Département
D1: Algorithms, Computation, Image & Geometry

Équipe GAMBLE

Geometric Algorithms & Models Beyond the Linear & Euclidean realm

Laboratoire lorrain de recherche en informatique et ses applications

Rapport d'activité 2025

En partenariat avec

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Project-Team GAMBLE

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Keywords

Computer sciences and digital sciences

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2 Overall objectives

Starting in the eighties, the emerging computational geometry community has put a lot of effort into designing and analyzing algorithms for geometric problems. The most commonly used framework was to study the worst-case theoretical complexity of geometric problems involving linear objects (points, lines, polyhedra...) in Euclidean spaces. This so-called *classical computational geometry* has some known limitations:

- Objects: dealing with objects only defined by linear equations.
- Ambient space: considering only Euclidean spaces.
- Complexity: worst-case complexities often do not capture realistic behaviour.
- Dimension: complexities are often exponential in the dimension.
- Robustness: ignoring degeneracies and rounding errors.

Even if these limitations have already got some attention from the community [45], a quick look at the proceedings of the flagship conference SoCG[1] shows that these topics still need a big effort.

It should be stressed that, in this document, the notion of certified algorithms is to be understood with respect to robustness issues. In other words, certification does not refer to programs that are proven correct with the help of mechanical proof assistants such as Coq, but to algorithms that are proven correct on paper even in the presence of degeneracies and computer-induced numerical rounding errors.

We address several of the above limitations:

• **Non-linear computational geometry.** Curved objects are ubiquitous in the world we live in. However, despite this ubiquity and decades of research in several communities, curved objects are far from being robustly and efficiently manipulated by geometric algorithms. Our work on, for instance, quadric intersections and certified drawing of plane curves has proven that dramatic improvements can be accomplished when the right mathematics and computer science concepts are put into motion. In this direction, many problems are fundamental and solutions have potential industrial impact in Computer Aided Design and Robotics for instance. Intersecting NURBS (Non-uniform rational basis splines) and meshing singular surfaces in a certified manner are important examples of such problems.

• **Non-Euclidean computational geometry.** Triangulations are central geometric data structures in many areas of science and engineering. Traditionally, their study has been limited to the Euclidean setting. Needs for triangulations in non-Euclidean settings have emerged in many areas dealing with objects whose sizes range from the nuclear to the astrophysical scale, and both in academia and in industry. It has become timely to extend the traditional focus on $\mathbb{R}^d$ of computational geometry and encompass non-Euclidean spaces.

• **Probability in computational geometry.** The design of efficient algorithms is driven by the analysis of their complexity. Traditionally, worst-case input and sometimes uniform distributions are considered and many results in these settings have had a great influence on the domain. Nowadays, it is necessary to be more subtle and to prove new results in between these two extreme settings. For instance, smoothed

[1] Symposium on Computational Geometry. www.computational-geometry.org/.

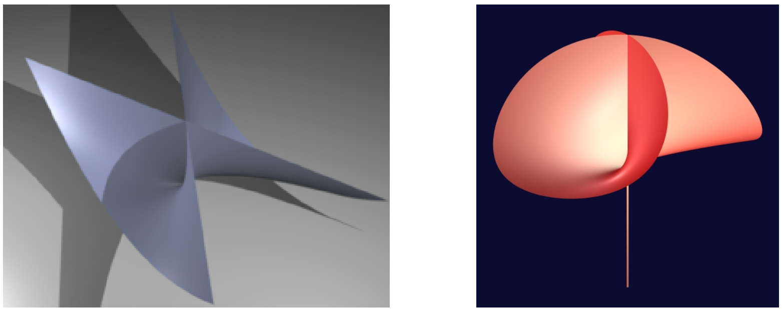

Figure 1: Two views of the Whitney umbrella (on the left, the "stick" of the umbrella, i.e., the negative z-axis, is missing). Right picture from [Wikipedia], left picture from [Lachaud et al.].

analysis, which was introduced for the simplex algorithm and which we applied successfully to convex hulls, proves that such promising alternatives exist.

• **Discrete geometric structures.** Many geometric algorithms work, explicitly or implicitly, over discrete structures such as graphs, hypergraphs, lattices that are induced by the geometric input data. For example, convex hulls or straight-line graph drawing are essentially based on orientation predicates, and therefore operate on the so-called *order type* of the input point set. Order types are a subclass of oriented matroids that remains poorly understood: for instance, we do not even know how to sample this space with reasonable bias. One of our goals is to contribute to the development of these foundations by better understanding these discrete geometric structures.

3 Research program

3.1 Non-linear computational geometry

As mentioned above, curved objects are ubiquitous in real world problems and in computer science and, despite this fact, there are very few problems on curved objects that admit robust and efficient algorithmic solutions without first discretizing the curved objects into meshes. Meshing curved objects induces a loss of accuracy which is sometimes not an issue but which can also be most problematic depending on the application. In addition, discretization induces a combinatorial explosion which could cause a loss in efficiency compared to a direct solution on the curved objects (as our work on quadrics has demonstrated with flying colors [54, 55, 56, 59, 65]). But it is also crucial to know that even the process of computing meshes that approximate curved objects is far from being resolved. As a matter of fact there is no algorithm capable of computing in practice meshes with certified topology of even rather simple singular (that is auto-intersecting) 3D surfaces, due to the high constants in the theoretical complexity and the difficulty of handling degenerate cases. Part of the difficulty comes from the unintuitive fact that the structure of an algebraic object can be quite complicated, as depicted in the Whitney umbrella (see Figure 1), the surface with equation $x^2 = y^2 z$ whose origin (the "special" point of the surface) is a vertex of the arrangement induced by the surface while the singular locus is simply the whole z-axis. Even in 2D, meshing an algebraic curve with the correct topology, that is in other words producing a correct drawing of the curve (without knowing where the domain of interest is), is a very difficult problem on which we have recently made important contributions [38, 39, 14].

Thus producing practical, robust, and efficient algorithmic solutions to geometric problems on curved objects is a challenge on all and even the most basic problems. The basicness and fundamentality of the two problems we mentioned above on the intersection of 3D quadrics and on the drawing in a topologically certified way of plane algebraic curves show rather well that the domain is still in its infancy. And it should be stressed that these two sets of results were not anecdotal but flagship results produced during the lifetime of the VEGAS team (the team preceding GAMBLE).

There are many problems in this theme that are expected to have high long-term impacts. Intersecting NURBS (Non-uniform rational basis splines) in a certified way is an important problem in computer-

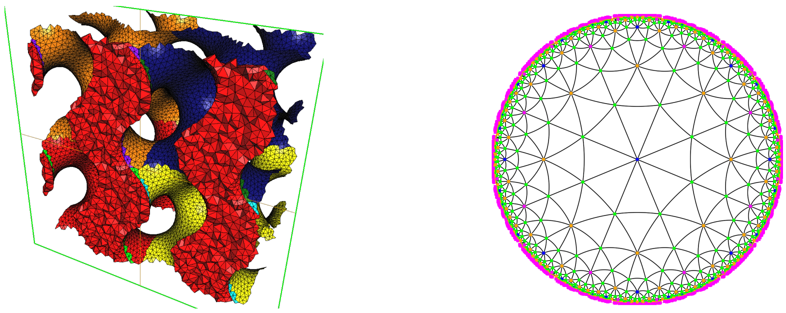

Figure 2: Left: 3D mesh of a gyroid (triply periodic surface) [68]. Right: Simulation of a periodic Delaunay triangulation of the hyperbolic plane [34].

aided design and manufacturing. As hinted above, meshing objects in a certified way is important when topology matters. The 2D case, that is essentially drawing plane curves with the correct topology, is a fundamental problem with far-reaching applications in research or R&D. Notice that on such elementary problems it is often difficult to predict the reach of the applications; as an example, we were astonished by the scope of the applications of our software on 3D quadric intersection[2] which was used by researchers in, for instance, photochemistry, computer vision, statistics and mathematics.

3.2 Non-Euclidean computational geometry

Triangulations, in particular Delaunay triangulations, in the *Euclidean space* $\mathbb{R}^d$ have been extensively studied throughout the 20th century and they are still a very active research topic. Their mathematical properties are now well understood, many algorithms to construct them have been proposed and analyzed (see the book of Aurenhammer *et al.* [31]). Some members of GAMBLE have been contributing to these algorithmic advances (see, e.g. [37, 75, 50, 36]); they have also contributed robust and efficient triangulation packages through the state-of-the-art Computational Geometry Algorithms Library CGAL whose impact extends far beyond computational geometry. Application fields include particle physics, fluid dynamics, shape matching, image processing, geometry processing, computer graphics, computer vision, shape reconstruction, mesh generation, virtual worlds, geophysics, and medical imaging.[3]

It is fair to say that little has been done on non-Euclidean spaces, in spite of the large number of questions raised by application domains. Needs for simulations or modeling in a variety of domains[4] ranging from the infinitely small (nuclear matter, nano-structures, biological data) to the infinitely large (astrophysics) have led us to consider 3D periodic Delaunay triangulations, which can be seen as Delaunay triangulations of the 3D *flat torus*, i.e., the quotient of $\mathbb{R}^3$ under the action of some group of translations [43]. This work has already yielded a fruitful collaboration with astrophysicists [60, 77] and new collaborations with physicists are emerging. To the best of our knowledge, our CGAL package [42] is the only publicly available software that computes Delaunay triangulations of a 3D flat torus, in the special case where the domain is cubic. This case, although restrictive, is already useful.[5] We have also generalized this algorithm to the case of general d-dimensional compact flat manifolds [44]. As far as non-compact manifolds are concerned, past approaches, limited to the two-dimensional case, have stayed theoretical [67].

Interestingly, even for the simple case of triangulations on the *sphere*, the software packages that are currently available are far from offering satisfactory solutions in terms of robustness and efficiency [41].

Moreover, while our solution for computing triangulations in hyperbolic spaces can be considered as ultimate [34], the case of *hyperbolic manifolds* has hardly been explored. Hyperbolic manifolds are

[2] QI: web.
[3] See Projects using CGAL for details.
[4] See CGAL Prospective Workshop on Geometric Computing in Periodic Spaces, Subdivide and Tile: Triangulating spaces for understanding the world, Computational geometry in non-Euclidean spaces, Shape Up 2015 : Exercises in Materials Geometry and Topology
[5] See examples at Projects using CGAL

quotients of a hyperbolic space by some group of hyperbolic isometries. Their triangulations can be seen as hyperbolic periodic triangulations. Periodic hyperbolic triangulations and meshes appear for instance in geometric modeling [71], neuromathematics [46], or physics [72]. Even the case of the Bolza surface (a surface of genus 2, whose fundamental domain is the regular octagon in the hyperbolic plane) shows mathematical difficulties [35][12].

3.3 Probability in computational geometry

In most computational geometry papers, algorithms are analyzed in the worst-case setting. This often yields too pessimistic complexities that arise only in pathological situations that are unlikely to occur in practice. On the other hand, probabilistic geometry provides analyses with great precision [69, 70, 40], but using hypotheses with much more randomness than in most realistic situations. We are developing new algorithmic designs improving state-of-the-art performance in random settings that are not overly simplified and that can thus reflect many realistic situations.

Sixteen years ago, smooth analysis was introduced by Spielman and Teng analyzing the simplex algorithm by averaging on some noise on the data [74] (and they won the Gödel prize). In essence, this analysis smoothes the complexity around worst-case situations, thus avoiding pathological scenarios but without considering unrealistic randomness. In that sense, this method makes a bridge between full randomness and worst case situations by tuning the noise intensity. The analysis of computational geometry algorithms within this framework is still embryonic. To illustrate the difficulty of the problem, we started working in 2009 on the smooth analysis of the size of the convex hull of a point set, arguably the simplest computational geometry data structure; then, only one very rough result from 2004 existed [48] and we only obtained in 2015 breakthrough results, but still not definitive [52, 51, 58].

Another example of a problem of different flavor concerns Delaunay triangulations, which are rather ubiquitous in computational geometry. When Delaunay triangulations are computed for reconstructing meshes from point clouds coming from 3D scanners, the worst-case scenario is, again, too pessimistic and the full randomness hypothesis is clearly not adapted. Some results exist for "good samplings of generic surfaces" [30] but the big result that everybody wishes for is an analysis for random samples (without the extra assumptions hidden in the "good" sampling) of possibly non-generic surfaces.

Trade-offs between full randomness and worst case may also appear in other forms such as dependent distributions, or random distributions conditioned to be in some special configurations. In particular, simulating geometric distributions with repulsive properties, such as the determinantal point process, is currently out of reach for more than a few hundred points [61]. Yet it has practical applications in physics to simulate particules with repulsion such as electrons [66], to simulate the distribution of network antennas [32], or in machine learning [64].

3.4 Discrete geometric structures

Our work on discrete geometric structures develops in several directions, each one probing a different type of structure. Although these objects appear unrelated at first sight, they can be tackled by the same set of probabilistic and topological tools.

A first research topic is the study of *Order types.* Order types are combinatorial encodings of finite (planar) point sets, recording for each triple of points the orientation (clockwise or counterclockwise) of the triangle they form. This already determines properties such as convex hulls or half-space depths, and the behaviour of algorithms based on orientation predicates. These properties for all (infinitely many) n-point sets can be studied through the finitely many order types of size n. Yet, this finite space is poorly understood: its estimated size leaves an exponential margin of error, no method is known to sample it without concentrating on a vanishingly small corner, the effect of pattern exclusion or VC dimension-type restrictions are unknown. These are all directions we actively investigate.

A second research topic is the study of *Embedded graphs and simplicial complexes.* Many topological structures can be effectively discretized, for instance combinatorial maps record homotopy classes of embedded graphs and simplicial complexes represent a large class of topological spaces. This raises many structural and algorithmic questions on these discrete structures; for example, given a closed walk in an embedded graph, can we find a cycle of the graph homotopic to that walk? (The complexity status of that problem is unknown.) Going in the other direction, some purely discrete structures can be given an associated topological space that reveals some of their properties (*e.g.* the Nerve theorem for intersection patterns). An open problem is for instance to obtain fractional Helly theorems for set systems of bounded topological complexity.

Another research topic is that of *Sparse inclusion-exclusion formulas.* For any family of sets $A_1, A_2, \ldots, A_n$, by the principle of inclusion-exclusion we have

$$\mathbb{1}_{\bigcup_{i=1}^n A_i} = \sum_{I \subseteq \{1,2,\ldots,n\}} (-1)^{|I|+1} \mathbb{1}_{\bigcap_{i \in I} A_i} \tag{1}$$

where $\mathbb{1}_X$ is the indicator function of X. This formula is universal (it applies to any family of sets) but its number of summands grows exponentially with the number n of sets. When the sets are balls, the formula remains true if the summation is restricted to the regular triangulation; we proved that similar simplifications are possible whenever the Venn diagram of the A_i is sparse. There is much room for improvements, both for general set systems and for specific geometric settings. Another interesting problem is to combine these simplifications with the inclusion-exclusion algorithms developed, for instance, for graph coloring.

4 Application domains

Many domains of science can benefit from the results developed by GAMBLE. Curves and surfaces are ubiquitous in all sciences to understand and interpret raw data as well as experimental results. Still, the non-linear problems we address are rather basic and fundamental, and it is often difficult to predict the impact of solutions in that area. The short-term industrial impact is likely to be small because, on basic problems, industries have used ad hoc solutions for decades and have thus got used to it.

The example of our work on quadric intersection is typical: even though we were fully convinced that intersecting 3D quadrics is such an elementary/fundamental problem that it ought to be useful, we were the first to be astonished by the scope of the applications of our software [6] (which was the first and still is the only one —to our knowledge— to compute robustly and efficiently the intersection of 3D quadrics) which has been used by researchers in, for instance, photochemistry, computer vision, statistics, and mathematics. Our work on certified drawing of plane (algebraic) curves falls in the same category. It seems obvious that it is widely useful to be able to draw curves correctly (recall also that part of the problem is to determine where to look in the plane) but it is quite hard to come up with specific examples of fields where this is relevant. A contrario, we know that certified meshing is critical in mechanical-design applications in robotics, which is a non-obvious application field. There, the singularities of a manipulator often have degrees higher than 10 and meshing the singular locus in a certified way is currently out of reach. As a result, researchers in robotics can only build physical prototypes for validating, or not, the approximate solutions given by non-certified numerical algorithms.

The fact that several of our pieces of software for computing non-Euclidean triangulations had already been requested by users long before they become public in CGAL is a good sign for their wide future impact. This will not come as a surprise, since most of the questions that we have been studying followed from discussions with researchers outside computer science and pure mathematics. Such researchers are either users of our algorithms and software, or we meet them in workshops. Let us only mention a few names here. Rien van de Weijgaert [60, 77] (astrophysicist, Groningen, NL) and Michael Schindler [73] (theoretical physicist, ENSPCI, CNRS, France) used our software for 3D periodic weighted triangulations. Stephen Hyde and Vanessa Robins (applied mathematics and physics at Australian National University) used our package for 3D periodic meshing. Olivier Faugeras (neuromathematics, INRIA Sophia Antipolis) had come to us and mentioned his needs for good meshes of the Bolza surface [46] before we started to study them. Such contacts are very important both to get feedback about our research and to help us choose problems that are relevant for applications. These problems are at the same time challenging from the mathematical and algorithmic points of view. Note that our research and our software are generic, i.e., we are studying fundamental geometric questions, which do not depend on any specific application. This recipe has made the sucess of the CGAL library.

Probabilistic models for geometric data are widely used to model various situations ranging from cell phone distribution to quantum mechanics. The impact of our work on probabilistic distributions

[6] QI: web.

is twofold. On the one hand, our studies of properties of geometric objects built on such distributions will yield a better understanding of the above phenomena and has potential impact in many scientific domains. On the other hand, our work on simulations of probabilistic distributions will be used by other teams, more maths oriented, to study these distributions.

5 Highlights of the year

A very positive highlight of this year is the nomination of Vincent Despré as junior member of the Institut Universitaire de France (IUF, promotion 2025).

Another highlight is the retirement, in July, of Monique and Olivier, two senior members of Gamble, including its scientific leader. The team wishes them the best in their future projects. A new team-project has been proposed.

On the negative side, the team was deeply affected by the decision of the presidence of INRIA to not call candidates ranked 4 to 8 on the CRCN list, resulting in the cancelling of the two CRCN positions initially opened in Nancy. This, in particular, deprived Gamble of an excellent recruitment opportunity, as our candidate was ranked 2nd by the admissibility jury and 4th by the admissions jury.

6 Latest software developments, platforms, open data

6.1 Latest software developments

6.1.1 CGAL Package: 2D Triangulations on Hyperbolic Surfaces

Keyword: Hyperbolic geometry

Functional Description: This package introduces a data structure and algorithms for triangulations of closed orientable hyperbolic surfaces.

URL: `https://doc.cgal.org/latest/Triangulation_on_hyperbolic_surface_2/index.html`

Contact: Marc Pouget

6.1.2 wdkroots

Name: Weierstrass-Durand-Kerner roots

Keywords: Complex number, Root, Polynomial equations

Functional Description: This code uses Durand-Kerner (or Weierstrass) method to find polynomial complex roots in double precision. The code has been written to benefit from auto-vectorization, while reducing the risks of overflow in floating-point arithmetic.

This component is included in the main branch of the Flint scientific computing library since the end of 2025.

URL: `https://gitlab.inria.fr/gmoro/wdkroots`

Contact: Guillaume Moroz

6.1.3 3D SnapHeur

Name: 3D SnapHeur

Keywords: Mesh rounding, 3D modeling, Triangle-triangle intersection

Functional Description: 3D SnapHeur is a heuristic for rounding 3D meshes or the vertices in a soup of triangles in 3D, without creating self-intersections. It is designed to robustly handle intersections in complex 3D models.

The approach is presented and evaluated in a publication by the authors in the 2025 Symposium on Geometry Processing and has been integrated into CGAL by Léo Valque in the autorefine_triangle_soup CGAL function (https://doc.cgal.org/latest/Polygon_mesh_processing/group__PMP__corefinement__grp.html#gaf7747d676c459d9e5da9b13be7d12bb5).

URL: https://gitlab.inria.fr/lazard/3d-snap-rounding

Publication: hal-05242294

Contact: Sylvain Lazard

Participants: Sylvain Lazard, Leo Valque

Partner: Université de Lorraine

6.1.4 3D Snap Rounding

Name: 3D Snap Rounding

Keywords: Mesh rounding, 3D modeling, Triangle-triangle intersection

Functional Description: 3D Snap Rounding is a software for rounding 3D meshes or the vertices in a soup of triangles in 3D, without creating self-intersections. It is designed to robustly handle intersections in complex 3D models. and it is based on an exact (non-heuristic) algorithm published in Léo Valque's 2024 PhD Thesis.

Contact: Sylvain Lazard

Participants: Sylvain Lazard, Leo Valque

Partner: Université de Lorraine

7 New results

7.1 Non-Linear Computational Geometry

Participants: Laurent Dupont, Nuwan Herath Mudiyanselage, Sylvain Lazard, Guillaume Moroz, Marc Pouget, Léo Valque.

7.1.1 On Arrangements of Quadrics in Decomposing the Parameter Space of 3D Digitized Rigid Motions

Computing the arrangement of quadrics in 3D is a fundamental problem in symbolic computation, with challenges arising when handling degenerate cases and asymptotic critical values. State-of-the-art methods typically require a generic change of coordinates to manage these asymptotes, rendering certain problems intractable. A specific instance of this challenge appears in digital geometry, where comparing 3D shapes up to isometry requires applying a 3D rigid motion on and mapping the result back to , a process typically achieved via a digitization operator. However, such motions do not preserve the topology of digital objects, making the analysis of digitized rigid motions crucial. Our main contribution is the decomposition of the 6D parameter space of digitized rigid motions for image patches of radius up to three. This problem reduces to computing the arrangement of up to 741 quadrics, some of which are degenerate. To address the computational challenges, we introduce and implement a new algorithm for computing arrangements of quadrics in 3D, specifically designed to handle degenerate directions and asymptotic critical values. This approach allows us to overcome the limitations of existing methods, making the problem tractable in the context of digital geometry.

This result was accepted in Journal of Symbolic Computation [21].

In collaboration with Kacper Pluta, Yukiko Kenmochi, Pascal Romon.

7.1.2 A Subquadratic Algorithm for Computing the L_1-distance between Two Terrains

We study the problem of computing the L_1-distance between two piecewise-linear bivariate functions f and g, defined over a common bounded domain $\mathbb{M} \subset \mathbb{R}^2$, that is, computing the quantity $\|f-g\|_1 = \int_{\mathbb{M}} |f(x,y)-g(x,y)|\,dx\,dy$. If f and g are defined by linear interpolation over triangulations $\mathbf{T}_f$ and $\mathbf{T}_g$, respectively, of $\mathbb{M}$ with a total of n triangles, we show that $\|f-g\|_1$ can be computed in $\tilde{O}(n^{(\omega+1)/2})$ time, where $\Theta(n^{\omega})$ is the time required to multiply two $n \times n$ matrices and $\tilde{O}$ notation hides polylogarithmic factors; this bound holds for the currently best known value of ω, which is approximately 2.37. The previously best known algorithm for computing $\|f-g\|_1$ takes $\Theta(n^2)$ time in the worst case.

More generally, if the complexity of the overlay of $\mathbf{T}_f$ and $\mathbf{T}_g$ is κ, then the runtime of our algorithm is $\tilde{O}(\kappa^{(\omega-1)/2} n^{(3-\omega)/2})$ [23]. This article was accepted at the conference SoCG 2025.

In collaboration with Pankaj K. Agarwal and Boris Aronov.

7.1.3 3D snap rounding

Most algorithms for processing 3D polygonal objects use fixed-precision coordinates for both input and output data. However, geometric operations often produce output coordinates that require higher precision than the input. This discrepancy implies the need for rounding new coordinates to match the precision of the input, while preserving the integrity of the model. The critical problem we address is the removal of self-intersections in 3D models, achieved by subdividing faces along their intersections and rounding the resulting coordinates, from their exact mathematical values to a fixed-precision floating-point format, while ensuring that the model remains free from self-intersections. This problem is known as the snap rounding problem.

We present in [22] a straightforward and robust heuristic for resolving this problem. Our method takes as input a soup of triangles and outputs intersection-free models whose vertices coordinates are all represented with double-precision floating-point format. We evaluated our approach thoroughly, considering a large collection of meshes. In particular, we can process all the 4 524 models in Thingi10K [79] that contain self-intersections. This outperforms previous state-of-the-art approaches: On the 527 models of Thingi10K for which naive rounding fails, Zhou et al.'s approach [78] is capable of handling 91% of them, and Valque's 94% [76]. In terms of time efficiency, our approach handles about 50k vertices per second on average, which is faster to that of Zhou et al. by a factor 1.4 on these non-trivial models and is faster than that of Valque by several order of magnitude.

7.2 Non-Euclidean Computational Geometry

Participants: Vincent Despré, Loïc Dubois, Camille Lanuel, Alba Marina Málaga Sabogal, Marc Pouget, Monique Teillaud.

7.2.1 A Discrete Analog of Tutte's Barycentric Embeddings on Surfaces

Tutte's celebrated barycentric embedding theorem describes a natural way to build straight-5 line embeddings (crossing-free drawings) of a (3-connected) planar graph: map the vertices of the outer face to the vertices of a convex polygon, and ensure that each remaining vertex is in convex position, namely, a barycenter with positive coefficients of its neighbors. Actually computing an embedding then boils down to solving a system of linear equations. A particularly appealing feature of this method is the flexibility given by the choice of the barycentric weights. Generalizations of Tutte's theorem to surfaces of nonpositive curvature are known, but due to their inherently continuous nature, they do not lead to an algorithm. In this paper, we propose a purely discrete analog of Tutte's theorem for surfaces (with or without boundary) of nonpositive curvature, based on the recently introduced notion of reducing triangulations. We prove a Tutte theorem in this setting: every drawing homotopic to an embedding such that each vertex is harmonious (a discrete analog of being in convex position) is a weak embedding (arbitrarily close to an embedding). We also provide a polynomial-time algorithm to make an input drawing harmonious without increasing the length of any edge, in a similar way as a drawing can be put in convex position without increasing the edge lengths.

In collaboration with Éric Colin de Verdière, Université Gustave Eiffel.

7.2.2 ϵ-Net Algorithm Implementation on Hyperbolic Surface

We propose an implementation, using the CGAL library, of an algorithm to compute ϵ-nets on hyperbolic surfaces initially presented in [49]. We describe the data structure, detail the implemented algorithm and report experimental results on hyperbolic surfaces of genus 2. The implementation differs from the cited algorithm on several aspects. In particular, we use a different data structure, using a combinatorial map, to represent a triangulation of a surface. Also for the critical step of locating points on the surface, we use the visibility walk and prove its termination in the hyperbolic setting [25]. This work is also a chapter of the PhD thesis of Camille Lanuel [26].

7.3 Discrete Geometric structures

Participants: Marguerite Bin, Niloufar Fuladi, Xavier Goaoc, Sarah Wajsbrot, Mario Valencia-Pabon.

7.3.1 Hitting and Covering Affine Families of Convex Polyhedra, with Applications to Robust Optimization

Geometric hitting set problems, in which we seek a smallest set of points that collectively hit a given set of ranges, are ubiquitous in computational geometry. Most often, the set is discrete and is given explicitly. We propose new variants of these problems, dealing with continuous families of convex polyhedra, and show that they capture decision versions of the two-level finite adaptability problem in robust optimization. We show that these problems can be solved in strongly polynomial time when the size of the hitting/covering set and the dimension of the polyhedra and the parameter space are constant. We also show that the hitting set problem can be solved in strongly quadratic time for one-parameter families of convex polyhedra in constant dimension. This leads to new tractability results for finite adaptability that are the first ones with so-called left-hand-side uncertainty, where the underlying problem is non-linear.

This result was accepted in the conference Mathematical Foundation of Computer Science [24].

In collaboration with Jean Cardinal.

7.3.2 An asymptotic rigidity property from the realizability of chirotope extensions

Let P be a finite full-dimensional point configuration in $\mathbb{R}^d$. We show that if a point configuration Q has the property that all finite chirotopes realizable by adding (generic) points to P are also realizable by adding points to Q, then P and Q are equal up to a direct affine transform. We also show that for any point configuration P and any $\epsilon > 0$, there is a finite, (generic) extension $\hat{P}$ of P with the following property: if another realization Q of the chirotope of P can be extended so as to realize the chirotope of $\hat{P}$, then there exists a direct affine transform that maps each point of Q within distance ϵ of the corresponding point of P [27].

7.3.3 Intersection patterns of set systems on manifolds with slowly growing homological shatter functions

A theorem of Matoušek asserts that for any $k \geq 2$, any set system whose shatter function is $o(n^k)$ enjoys a fractional Helly theorem: in the k-wise intersection hypergraph, positive density implies a linear-size clique. Kalai and Meshulam conjectured a generalization of that phenomenon to homological shatter functions. It was verified for set systems with bounded homological shatter functions and ground set with a forbidden homological minor (which includes $\mathbb{R}^d$ by a homological analogue of the van Kampen-Flores theorem). We present two contributions to this line of research:

- We study homological minors in certain manifolds (possibly with boundary), for which we prove analogues of the van Kampen-Flores theorem and of the Hanani-Tutte theorem.
- We introduce graded analogues of the Radon and Helly numbers of set systems and relate their growth rate to the original parameters. This allows to extend the verification of the Kalai-Meshulam conjecture for sufficiently slowly growing homological shatter functions.

In collaboration with Sergey Avvakumov.

7.3.4 Computing shortest closed curves on non-orientable surfaces

We initiate the study of computing shortest non-separating simple closed curves with some given topological properties on non-orientable surfaces. While, for orientable surfaces, any two non-separating simple closed curves are related by a self-homeomorphism of the surface, and computing shortest such curves has been vastly studied, for non-orientable ones the classification of non-separating simple closed curves up to ambient homeomorphism is subtler, depending on whether the curve is one-sided or two-sided, and whether it is orienting or not (whether it cuts the surface into an orientable one). We prove that computing a shortest orienting (weakly) simple closed curve on a non-orientable combinatorial surface is NP-hard but fixed-parameter tractable in the genus of the surface. In contrast, we can compute a shortest non-separating non-orienting (weakly) simple closed curve with given sidedness in $g^{O(1)} n \log n$ time, where g is the genus and n the size of the surface. For these algorithms, we develop tools that can be of independent interest, to compute a variation on canonical systems of loops for non-orientable surfaces based on the computation of an orienting curve, and some covering spaces that are essentially quotients of homology covers.

This result was accepted in the Journal of Computational Geometry [18].

In collaboration with Denys Bulavka and Éric Colin de Verdière.

7.3.5 A canonical tree decomposition for order types, and some applications

We introduce and study a notion of decomposition of planar point sets (or rather of their chirotopes) as trees decorated by smaller chirotopes. This decomposition is based on the concept of mutually avoiding sets (which we rephrase as *modules*), and adapts in some sense the modular decomposition of graphs in the world of chirotopes. The associated tree always exists and is unique up to some appropriate constraints. We also show how to compute the number of triangulations of a chirotope efficiently, starting from its tree and the (weighted) numbers of triangulations of its parts.

This result was accepted in SIAM Journal on Discrete Mathematics [17].

In collaboration with Mathilde Bouvel, Florent Koechlin and Valenting Feray.

7.3.6 Computing Distances on Graph Associahedra Is Fixed-Parameter Tractable

An elimination tree of a connected graph G is a rooted tree on the vertices of G obtained by choosing a root v and recursing on the connected components of G-v to obtain the subtrees of v. The graph associahedron of G is a polytope whose vertices correspond to elimination trees of G and whose edges correspond to tree rotations, a natural operation between elimination trees. These objects generalize associahedra, which correspond to the case where G is a path. Ito et al. [63] recently proved that the problem of computing distances on graph associahedra is NP-hard. In this paper we prove that the problem, for a general graph G, is fixed-parameter tractable parameterized by the distance k. Prior to our work, only the case where G is a path was known to be fixed-parameter tractable. To prove our result, we use a novel approach based on a marking scheme that restricts the search to a set of vertices whose size is bounded by a (large) function of k.

This result was accepted in the conference *International Colloquium on Automata, Languages and Programming* (ICALP) [47].

In collaboration with Luís Felipe I. Cunha, Ignasi Sau and Uéverton Souza.

7.3.7 Spectral properties of stellohedra

In this article we contribute to the analysis of the spectral properties of graph associahedra, providing a lower bound for the second largest eigenvalue of the graph associahedra $A(G)$ of G. Additionally, using equitable partitions, we analyze the spectrum of stellohedra $A(K1, n)$, proving the existence of an eigenvalue in the interval $(n-2, n-1]$ and identifying two additional small eigenvalues.

This result was accepted in the conference *Latin American Algorithms, Graphs, and Optimization Symposium* (LAGOS 2025) [57].

In collaboration with Ana Gargantini, Adrián Pastine and Pablo Torres.

8 Bilateral contracts and grants with industry

8.1 Bilateral contracts with industry

8.1.1 Waterloo Maple Inc.

Participants: Laurent Dupont, Sylvain Lazard, Guillaume Moroz, Marc Pouget, Rémi Imbach.

Company: Waterloo Maple Inc.
Duration: 2 years, renewable
Participants: Gamble and Ouragan Inria teams

Abstract: A renewable two-years licence and cooperation agreement was signed on April 1st, 2018 between Waterloo Maple Inc., Ontario, Canada (represented by Laurent Bernardin, its Executive Vice President Products and Solutions) and Inria. On the Inria side, this contract involves the teams Gamble and Ouragan (Paris), and it is coordinated by Fabrice Rouillier (Ouragan).

F. Rouillier and Gamble are the developers of the Isotop software for the computation of topology of curves. The transfer of a version of Isotop to Waterloo Maple Inc. should be done on the long run.

This contract was amended last year to include the new software hefroots for the isolation of the complex roots of a univariate polynomial. The transfer of hefroots to Waterloo Maple Inc. started at the end of 2021 with the help of the independent contractor Rémi Imbach. Rémi Imbach was then hired for one year by Inria through the ADT program. This led to the inclusion of hefroots in Maple 2023, and to the development of a improved software pwpoly included in Maple 2024.

8.1.2 GeometryFactory

Participants: Vincent Despré, Loïc Dubois, Camille Lanuel, Marc Pouget, Monique Teillaud.

Company: GeometryFactory
Duration: permanent
Participants: Inria and GeometryFactory
Abstract: Cgal packages developed in Gamble are commercialized by GeometryFactory.

9 Partnerships and cooperations

9.1 International initiatives

9.1.1 Inria associate team not involved in an IIL or an international program

ConforLux - Computational Conformal Geometry

Participants: Vincent Despré, Marc Pouget, Alba Marina Malaga Sabogal, Dorian Perrot.

Title: ConforLux

Duration: 2025 to 2027

Coordinators: Marc Pouget and Jean-Marc Schlenker (University of Luxembourg)

Inria contact: Marc Pouget

Summary: ConforLux (Computational Conformal Geometry) is a collaborative research initiative uniting the GAMBLE project-team (Inria, France) and the research group of Jean-Marc Schlenker (University of Luxembourg).

The project operates at the frontier of theoretical mathematics and computer science, focusing on Geometric Topology and Algorithmic Geometry. The collaboration aims to leverage complementary expertise: the mathematical depth of the Luxembourg group regarding complex structures on surfaces, and the algorithmic expertise of the GAMBLE team in designing data structures and implementations for the CGAL library.

DIPPS - Discrete models for Intersection Patterns and Point Sets

Participants: Xavier Goaoc, Niloufar Fuladi, Sarah Wajsbrot, Marguerite Bin.

Title: DIPPS

Duration: 2025 to 2027

Coordinators: Xavier Goaoc and Andreas Holmsen (KAIST)

Inria contact: Xavier Goaoc

Summary: DIPPS is a collaborative research initiative uniting the GAMBLE project-team (Inria, France) and the research group of Andreas Holmsen (KAIST, South Korea).

The project brings together 11 participants (including 3 members from other institutions: Ponts et Chaussée, Université Gustave Eiffel, and GIST). It tackles two established topics of discrete and computational geometry: convexity spaces and order types. The collaboration leverages the complementarity of the Korean partners, who have strong connections to discrete mathematics and extremal combinatorics, two topics under-represented in France, and the French partners, who have strong connection to algorithms.

9.2 International research visitors

9.2.1 Visits of international scientists

Other international visits to the team

Sergey Avvakumov

Status Assistant professor

Institution of origin: Tel Aviv University

Country: Israel

Dates: April (1 week)

Context of the visit: Collaboration on topological combinatorics

Mobility program/type of mobility: research stay

Jean Cardinal

Status professor

Institution of origin: Université libre de Bruxelles

Country: Belgium

Dates: December (2 weeks)

Context of the visit: Seminar on geometric algorithms

Mobility program/type of mobility: Research stay / Lecture

Otfried Cheong

Status researcher

Institution of origin: Scalgo / Bayreuth University

Country: Germany

Dates: October (1 week)

Context of the visit: Collaboration on geometric computing

Mobility program/type of mobility: research stay

Dohyeon Lee

Status PhD student

Institution of origin: KAIST

Country: South Korea

Dates: July 1–20

Context of the visit: Collaboration on discrete geometry

Mobility program/type of mobility: research stay (associate team DIPPS)

9.2.2 Visits to international teams

Research stays abroad

Niloufar Fuladi

Visited institution: Institute for Basic Science (IBS)

Country: South Korea

Dates: May – June 2025 (2 months)

Context of the visit: Research visit to the Discrete Mathematics Group (DIMAG)

Mobility program/type of mobility: Associate team DIPPS

Sarah Wajsbrot

Visited institution: Institute for Basic Science (IBS)

Country: South Korea

Dates: May – June 2025 (2 months)

Context of the visit: Research visit to the Discrete Mathematics Group (DIMAG)

Mobility program/type of mobility: DREAM mobility program (Lorraine Université d'Excellence)

Marguerite Bin

Visited institution: Centre de Recerca Matemàtica (CRM)

Country: Spain

Dates: October – November 2025 (2 months)

Context of the visit: Research School on "Combinatorial Geometries & Geometric Combinatorics"

Mobility program/type of mobility: Doctoral school + formation par la recherche + invitation

Mario Valencia-Pabon

Visited institution: University of Buenos Aires (UBA)

Country: Argentina

Dates: November 2025 (2 weeks)

Context of the visit: Research visit to the Graph Theory and Combinatorial Optimization group

Mobility program/type of mobility: International Research Project (IRP) SINFIN

9.3 National initiatives

9.3.1 ANR PRC

Participants: Sylvain Lazard, Alba Málaga Sabogal, Guillaume Moroz, Marc Pouget.

ANR StratMesh

Title: StratMesh

Duration: 2025 to 2029

Coordinator: Guillaume Moroz (Inria)

Inria contact: Guillaume Moroz

Summary: StratMesh aims to develop provably-correct triangulation algorithms for stratified spaces. Our focus is on stratified spaces that are the projection of smooth manifolds, which arise in many applications such as robotics, control theory, and medial axis computation for learning from geometric data.

9.3.2 ANR JCJC

Participants: Vincent Despré.

ANR Abysm

Title: Abysm

Duration: 2024 to 2028

Coordinator: Vincent Despré (Université de Lorraine)

Inria contact: Vincent Despré

Summary: The central theme of this project is the study of geometric and combinatorial structures related to hyperbolic surfaces and their moduli from an algorithmic point of view. The needs for hyperbolic geometries are arising, e.g., in crystallography, in geometric modeling, neuromathematics, or physics. The generic need regarding computer science in all those examples is clearly stated in a very recent paper on Nature Communications: "Spaces with negative curvature are difficult to realize and investigate experimentally". In order to solve this issue, our goal is to develop the study of hyperbolic surfaces in computational geometry and make our results readily available for users. We intend to design efficient and algorithms with precise data structures to compute geometrical characteristics of hyperbolic surfaces such as the systole, the diameter and optimal pants decompositions. We also want to study the regularity of the previous parameters while moving through the Teichmüller and moduli spaces. We plan to implement our algorithms and make them publicly available to users.

10 Dissemination

10.1 Promoting scientific activities

Member of the organizing committees Mario Valencia-Pabon was a member of the program committee of *XIII Latin American Algorithms, Graphs, and Optimization Symposium (LAGOS 2025)*.

10.1.1 Scientific events: selection

Reviewer All members of the team are regular reviewers for the conferences of our field, namely Symposium on Computational Geometry (SoCG), European Symposium on Algorithms (ESA), Symposium on Discrete Algorithms (SODA), International Symposium on Symbolic and Algebraic Computation (ISSAC), etc.

10.1.2 Journal

Reviewer - reviewing activities All members of the team are regular reviewers for the journals of our field, namely Discrete and Computational Geometry (DCG), Journal of Computational Geometry (JoCG), International Journal on Computational Geometry and Applications (IJCGA), Journal on Symbolic Computations (JSC), SIAM Journal on Computing (SICOMP), Mathematics in Computer Science (MCS), etc.

10.1.3 Software Project

Member of the Editorial Boards. Marc Pouget and Monique Teillaud are members of the CGAL editorial board.

10.1.4 Leadership within the scientific community

Guillaume Moroz was a coorganizer of the *Journées de Géométrie Algorithmique* workshop in Roscoff. (October 2025)

10.1.5 Research administration

Team members are involved in various committees managing the scientific life of the lab or at a national level.

Local

- INRIA Commission Information et Édition Scientifique (Laurent Dupont),
- INRIA Comité de centre (Xavier Goaoc),
- LORIA Conseil scientifique (Sylvain Lazard),
- LORIA associate director (Sylvain Lazard),
- École doctorale IAEM, Computer science board (co-chair, Xavier Goaoc; member, Sylvain Lazard),
- Conseil du Pole scientifique Am2I of University of Lorraine (Xavier Goaoc)
- INRIA Comité des utilisateurs des moyens informatiques (chair, Guillaume Moroz)
- INRIA Commission de développement technologique (Guillaume Moroz),
- FSS (Guillaume Moroz),
- INRIA and LORIA PhD and postdoc hiring committee (Marc Pouget),
- Member of the mentoring committee at LORIA (Monique Teillaud),
- LORIA Conseil du laboratoire (Mario Valencia-Pabon)

National

- INRIA Mission Jeunes Chercheurs (chair, Sylvain Lazard).

Hiring Committees

- Xavier Goaoc was vice-chair of the hiring committee for a full professor position at LORIA and École des Mines (Université de Lorraine).
- Sylvain Lazard chaired the hiring committee for a full professor position at at LORIA and IUT Nancy-Charlemagne (Université de Lorraine).
- Xavier Goaoc served on the "repyramidage" committees for section CNU 27 at Sorbonne Université and Université Montpellier.

10.1.6 Teaching Committees

- Laurent Dupont: Head of the Bachelor diploma Licence Professionnelle Animateur, Facilitateur de Tiers-lieux Eco-Responsables, Université de Lorraine (not open this year)
- Laurent Dupont: Responsible for the course "Création Numérique" of the Bachelor (BUT) "Métiers du Multimédia et de l'Internet"
- Laurent Dupont: Responsible for fablab "Charlylab" of I.U.T. Nancy-Charlemagne,
- Xavier Goaoc is the chair of the computer science department of École des Mines de Nancy.
- Xavier Goaoc is a member of the Conseil d'administration de l'École des Mines de Nancy.
- Mario Valencia-Pabon is responsible of the 5th year Polytech computer science engineering internships.

10.2 Teaching - Supervision - Juries

10.2.1 Teaching

- Licence: Vincent Despre, *Algorithmique*, 44h, L2 PEIP, Polytech Nancy, France.
- Licence: Vincent Despre, *Programmation orientée objet*, 84h, L3 IA2R, Polytech Nancy, France. (web).
- Licence: Laurent Dupont, *Web development*, 45h, L1, Université de Lorraine, France.
- Licence: Laurent Dupont, *Web development*, 150h, L2, Université de Lorraine, France.
- Licence: Laurent Dupont, *Web development*, 70h, L3, Université de Lorraine, France.
- Licence: Laurent Dupont, *3D printing and CAO* 40h, L3, Université de Lorraine, France.
- Licence : Xavier Goaoc, *Algorithms and complexity*, 60 HETD, L3, École des Mines de Nancy, France.
- Master: Xavier Goaoc, *Computer architecture*, 32 HETD, M1, École des Mines de Nancy, France.
- Master: Xavier Goaoc, *Introduction to blockchains*, 32 HETD, M1, École des Mines de Nancy, France.
- Master: Xavier Goaoc, *Réalité augmentée et modèles géométriques pour la vision*, 12h, M2 AVR, Université de Lorraine, France
- Master: Guillaume Moroz, *Software Engineering*, 20h, M1, École des Mines de Nancy, France.
- Master: Marc Pouget, *Introduction to computational geometry*, 10.5h, M2, École Nationale Supérieure de Géologie, France.
- Licence: Mario Valencia-Pabon, *Conception d'algorithmes*, 44h, L3, Polytech Nancy, France.
- Licence: Mario Valencia-Pabon, *Complexité algorithmique*, 23h, L3, École des Mines de Nancy, France.

10.2.2 Supervision

- Master internship M1: Yacine Rouina, Subdivision versus suivi pour l'approximation de surfaces Sept. 2025-Feb. 2026, supervised by Guillaume Moroz and Marc Pouget.
- Master internship M2: Gautier Schanzenbacher, Geometry and triangulation of Hyperbolic surfaces, Mar-Jun 2025, supervised by Vincent Despre, Marc Pouget, Julien Maubon (IECL) and Samuel Tapie (IECL).

- Master internship M2: Rachel Dufau-Sansot, Shattering sets of permutations, Sep 2025-Jan 2026, supervised by Xavier Goaoc.
- PhD in progress: Gautier Schanzenbacher, Systole, entropie et espace des modules des surfaces hyperboliques de type fini, started in Sept. 2025, supervised by Vincent Despre, Marc Pouget, Julien Maubon (IECL) and Samuel Tapie (IECL).
- PhD in progress: Marguerite Bin, Order types: decomposition and complexity, started in Sept. 2024, supervised by Xavier Goaoc and Alfredo Hubard (LIGM, Université Gustave Eiffel).
- PhD in progress: Dorian Perrot, Hyperbolic surfaces and computational geometry, started in Sept. 2024, supervised by Vincent Despre and Marc Pouget.
- PhD defended in Sep. 2025: Loïc Dubois, Algorithms for Topological and Metric Spaces, supervised by Vincent Despre and Éric Colin de Verdière (Marne la Vallée).
- PhD defended in Nov. 2025: Camille Lanuel, Computing an ε-net of a hyperbolic surface, supervised by Vincent Despre, Marc Pouget and Monique Teillaud.
- PhD in progress: Sarah Wajsbrot, Combinatorial convexity, its generalizations and applications to optimization, started in Oct. 2023, supervised by Xavier Goaoc.
- PhD in progress: Yacine Abdelsadok, Characterization and analysis of the singularity surfaces of cuspidal 6r robots and tensegrity robots, started in Nov. 2025, supervised by Guillaume Moroz, Damien Chablat and Philippe Wenger.

10.2.3 Juries

- Xavier Goaoc chaired the PhD defense committee of Nathan Claudet, Université de Lorraine.
- Xavier Goaoc chaired the PhD defense committee of Anton Medvedev, CNAM.
- Xavier Goaoc was on the reading and defense committees of the PhD thesis of Yann Marin, Université de Montpellier.
- Guillaume Moroz was on the reading and defense committees of the PhD thesis of Alexandre Goyer, Université Paris-Saclay.

10.3 Popularization

10.3.1 Education

- Olivier Devillers presented research career in several different classes in highschool within the Chiche program.
- Alba Málaga Sabogal, Dorian Perrot and Paul Remy have been invited to the festival *Les Maths Dans Tous Leurs États* in Thionville (April, 24-25 2025), to present the Hilbert slide.
- Alba Málaga is a member of the scientific board for the association *Les maths en scène* and the *marraine* for a high-school math student club in Thionville, *le labo Rosa Parks*.
- Guillaume Moroz is member of the Olympiades committee of the Académie Nancy-Metz.

10.3.2 Interventions

- Laurent Dupont, Marc Pouget, Dorian Perrot, Gautier Schanzenbacher organized a workshop "Coloriage avec un crayon fin : boostez vos courbes !" for the "Fête de la science" in October 10-11 in Nancy.

11 Scientific production

11.1 Major publications

[1] N. Bonichon, P. Bose, J.-L. De Carufel, V. Despré, D. Hill and M. Smid. 'Improved Routing on the Delaunay Triangulation'. In: *ESA 2018 - 26th Annual European Symposium on Algorithms*. Helsinki, Finland, 2018. DOI: 10.4230/LIPIcs.ESA.2018.22. URL: https://hal.archives-ouvertes.fr/hal-01881280.

[2] L. Castelli Aleardi and O. Devillers. 'Array-based Compact Data Structures for Triangulations: Practical Solutions with Theoretical Guarantees'. In: *Journal of Computational Geometry* 9.1 (2018), pp. 247–289. DOI: 10.20382/jocg.v9i1a8. URL: https://hal.inria.fr/hal-01846652.

[3] N. Chenavier and O. Devillers. 'Stretch Factor in a Planar Poisson-Delaunay Triangulation with a Large Intensity'. In: *Advances in Applied Probability* 50.1 (2018), pp. 35–56. DOI: 10.1017/apr.2018.3. URL: https://hal.inria.fr/hal-01700778.

[4] V. Despré, J.-M. Schlenker and M. Teillaud. 'Flipping Geometric Triangulations on Hyperbolic Surfaces'. In: *SoCG 2020 - 36th International Symposium on Computational Geometry*. Zurich, Switzerland, 2020. DOI: 10.4230/LIPIcs.SoCG.2020.35. URL: https://hal.inria.fr/hal-02886493.

[5] O. Devillers, M. Karavelas and M. Teillaud. 'Qualitative Symbolic Perturbation: Two Applications of a New Geometry-based Perturbation Framework'. In: *Journal of Computational Geometry* 8.1 (2017), pp. 282–315. DOI: 10.20382/jocg.v8i1a11. URL: https://hal.inria.fr/hal-01586511.

[6] O. Devillers, S. Lazard and W. Lenhart. '3D Snap Rounding'. In: *Proceedings of the 34th International Symposium on Computational Geometry*. Budapest, Hungary, June 2018, 30:1–30:14. DOI: 10.4230/LIPIcs.SoCG.2018.30. URL: https://hal.inria.fr/hal-01727375.

[7] O. Devillers, S. Lazard and W. Lenhart. 'Rounding meshes in 3D'. In: *Discrete and Computational Geometry* (Apr. 2020). DOI: 10.1007/s00454-020-00202-2. URL: https://hal.inria.fr/hal-02549290.

[8] X. Goaoc, P. Paták, Z. Patáková, M. Tancer and U. Wagner. 'Shellability is NP-complete'. In: *Journal of the ACM (JACM)* 66.3 (2019). DOI: 10.1145/3314024. URL: https://hal.inria.fr/hal-02050505.

[9] X. Goaoc and E. Welzl. 'Convex Hulls of Random Order Types'. In: *SoCG 2020 - 36th International Symposium on Computational Geometry*. Ed. by S. Cabello and D. Z. Chen. Vol. 164. 36th International Symposium on Computational Geometry (SoCG 2020). Best paper award. Zürich / Virtual, Switzerland, 2020, 49:1–49:15. DOI: 10.4230/LIPIcs.SoCG.2020.49. URL: https://hal.inria.fr/hal-02879289.

[10] R. Imbach, G. Moroz and M. Pouget. 'Reliable Location with Respect to the Projection of a Smooth Space Curve'. In: *Reliable Computing* 26 (2018), pp. 13–55. URL: https://hal.archives-ouvertes.fr/hal-01920444.

[11] R. Imbach, M. Pouget and C. Yap. 'Clustering Complex Zeros of Triangular Systems of Polynomials'. In: *Mathematics in Computer Science* (June 2020). DOI: 10.1007/s11786-020-00482-0. URL: https://inria.hal.science/hal-02878388.

[12] I. Iordanov and M. Teillaud. 'Implementing Delaunay Triangulations of the Bolza Surface'. In: *33rd International Symposium on Computational Geometry (SoCG 2017)*. Brisbane, Australia, July 2017, 44:1–44:15. DOI: 10.4230/LIPIcs.SoCG.2017.44. URL: https://hal.inria.fr/hal-01568002.

[13] R. Jha, D. Chablat, L. Baron, F. Rouillier and G. Moroz. 'Workspace, Joint space and Singularities of a family of Delta-Like Robot'. In: *Mechanism and Machine Theory* 127 (Sept. 2018), pp. 73–95. DOI: 10.1016/j.mechmachtheory.2018.05.004. URL: https://hal.archives-ouvertes.fr/hal-01796066.

[14] S. Lazard, M. Pouget and F. Rouillier. 'Bivariate triangular decompositions in the presence of asymptotes'. In: *Journal of Symbolic Computation* 82 (2017), pp. 123–133. DOI: 10.1016/j.jsc.2017.01.004. URL: https://hal.inria.fr/hal-01468796.

[15] P. Machado Manhães De Castro and O. Devillers. 'Expected Length of the Voronoi Path in a High Dimensional Poisson-Delaunay Triangulation'. In: *Discrete and Computational Geometry* 60.1 (2018), pp. 200–219. DOI: 10.1007/s00454-017-9866-y. URL: https://hal.inria.fr/hal-01477030.

[16] G. Moroz. 'New data structure for univariate polynomial approximation and applications to root isolation, numerical multipoint evaluation, and other problems'. In: *2021 IEEE 62nd Annual Symposimum on Foundations of Computer Science (FOCS)*. FOCS 2021 - 62nd Annual IEEE Symposimum on Foundations of Computer Science. Denver, United States, Dec. 2021. DOI: 10.1109/FOCS52979.2021.00108. URL: https://hal.science/hal-03249123.

11.2 Publications of the year

International journals

[17] M. Bouvel, V. Féray, X. Goaoc and F. Koechlin. 'A canonical tree decomposition for order types, and some applications'. In: *SIAM Journal on Discrete Mathematics* 39.4 (28th Oct. 2025), pp. 2189–2241. DOI: 10.1137/24M1672201. URL: https://hal.science/hal-04528939.

[18] D. Bulavka, É. Colin de Verdière and N. Fuladi. 'Computing shortest closed curves on non-orientable surfaces'. In: *Journal of Computational Geometry* 16.2 (2025), pp. 237–264. DOI: 10.20382/jocg.v16i2a8. URL: https://hal.science/hal-05372363.

[19] V. Despré, B. Kolbe, H. Parlier and M. Teillaud. 'Computing a Dirichlet domain for a hyperbolic surface'. In: *Journal of Computational Geometry* 15.2 (2025), pp. 40–56. DOI: 10.20382/jocg.v15i2a2. URL: https://hal.science/hal-04995536.

[20] R. Imbach and G. Moroz. 'Fast evaluation and root finding for polynomials with floating-point coefficients'. In: *Journal of Symbolic Computation* 127 (Mar. 2025), p. 102372. DOI: 10.1016/j.jsc.2024.102372. URL: https://hal.science/hal-04910384.

[21] K. Pluta, G. Moroz, Y. Kenmochi and P. Romon. 'On Arrangements of Quadrics in Decomposing the Parameter Space of 3D Digitized Rigid Motions'. In: *Journal of Symbolic Computation* 131 (Apr. 2025), p. 102447. DOI: 10.1016/j.jsc.2025.102447. URL: https://hal.science/hal-05036487.

[22] L. Valque and S. Lazard. 'Resolving self-intersections in 3D meshes while preserving floating-point coordinates'. In: *Computer Graphics Forum* 44.5 (28th Aug. 2025), e70197. DOI: 10.1111/cgf.70197. URL: https://hal.science/hal-05242294.

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