



RESEARCH CENTER  
Nancy - Grand Est

FIELD

Activity Report 2014

# Section Highlights of the Team

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**ALGORILLE Project-Team (section vide)**

## ALICE Project-Team

### 6.1. Highlights of the Year

*Fabrication:* We proposed a novel technique to automatically generate support structures for additive manufacturing with filament based processes. The deposited filament has to be properly supported at all times, which complicates printing of overhanging shapes: a disposable support has to be generated to temporarily hold the filament deposited above. Existing techniques either generate large structures, wasting material, or generate very thin structures that are hard to print and prone to failure. In contrast, our technique optimizes a scaffolding which is made of vertical pillars and horizontal bridges – such horizontal bridges print properly as long and the filament is deposited in straight line from one pillar to the next. We showed how to formulate scaffolding generation as a minimization problem and proposed a heuristic algorithm based on an efficient plane sweeping approach. The work was published [9] in ACM Transactions on Graphics in 2014 (proceedings of SIGGRAPH 2014). It is integrated within our 3D modeler for additive manufacturing, IceSL.

*Optimal transport:* this is an active research topics in the mathematics community. Given two measures  $\mu$  and  $\nu$ , optimal transport defines a distance between  $\mu$  and  $\nu$ , as the minimum cost of “morphing”  $\mu$  into  $\nu$ . This distance (called the *Wasserstein distance*) structures the space of measures and offers new ways of solving some highly non-linear PDEs (Monge-Ampere, Fokker-Plank ...). This requires a numerical way of computing the Wasserstein distance and its gradients. We studied a semi-discrete technique [21] submitted to ESAIM J. M2AN), that optimizes power diagrams. This is to our knowledge the first numerical implementation of optimal transport for volumetric densities (computes the Wasserstein distance between a sum of Dirac masses and a piece-wise linear density supported on a tetrahedral mesh).

**BIGS Project-Team (section vide)**

## **CAMUS Team**

### **6.1. Highlights of the Year**

One of Philippe Clauss' early papers on Ehrhart polynomials has been celebrated, 18 years later, in a selection of papers for the International Conference on Supercomputing (ICS) 25th anniversary retrospective [13]. 35 papers have been selected among roughly 1800 papers published between 1987 and 2011. The paper is:

"Counting Solutions to Linear and Nonlinear Constraints Through Ehrhart Polynomials: Applications to Analyze and Transform Scientific Programs", by Philippe Clauss, ICS'96, which introduced Ehrhart polynomials in the field of program analysis and optimization.

Philippe Clauss wrote an additional retrospective [12] related to this research which complements the paper in the ICS special issue.

## **CAMEL Project-Team**

### **6.1. Highlights of the Year**

Razvan Barbulescu, ex-PhD student in the team, has received the award “Prix Le Monde de la recherche universitaire”, as one of the top-5 PhD thesis in exact science in 2014.

Emmanuel Thomé has received the “Prix Régional du Chercheur” of the Région Lorraine.

Emmanuel Thomé has received the “Prix de l’Association des Amis de l’Université de Lorraine”.

BEST PAPER AWARD :

[17] **Eurocrypt 2014**. R. BARBULESCU, P. GAUDRY, A. JOUX, E. THOMÉ.



## CARTE Project-Team

### 6.1. Highlights of the Year

Our team made remarkable progress into the understanding of complexity of higher-order functionals. While a robust class of computable functionals exists at any finite type built from  $\mathbb{N}$  and  $\rightarrow$  (the Kleene-Kreisel functionals), no satisfying complexity classes had been defined so far, except the class BFF of Basic Feasible Functionals. However that class is not a complexity class in the usual sense and does not offer the possibility to define space complexity or non-deterministic time complexity. In his PhD Hugo Férée has developed a non-trivial notion of size for higher-order functionals using game semantics and he has defined a notion of polynomial-time computable functional including BFF but behaving more satisfactorily in several ways. A paper in preparation will gather these results.

## CASSIS Project-Team

### 6.1. Highlights of the Year

Véronique Cortier was one of the two FLoC plenary speakers during the Vienna Summer of Logic [31].

Steve Kremer and Robert Künnemann got a paper accepted at the 35th IEEE symposium on Security and Privacy [45].

The ANR project SEQUOIA has been accepted.

BEST PAPERS AWARDS :

[43] **Software Security and Reliability (SERE)**. E. FOURNERET, J. CANTENOT, F. BOUQUET, B. LEGEARD, J. BOTELLA.

[47] **The 7th International Symposium on Foundations & Practice of Security FPS'2014**. H. H. NGUYEN, A. IMINE, M. RUSINOWITCH.

**COAST Team (section vide)**

## **CORIDA Team**

### **6.1. Highlights of the Year**

The CORIDA team organized two scientific meetings in 2014.

The first workshop, “Observers for finite and infinite dimensional systems” in April 2014, gathered people working in the field of control theory for finite and infinite dimensional systems.

Ten speakers from France, India, Portugal and Germany were invited for the second workshop, “Workshop in Mathematical Fluid Dynamics”, in November 2014.

## **MADYNES Project-Team**

### **6.1. Highlights of the Year**

The following points of 2014 deserves to be highlighted:

- One new permanent member joined the MADYNES team: Jérôme François as Inria researcher.
- An IBM Faculty Award has been received by a team member (Rémi Badonnel, TELECOM Nancy) for his work on security and cloud computing.

BEST PAPER AWARD :

**[21] 8th IFIP WG 6.6 International Conference on Autonomous Infrastructure, Management, and Security, AIMS 2014. A. MAYZAUD, A. SEHGAL, R. BADONNEL, I. CHRISMENT, J. SCHÖNWÄLDER.**

## **MAGRIT Project-Team**

### **6.1. Highlights of the Year**

We were invited to present our work on *Impact of Soft Tissue Heterogeneity on Augmented Reality for Liver Surgery* in the TVCG Special Session at SIGGRAPH Asia 2014.

## **MAIA Project-Team**

### **6.1. Highlights of the Year**

- Two Research Fellow have been recruited with a focus on Service Robotics: Serena Ivaldi (CR2) and Francis Colas (CR1).
- The paper entitled : Exploiting Separability in Multiagent Planning with Continuous-State MDPs Jilles Dibangoye, Christopher Amato, Olivier Buffet, François Charpillet won the best paper award at AAMAS'2014, the international conference on autonomous agents and multi-agents.
- Jilles Dibangoye got an Assistant Professor position at INSA Lyon.

BEST PAPER AWARD :

[12] **13th International Conference on Autonomous Agents and Multiagent Systems**. J. S. DIBANGOYE, C. AMATO, O. BUFFET, F. CHARPILLET.

## MASAIE Project-Team

### 5.1. Highlights of the Year

The estimation of sequestered parasite population has been a challenge for the biologist and modeler, with many authors having studied this problem. The difficulty is that the infected erythrocyte leaves the circulating peripheral blood and binds to the endothelium in the microvasculature of various organs. A measurement of *Plasmodium falciparum* parasitaemia taken from a blood smear therefore samples young parasites only and there is no clinical methods to measure the sequestered parasites. We have developed a simple tool to estimate the sequestered parasites and hence the total parasite burden for *Plasmodium falciparum* malaria patients. We have also given a method to estimate a crucial parameter in the model of infection. This parameter  $\beta$  can be thought as the "transmission/invading" factor between merozoites and erythrocytes. This work [9] has been published in "Mathematical Biosciences and Engineering".



## **MULTISPEECH Team**

### **6.1. Highlights of the Year**

The version 2 of our source separation toolbox FASST [65] has been downloaded more than 300 times since its release in January 2014.

## NEUROSYS Team

### 6.1. Highlights of the Year

Microscopic action affects mesoscopic and macroscopic action in neural systems. In the context of general anaesthesia, it is not understood how single neuron properties, such as ion-channel conductivities or anesthetic action on neuron receptors, translate to population dynamics and consequently to behavior. The work of Laure Buhry and Axel Hutt [4] proposes a modelling approach how to bridge the microscopic and the mesoscopic scale. The most interesting aspect is that this model bridge allows to extend standard neural field theory on the mesoscopic scale instead of introducing a new model.

In addition, we have developed strong collaborations with medical doctors. First, we have established a collaboration with Dr. Denis Schmartz and Dr. Claude Meistelmann at the *CHU Nancy* to plan and perform well-controlled resting state experiments under propofol anaesthesia. Second, we are in close contact to Jean-Luc Schaff at the *CHU Nancy* (together with Laurent Koessler at *CRAN*) in the context of sleep monitoring. Dr. Schaff has provided us polysomnographic data measured during sleep of insomnia patients.

## ORPAILLEUR Project-Team

### 6.1. Highlights of the Year

As highlights of the year, we would like to mention several elements, an award in a competition and a best paper. In addition we would like to also mention the importance gained by two other papers.

- Yen Low, a postdoctoral fellow from Stanford and Adrien Coulet (Orpailleur team) jointly developed a prototype named *Whypothesis?* whose goal is to provide explanations on drug side effects for which the molecular mechanism remains unknown. This prototype won the “Best Application Award” at the 2014 NCBO Hackathon (National Center for Biomedical Ontology), held at Stanford University, April 26-27 ([http://www.bioontology.org/2014\\_NCBO\\_Hackathon](http://www.bioontology.org/2014_NCBO_Hackathon)).
- The paper [2] describing a first and original proposition for combining pattern structures and relational concept analysis won the best paper award at the International Conference on Formal Concept Analysis in Cluj-Napoca, Romania.
- The paper [10] published in Nucleic Acids Research describes the latest version of KBDOCK, which has had over 12,000 non-duplicate visitors since 2011.
- The paper [44] on polypharmacology represents a nice collaboration with Harmonic Pharma, and it was used for the cover issue of Journal Chemical Information (<http://pubs.acs.org/toc/jcisd8/54/3>).

BEST PAPER AWARD :

[56] **Formal Concept Analysis - 12th International Conference - Proceedings.** V. CODOCEDO, A. NAPOLI.

**PAREO Project-Team (section vide)**

**SEMAGRAMME Project-Team (section vide)**

## SHACRA Project-Team

### 5.1. Highlights of the Year

#### 5.1.1. Intra-operative guidance

Each year in Europe 50,000 new liver cancer cases are diagnosed for which hepatic surgery combined to chemotherapy is the most common treatment. In particular the number of laparoscopic liver surgeries has increased significantly over the past years. Minimally invasive procedures are challenging for the surgeons due to the limited field of view.

Providing new solutions to assist surgeons during the procedure is of primary interest. This year, the team developed an innovative system for augmented reality in the scope of minimally invasive hepatic surgery. The first issue is to align preoperative data with the intra-operative images. We first proposed a semi-automatic approach [28] for solving the ill-posed problem of initial alignment for augmented reality systems during liver surgery. Our registration method relies on anatomical landmarks extracted from both the laparoscopic images and a three-dimensional model, using an image-based soft-tissue reconstruction technique and an atlas-based approach, respectively.

Second, we introduced a method for tracking the internal structures of the liver during robot-assisted procedures [25]. Vascular network, tumors and cut planes, computed from pre-operative data, can be overlaid onto the laparoscopic view for image-guidance, even in the case of large motion or deformation of the organ. This is made possible by relying on a fast yet accurate 3D biomechanical model of the liver combined with a robust visual tracking approach designed to properly constrain the model. Our augmented reality proved to be accurate and extremely promising on in-vivo sequences of a human liver during robotic surgery.

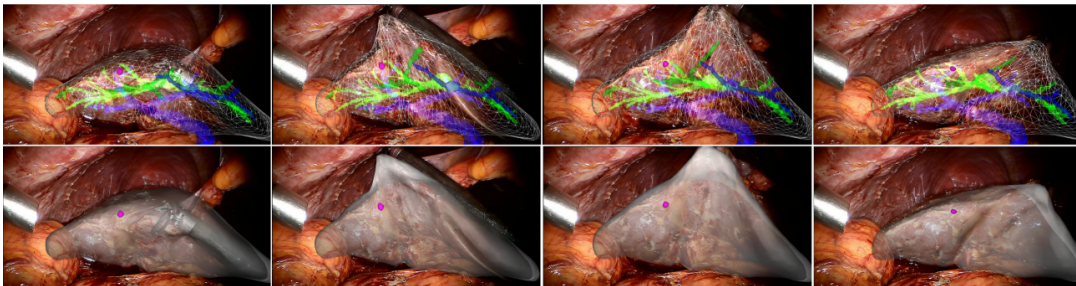


Figure 4. Augmented reality on the liver with 3D visualization of the blood vessels

#### 5.1.2. Ph.D. defenses

The year 2014 was also special since many PhDs have been defended. Four PhD defenses took place with:

- Ahmed Yureidini's defense about *Robust blood vessel surface reconstruction for interactive simulations from patient data* [15] in May 2014,
- Guillaume Kazmitcheff's defense about *Minimal invasive robotics dedicated to otological surgery* [13] in June 2014,
- Hugo Talbot's defense about *Interactive patient-specific simulation of cardiac electrophysiology* [14] in July 2014,
- Alexandre Bilger's defense about *Patient-specific biomechanical simulation for deep brain stimulation* [12] in December 2014.

### 5.1.3. Organization of ISBMS 2014

The team co-organized the 6<sup>th</sup> International Symposium on Biomedical Simulation (ISBMS) 2014, which was held in Strasbourg (France) on October 16 – 17, 2014. The ISBMS conference is a well-established scientific meeting that provides an international forum for researchers interested in using biomedical simulation technology for the improvement of patient care and patient safety. The SiMMS group from Imperial College London and IHU-Strasbourg were the two other co-organizers. The event was hosted at IRCAD, a center of excellence in surgical training. The ISBMS chairs were:

- Stéphane Cotin (Inria),
- Fernando Bello (Imperial College London),
- Jérémie Dequidt (Univ. Lille),
- Igor Peterlik (IHU Strasbourg & Masaryk Univ.).

The whole team was involved in the organization of the event. About 65 participants joined the conference. Regarding their feedback, the conference was a real success. For more information about ISBMS, refer to the official website <http://www.isbms.org>.

Finally, a day dedicated to our software SOFA ("SOFA Day") was organized the day after the ISBMS conference. This was the opportunity to introduce SOFA to the ISBMS community and to share with the SOFA users.



(a) Setup of our demo



(b) With Genevieve Fioraso

Figure 5. Presentation of our work at the French National Assembly. Genevieve Fioraso is the French national research secretary

### 5.1.4. Demonstration at the French National Assembly

On Tuesday 21<sup>st</sup> January 2014, the team SHACRA presented its work during the "Internet et société numérique" working group. This was a joint event between Inria and the French National Assembly (Assemblée Nationale). On this special occasion, we made a demonstration of our simulations and the CEO from Inria Michel Cosnard also presented more globally the role of Inria in healthcare but also education, cloud computing, big data.

## **TONUS Team**

### **6.1. Highlights of the Year**

We have implemented an OpenCL task graph version of our Discontinuous Galerkin solver that allows to overlap GPU computations and MPI communications. With this optimizations, we were recently able to achieve a 14 GFLOPS simulation with 8 GPUs on an electromagnetic test case. These results are included in the PhD of Thomas Strub (defence planned in March 2015) under the supervision of Philippe Helluy.



**TOSCA Project-Team (section vide)**

**VEGAS Project-Team (section vide)**

## **VERIDIS Project-Team**

### **6.1. Highlights of the Year**

The veriT solver (section 5.1 ) participated in the **SMT competition 2014**, part of the Vienna Summer Of Logic Olympic Games, and received the gold medal for the SMT category.