Programme de la journée du département 1
Algorithmique, calcul, image et géométrie
31 mai 2017

9h30	Antoine Fond (Magrit)	Joint facade segmentation and registration using Expectation-Maximisation
	Charles Dumenil (Gamble)	Delaunay triangulation of points evenly distributed on a surface
	Svyatoslav Covanov (Caramba)	Improved method to find optimal formulae for bilinear maps
10h30	Pause	
11h	Simon Abelard (Caramba)	Complexity bounds for point-counting on hyperelliptic curves
	Vincent Gaudillière (Magrit)	Visual Place Recognition in Industrial Environment
	Iordan Iordanov (Gamble)	Delaunay triangulations of the Bolza surface
12h	Déjeuner	
13h30	Maxence Reberol (Alice)	Evaluating the accuracy of hex-dominant meshes for the finite element method
	Florian Lietard	Evitabilité des cubes additifs en combinatoire des mots.
	Senny Diatta (Gamble)	Projection of analytic surfaces
14h30	Pause	
15h	Khadija Musayeva (ABC)	Metric Entropy and Rademacher Complexity of Margin Multi-category Classifiers
	Raffaella Trivisonne (Magrit)	Numerical Simulation using Stochastic Filters for Computer-Assisted Minimally Invasive Endovascular Procedures

Simon Abelard (Caramba) : Complexity bounds for point-counting on hyperelliptic curves

Counting points on (Jacobians of) curves over finite fields and computing their zeta functions are important routines for effective number theorists as well as cryptologists. We propose an algorithm à la Schoof for hyperelliptic curves and study its complexity in large characteristic and high genus. Our algorithm heavily relies on the computation of the r-torsion of the Jacobian for sufficiently many r, which we perform by solving polynomial systems built from Cantor's analogues to division polynomials for hyperelliptic curves. Taking advantage of the very particular structure of such systems, we improve on previous complexity bounds established by Adleman and Huang in 2001.

Svyatoslav Covanov (Caramba) : Improved method to find optimal formulae for bilinear maps.

In 2012, Barbulescu, Detrey, Estibals and Zimmermann proposed a new framework to exhaustively search for optimal formulae for evaluating bilinear maps, such as Strassen or Karatsuba formulae.
The main contribution of this work is a new criterion to aggressively prune useless branches in the exhaustive search, thus leading to the computation of new optimal formulae, in particular for the short product modulo X^5 and the circulant product modulo (X^5 − 1). Moreover , we are able to prove that there is essentially only one optimal decomposition of the product of 3 × 2 by 2 × 3 matrices up to the action of some group of automorphisms.

Seny Diatta (Gamble) : Projection of analytic surfaces

For some robotic problems we need to represent a singular surface that is the projection of a smooth surface embedded in higher dimension. In this work, we focus on the problem of computing a triangulation of the projection on R^3 of an analytic surface embedded in R^4. Based on

Transversality and Singularity Classification theories, we first show that, under generic assumptions, the set of singularities of the projected surface are generated by only three types of multi-germs: double points, triple points and cross-caps. Then, using this information we design an algorithm taking as input an analytic surface and returning a triangulation isotopic to its projected surface.

Charles Dumenil (Gamble) : Delaunay triangulation of points evenly distributed on a surface

Reconstructing a surface from a point set is one of the main use of 3D Delaunay triangulation in real applications. In such applications, by definition the points are not distributed in the whole 3D space but on a surface, thus understanding the expected complexity of the Delaunay triangulation of a random sample of a surface is an important problem with practical implications.

There are several results concerning the size of the Delaunay triangulation when the point set is a sampling of a surface. These results depends of course of the surface definition and the sampling definition. The surface can be smooth, or only piecewise smooth, it can also be generic if it does not include pieces of circle (no spheres, cones, cylinders...) or not. The sampling can be a *good-sampling* (no holes nor concentration in the sampling) or random. Current known results on the size of the triangulation of a sample of n points are:

- $O(n \log n)$ for a *good-sampling* of a generic surface,
- $\Omega(n \sqrt{n})$ for a sampling of a general (non-generic) surface satisfying the same *good-sampling* hypothesis, and
- $\Theta(n \log n)$ for a random sampling of a cylinder.

But these results are not tight, and the very reasonable case of a random sampling of a surface is not covered in a good way.

Antoine Fond (Magrit) : Joint facade segmentation and registration using Expectation-Maximisation

Due to strong perspective effects and repetitions pose computation in urban environments is a challenging problem where classic approaches fail. However the regularity in geometry and appearance of such scenes can be exploited. We first showed that vanishing points can be efficiently found to overcome viewpoint changes. Then we showed that in rectified image we could roughly detect and identify a building. These two steps can be seen as an initialization step of a pose estimation problem. We propose here to refine this pose by jointly solving semantic segmentation and registration using an Expectation-Maximisation framework.

Vincent Gaudilliere (Magrit) : Visual Place Recognition in Industrial Environment

Visual place recognition is a "well-defined but extremely challenging problem to solve", according to a survey published in 2016 in IEEE Transactions on Robotics (Lowry et al.*). Furthermore, performing visual place recognition in industrial environments surely leads to additional challenges. In this presentation, we will underline these issues, and then point out some potential solutions, illustrated by preliminary results.*

Iordan Iordanov (Gamble): Delaunay triangulations of the Bolza surface

Delaunay triangulations and their dual Voronoi diagrams are among the most important structures in Computational Geometry. They are well-studied and many algorithms to efficiently compute them exist. However, our knowledge and tools are mainly confined to the Euclidean d-dimensional space.
One extension that has been addressed in previous work is the computation of Delaunay triangulations on closed flat manifolds, which can be seen as compact quotient spaces of the Euclidean space by a discrete group of isometries. An implementation for the special case of the 3D flat torus exists in CGAL.

In this presentation, I will talk about our current work on the Bolza surface, which is a hyperbolic surface homeomorphic to the double torus, and can be seen as a compact quotient space of the hyperbolic plane by a discrete group of hyperbolic isometries. I will discuss such triangulations from both mathematical and practical viewpoint, and I will present our implementation of an algorithm to construct them. I will also discuss ideas for our future work on extending our algorithm to more general surfaces.

Florian Lietard : Evitabilité des cubes additifs en combinatoire des mots

En 2011, un article de J. Cassaigne, J. D. Currie, L. Schaeffer et J. Shallit montrait qu'il était possible en utilisant un alphabet de 4 chiffres, de construire un mot infini qui évite les cubes additifs. Autrement dit on ne peut pas trouver dans ce mot trois blocs consécutifs de mêmes tailles et de mêmes sommes de chiffres. Au delà de ce résultat, l'étude de la structure de cette preuve permet d'étendre le travail effectué par Cassaigne et al. et d'émettre plusieurs conjectures sur les mots évitant les cubes additifs.

Khadija Musayeva (ABC) : Metric Entropy and Rademacher Complexity of Margin Multi-category Classifiers

This presentation deals with the generalization performance of margin multi-category classifiers. To derive an upper bound on the probability of error, we adopt a standard approach involving the Rademacher complexity as capacity measure. Then, this complexity is related to a metric entropy by application of the chaining method. At last, the metric entropy is related to fat-shattering dimensions by means of a generalized Sauer-Shelah lemma. In this context, we investigate the optimal choice for the generalized Sauer-Shelah lemma with respect to the two major criteria: the dependencies of the resulting bound on the sample size and the number of categories.

Maxence Reberol (Alice): Evaluating the accuracy of hex-dominant meshes for the finite element method

The finite element method approximates the solutions of partial differential equations with polynomials defined piecewisely on the cells of a mesh. This talk presents a method allowing to compare the approximations obtained with different 3D meshes: tetrahedral, hexahedral and hex-dominant meshes. The main idea is to compute the L^p distance between scalar (or vector) fields using a large and regular sampling which is computed efficiently thanks to graphics hardware. We apply this method to large models and discuss the performance and accuracy of the approach.

Raffaella Trivisonne (Mimesis & Magrit) : Numerical Simulation using Stochastic Filters for Computer-Assisted Minimally Invasive Endovascular Procedures.

Endovascular surgery is a medical specialty of minimally invasive procedures which relies on the use of catheters and other endovascular devices, to reach and treat a variety of pathologies.
During the intervention, fluoroscopic images provide the clinician with live feedback on the anatomy of the patient, and the position and shape of the catheter.
In conventional 2D fluoroscopic guidance, the complexity of the procedure, the radiation exposure and the loss of depth perception in X-ray images, are the main issues who led to investigate new solutions.
The first aim of this thesis is to develop a numerical simulation of the real catheter's navigation, in order to enhance the visualization of such procedures.
The simulation will be based on physical models of the catheter and its movement, pre-operative vessels' anatomy and image features from fluoroscopic images.
Both the 3D catheter's navigation and the anatomy of the patient would be available to the clinician, having this way a better quality field of view.
In a second time, the simulation combined with some stochastic filters, will be used to reduce the acquisition frequency of the fluoroscopic images. The frame rate of the video will be the same: only one X-ray images per second will be ideally acquired whereas the simulation provides the rest of the ongoing procedure.
This will allow to significantly reduce the radiation exposure.