pre-operative support to the radiologist, but computational models can also be used intra-operatively. During the minimally-invasive liver surgery, only the partial surface view of the liver is usually provided to the surgeon via the laparoscopic camera. Therefore, it is necessary to estimate the actual position of the internal structures such as tumors and vessels from the pre-operative images. Nevertheless, such task can be highly challenging since during the intervention, the abdominal organs undergo significant deformations due to the pneumoperitoneum, respiratory and cardiac motion and the interaction with the surgical tools. Therefore, a reliable automatic system for intra-operative guidance requires fast and reliable registration of the pre- and intra-operative data. This year, we presented a complete pipeline for the registration of pre-operative patient-specific image data to the sparse and incomplete intra-operative data [21]. While the intra-operative data is represented by a point cloud extracted from the stereo-endoscopic images, the pre-operative data is used to reconstruct a biomechanical model which is necessary for accurate estimation of the position of the internal structures, considering the actual deformations. This model takes into account the patient-specific liver anatomy composed of parenchyma, vascularization and capsule, and is enriched with anatomical boundary conditions transferred from an atlas. The registration process employs the iterative closest point technique together with a penalty-based method. Following this work, we performed a quantitative assessment based on the evaluation of the target registration error on synthetic data as well as a qualitative assessment on real patient data. We demonstrated that the proposed registration method provides good results in terms of both accuracy and robustness w. r. t. the quality of the intra-operative data

4.1.2. Eurographics Award

In recent years, an active development of novel technologies dealing with medical training, planning and guidance has become an increasingly important area of interest in both research and health-care manufacturing. A combination of advanced physical models, realistic human-computer interaction and growing computational power is bringing new solutions in order to help both medical students and experts to achieve a higher degree

of accuracy and reliability in surgical interventions. In our work entitled "Surgery Training, Planning, and Guidance using the SOFA Framework" [26], we presented three different examples of medical physically-based simulations implemented in a common software platform called SOFA. Each example represented a different application: training for cardiac electrophysiology, pre-operative planning of cryosurgery and per-operative guidance for laparoscopy. This paper assessed the realism, accuracy and efficiency of the simulations, as well as the potential and flexibility of the SOFA platform.

Figure 6. First Dirk Medical Prize at Eurographics 2015

This work has been awarded at the Eurographics conference in Zurich and won the **1st prize of the Dirk Bartz Medical Prize**.

4.1.3. SOFA Consortium

After ten years of development, a Consortium around the simulation platform SOFA was founded by Inria in November 2015. The MIMESIS team intensively participated in the creation of this Consortium. The objectives of this Consortium are to make the SOFA community grow and encourage contributions from new SOFA users. The Consortium should also be a way to better answer to the needs of academic or industrial partners.

A member of the MIMESIS team is now in charge of the coordination of this Consortium. A new engineer was also hired to manage the support on the SOFA forum, handle the SOFA events and communicate about SOFA Consortium. The activity of the SOFA Consortium is expected to significantly grow in the coming years.

4.1.4. Evaluation by IHU Strasbourg

Every year, research done at IHU is evaluated by a group of 15 international experts, scientists and clinicians. The 2015 report highlighted our work in the field of modeling and augmented reality: "Interestingly, besides its numerous applications for computer assisted surgery, it paves the way to build a new science of anatomy, with the establishment of innovative, "big data" based organ atlases. The program truly shows the most disruptive results. It is scientifically impressive and potentially very practical. There is no doubt that this is the domain where IHU is close to be the leading group. The program has a real strategy beyond distinct projects, and clear synergies have been identified." This report attests to our involvement within the IHU Strasbourg.

4.1.5. Science & You

Science & You is an international event about scientific mediation in the field of digital technologies. In 2015, Science & You took place in Nancy from the 1st until the 6th June 2015. Inria co-organized the event with

INS2I and SIF. At this occasion, the MIMESIS team presented the results and prototypes developed in the team. This event drew a crowd and was a real success.

MULTISPEECH Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

We ranked 2nd among 9 teams for the "Professionally produced music recordings" task of the 2015 Signal Separation Evaluation Campaign (SiSEC) [75].

We ranked 4th among 25 teams and as the best European team for the 3rd CHiME Speech Separation and Recognition Challenge [55].

5.1.1. Awards

Baldwin Dumortier received the best poster prize at EWEA 2015 (European Wind Energy Association 2015 Annual Event) [31].

Best paper award at SIIE 2015 (6th International Conference on Information Systems and Economic Intelligence) [34].
BEST PAPERS AWARDS :
[34] **IEEE International Conference on Information Systems and Economic Intelligence**. D. FOHR, I. ILLINA.

NEUROSYS Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

- Laurent Bougrain co-organized an **international Brain-Computer Interfaces competition** on *Error Potential Detection with Cross-subject Generalization* with Maureen Clerc, Fabien Lotte, Emmanuel Maby, Jérémie Mattout and Théodore Papadopoulo. **311 participants of 260 different teams** in the world participated to the competition. Gao Shangkai and Bin He were in the advisory board. IEEE EMBS, Inria, and Institute for Engineering in Medicine at University of Minnesota were sponsors of this event. The prizes have been presented to winners during the IEEE EMBS Neural Engineering conference, April 22-24, 2015. The winner has been invited to publish a manuscript at IEEE Transactions on Biomedical Engineering.
  https://www.kaggle.com/c/inria-bci-challenge
- **We stepped up our collaboration with the department of anesthesia of the university hospital in Nancy** (Dr. Denis Schmartz and Pr. Claude Meistelmann) leading to a **PhD thesis co-funded** by the school of medicine of the university of Lorraine, Inria, the Lorraine laboratory for research in computer science (LORIA), the Lorraine Region and the urban community of Nancy. The PhD will start in January 2016 on the study of the dynamics of cerebral motor patterns during general anesthesia with Sébastien Rimbert under the supervision of Axel Hutt and Laurent Bougrain.

ORPAILLEUR Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

- Aleksey Buzmakov was nominated at the 13th International Conference on Formal Concept Analysis (ICFCA, Nerja Málaga, Spain, June 23-26 2015) as the "best promising researcher in Formal Concept Analysis" and won the best student paper award [53].
- Two (very) young researchers have made a stay in the team, Artuur Leeuwenberg in Spring 2014 and Alibek Sailanbayev in Spring 2015. Both young researchers have done a very good work which was rewarded by two conference publications, [66] and [46]. The Orpailleur team is particularly proud of the very good results of these young researchers.
- Three PhD students, namely Alam Mehwish, Aleksey Buzmakov and Victor Codocedo, have joined their efforts in their last year of thesis preparation for working on a common topic, the completion of web of data. This very good and very uncommon research work was rewarded by a publication in the very highly selective IJCAI 2015 Conference [1].
- The paper "Miguel Couceiro, Lucien Haddad, Karsten Schölzel, Tamas Waldhauser. Relation graphs and partial clones on a 2-element set. 44th IEEE International Symposium on Multiple-Valued Logic (ISMVL 2014), IEEE Computer Society, 161-166." was awarded the "Outstanding Contributed Paper Award" at the conference ISMVL 2015 (IEEE Computer Society).
- The Taaable system won 3 of the 5 prizes of the 8th "Computer Cooking Contest", which was held during the International Conference on Case-Based Reasoning, in Bad Homburg, Germany (http://ccc2015.loria.fr/?id=rules): the prize of the best cocktail system according to the jury, based on the technical/scientific paper reviews and on the comparison of the results of the systems on a same set of queries, the prizes of the public for the cocktail and sandwich systems, based on the vote after tasting.

5.1.1. Awards

BEST PAPERS AWARDS :
[53] **International Conference in Formal Concept Analysis - ICFCA 2015**. A. BUZMAKOV, S. O. KUZNETSOV, A. NAPOLI.

SEMAGRAMME Project-Team (section vide)

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).

TONUS Team

5. Highlights of the Year

5.1. Highlights of the Year

We have launched the SCHNAPS project: http://schnaps.gforge.inria.fr/. Its goal is to develop a high performance software for plasma simulations. It is based on the runtime tool StarPU developed at Inria Bordeaux. The objective is to perform asynchronous hybrid CPU/GPU computations on HPC computers.

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.

VEGAS Project-Team

4. Highlights of the Year

4.1. Highlights of the Year

In the context of drawing plane algebraic curves with the correct topology, we have obtained and submitted this year major results on the resolution of bivariate algebraic systems. In particular, we presented algorithms whose worst-case and expected (Las Vegas) complexities are not likely to be easily improved as such improvments would essentially require to improve bounds on other fundamental problems (such as computing resultants, checking the squarefreeness of univariate polynomials, and isolating their roots) that have hold for decades. See section 6.3.1 for details.

VERIDIS Project-Team

5. Highlights of the Year

5.1. Highlights of the Year

Pascal Fontaine and Thomas Sturm, together with Erika Abraham (RWTH Aachen) and Dongming Wang (Beihang University, Beijing) organized the Dagstuhl Seminar 15471 in November 2015, on the subject of *Symbolic Computation and Satisfiability Checking*, bringing together two communities on subjects that are particularly relevant for our team.

Jasmin Blanchette and Christoph Weidenbach, together with Nikolaj Bjørner (Microsoft) and Viorica Sofronie-Stokkermans (University of Koblenz-Landau) organized the Dagstuhl Seminar 15381 in September 2015, on the subject of *Information from Deduction: Models and Proofs*. That seminar focused on added value of deduction tools beyond a yes/no answer, in particular certificates of (un)satisfiability.

We have made considerable progresses with the symbolic analysis of reaction networks. Within this interdisciplinary project, our methods have been accepted at the leading conference in symbolic computation [33], and our results with those methods have been published in a renowned journal in the natural sciences [17].