Activity Report 2018

Team ELAN

modELing the Appearance of Nonlinear phenomena

RESEARCH CENTER
Grenoble - Rhône-Alpes

THEME
Numerical schemes and simulations

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Team ELAN

Creation of the Team: 2017 October 01

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1. Team, Visitors, External Collaborators

Research Scientist
Florence Descoubes [Team leader, Inria, Researcher, HDR]

PhD Students
Raphael Charrondiere [Univ Grenoble Alpes, from Sep 2018]
Mickael Ly [Inria]
Abdullah Haroon Rasheed [Inria]

Technical staff
Laurence Boissieux [SED Inria, 20%]
Eric Madaule [Inria, until Jul 2018]
Victor Romero Gramegna [Inria]

Interns
Raphael Charrondiere [Ecole Normale Supérieure Lyon, until Jul 2018]
Jean Jouve [Ecole normale supérieure de Rennes, from May 2018 until Jul 2018]

Administrative Assistant
Diane Courtiol [Inria]

2. Overall Objectives

2.1. Overall Objectives

ELAN is a new joint team of Inria and Laboratoire Jean Kuntzmann (UMR 5224), with an original positioning across Computer Graphics and Computational Mechanics. The team is focussed on the design of predictive, robust, efficient, and controllable numerical models for capturing the shape and motion of visually rich mechanical phenomena, such as the coiling of a viscous rod, the buckling of an elastic plate, or the entangling of large fiber assemblies. Target applications encompass the digital entertainment industry (e.g., feature film animation, special effects), as well as virtual prototyping for the mechanical engineering industry (e.g., aircraft manufacturing, cosmetology); though very different, these two application fields require predictive and scalable models for capturing complex mechanical phenomena at the macroscopic scale. An orthogonal objective is the improvement of our understanding of natural physical and biological processes involving slender structures, through active collaborations with soft matter physicists. To achieve its goals, the team strives to master as finely as possible the entire modeling pipeline, involving a pluridisciplinary combination of scientific skills across Mechanics and Physics, Applied Mathematics, and Computer Science.

3. Research Program

3.1. Discrete modeling of slender elastic structures

For the last 15 years, we have investigated new discrete models for solving the Kirchhoff dynamic equations for thin elastic rods [7], [9], [12]. All our models share a curvature-based spatial discretization, allowing them to capture inextensibility of the rod intrinsically, without the need for adding any kinematic constraint. Moreover, elastic forces boil down to linear terms in the dynamic equations, making them well-suited for implicit integration. Interestingly, our discretization methodology can be interpreted from two different points-of-views. From the finite-elements point-of-view, our strain-based discrete schemes can be seen as discontinuous Galerkin methods of zero and first orders. From the multibody system dynamics point of view, our discrete models can be interpreted as deformable Lagrangian systems in finite dimension, for which a dedicated community has started to grow recently [33]. We note that adopting the multibody system dynamics point of view helped us formulate a linear-time integration scheme [8], which had only be investigated in the case of multibody rigid bodies dynamics so far.

3.1.1. High-order spatial discretization schemes for rods, ribbons and shells

Our goal is to investigate similar high-order modeling strategies for surfaces, in particular for the case of inextensible ribbons and shells. Elastic ribbons have been scarcely studied in the past, but they are nowadays drawing more and more the attention from physicists [22], [31]. Their numerical modeling remains an open challenge. In contrast to ribbons, a huge litterature exists for shells, both from a theoretical and numerical viewpoints (see, e.g., [26], [13]). However, no real consensus has been obtained so far about a unified nonlinear shell theory able to support large displacements. In [10] we have started building an inextensible shell patch by taking as degrees of freedom the curvatures of its mid-surface, expressed in the local frame. As in the super-helix model, we show that when taking curvatures uniform over the element, each term of the equations of motion may be computed in closed-form; besides, the geometry of the element corresponds to a cylinder patch at each time step. Compared to the 1D (rod) case however, some difficulties arise in the 2D (plate/shell) case, where compatibility conditions are to be treated carefully.

3.1.2. Numerical continuation of rod equilibria in the presence of unilateral constraints

In Alejandro Blumentals' PhD thesis [11], we have adopted an optimal control point of view on the static problem of thin elastic rods, and we have shown that direct discretization methods [1] are particularly well-suited for dealing with scenarios involving both bilateral and unilateral constraints (such as contact). We would like to investigate how our formulations extend to continuation problems, where the goal is to follow a certain branch of equilibria when the rod is subject to some varying constraints (such as one fixed end being applied a constant rotation). To the best of our knowledge, classical continuation methods used for rods [23] are not able to deal with non-persistent or sliding contact.

3.2. Discrete modeling of frictional contact

Most popular approaches in Computer Graphics and Mechanical Engineering consist in assuming that the objects in contact are locally compliant, allowing them to slightly penetrate each other. This is the principle of penalty-based methods (or molecular dynamics), which consists in adding mutual repulsive forces of the form $k\,f(\delta)$, where δ is the penetration depth detected at current time step [14], [30]. Though simple to implement and computationally efficient, the penalty-based method often fails to prevent excessive penetration of the contacting objects, which may prove fatal in the case of thin objects as those may just end up traversing each other. One solution might be to set the stiffness factor k to a large enough value, however this causes the introduction of parasitical high frequencies and calls for very small integration steps [6]. Penalty-based approaches are thus generally not satisfying for ensuring robust contact handling.

In the same vein, the friction law between solid objects, or within a yield-stress fluid (used to model foam, sand, or cement, which, unlike water, cannot flow beyond a certain threshold), is commonly modeled using a regularized friction law (sometimes even with simple viscous forces), for the sake of simplicity and numerical tractability (see e.g., [32], [25]). Such a model cannot capture the threshold effect that characterizes friction between contacting solids or within a yield-stress fluid. The nonsmooth transition between sticking and sliding is however responsible for significant visual features, such as the complex patterns resting on the outer surface of hair, the stable formation of sand piles, or typical stick-slip instabilities occurring during motion.

The search for a realistic, robust and stable frictional contact method encouraged us to depart from those, and instead to focus on rigid contact models coupled to the exact nonsmooth Coulomb law for friction (and respectively, to the exact nonsmooth Drucker-Prager law in the case of a fluid), which better integrate the effects of frictional contact at the macroscopic scale. This motivation was the sense of the hiring of F. Bertails-Descoubes in 2007 in the Inria/LJK BIPOP team, specialized in nonsmooth mechanics and related convex optimization methods. In the line of F. Bertails-Descoubes's work performed in the BIPOP team, the ELAN team keeps on including some active research on the finding of robust frictional contact algorithms specialized for slender deformable structures.

3.2.1. Optimized algorithms for large nodal systems in frictional contact

In the fiber assembly case, the resulting mass matrix M is block-diagonal, so that the Delassus operator can be computed in an efficient way by leveraging sparse-block computations [15]. This justifies solving the reduced discrete frictional contact problem where primary unknowns are forces, as usually advocated in nonsmooth mechanics [28]. For cloth however, where primal variables (nodal velocities of the cloth mesh) are all interconnected via elasticity through implicit forces, the method developed above is computationally inefficient. Indeed, the matrix M (only block-sparse, but not block-diagonal) is costly to invert for large systems and its inverse is dense. Recently, we have leveraged the fact that generalized velocities of the system are 3D velocities, which simplifies the discrete contact problem when contacts occur at the nodes. Combined with a multiresolution strategy, we have devised an algorithm able to capture exact Coulomb friction constraints at contact, while retaining computational efficiency [29]. This work also supports cloth self-contact and cloth multilayering. How to enrich the interaction model with, e.g., cohesion, remains an open question. The experimental validation of our frictional contact model is also one of our goals in the medium run.

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[1] Within this optimal control framework, our previous curvature-based methods can actually be interpreted as a special case of direct single shooting methods.

3.2.2. Continuum modeling of large fiber assemblies

Though we have recently made progress on the continuum formulation and solving of granular materials in Gilles Daviet's PhD thesis [19], [17], [16], we are still far from a continuum description of a macroscopic dry fibrous medium such as hair. One key ingredient that we have not been considering in our previous models is the influence of air inside divided materials. Typically, air plays a considerable role in hair motion. To advance in that direction, we have started to look at a diphasic fluid representation of granular matter, where a Newtonian fluid and the solid phase are fully coupled, while the nonsmooth Drucker-Prager rheology for the solid phase is enforced implicitly [18]. This first approach could be a starting point for modeling immersed granulars in a liquid, or ash clouds, for instance.

A long path then remains to be achieved, if one wants to take into account long fibers instead of isotropic grains in the solid phase. How to couple the fiber elasticity with our current formulation remains a challenging problem.

3.3. Inverse design of slender elastic structures [ERC Gem]

With the considerable advance of automatic image-based capture in Computer Vision and Computer Graphics these latest years, it becomes now affordable to acquire quickly and precisely the full 3D geometry of many mechanical objects featuring intricate shapes. Yet, while more and more geometrical data get collected and shared among the communities, there is currently very little study about how to infer the underlying mechanical properties of the captured objects merely from their geometrical configurations.

An important challenge consists in developing a non-invasive method for inferring the mechanical properties of complex objects from a minimal set of geometrical poses, in order to predict their dynamics. In contrast to classical inverse reconstruction methods, our claim is that 1/ the mere geometrical shape of physical objects reveals a lot about their underlying mechanical properties and 2/ this property can be fully leveraged for a wide range of objects featuring rich geometrical configurations, such as slender structures subject to contact and friction (e.g., folded cloth or twined filaments).

In addition to significant advances in fast image-based measurement of diverse mechanical materials stemming from physics, biology, or manufacturing, this research is expected in the long run to ease considerably the design of physically realistic virtual worlds, as well as to boost the creation of dynamic human doubles.

To achieve this goal, we shall develop an original inverse modeling strategy based upon the following research topics:

3.3.1. Design of well-suited discrete models for slender structures

We believe that the quality of the upstream, reference physics-based model is essential to the effective connection between geometry and mechanics. Typically, such a model should properly account for the nonlinearities due to large displacements of the structures, as well as to the nonsmooth effects typical of contact and friction.

It should also be parameterized and discretized in such a way that inversion gets simplified mathematically, possibly avoiding the huge cost of large and nonconvex optimization. In that sense, unlike concurrent methods which impose inverse methods to be compatible with a generic physics-based model, we instead advocate the design of specific physics-based models which are tailored for the inversion process.

More precisely, from our experience on fiber modeling, we believe that reduced Lagrangian models, based on a minimal set of coordinates and physical parameters (as opposed to maximal coordinates models such as mass-springs), are particularly well-suited for inversion and physical interpretation of geometrical data [21], [20]. Furthermore, choosing a high-order coordinate system (e.g., curvatures instead of angles) allows for a precise handling of curved boundaries and contact geometry, as well as the simplification of constitutive laws (which are transformed into a linear equation in the case of rods). We are currently investigating high-order discretization schemes for elastic ribbons and developable shells [10].

3.3.2. Static inversion of physical objects from geometrical poses

We believe that pure static inversion may by itself reveal many insights regarding a range of parameters such as the undeformed configuration of the object, some material parameters or contact forces.

The typical settings that we consider is composed of, on the one hand, a reference mechanical model of the object of interest, and on the other hand a single or a series of complete geometrical poses corresponding each to a static equilibrium. The core challenge consists in analyzing theoretically and practically the amount of information that can be gained from one or several geometrical poses, and to understand how the fundamental under-determinacy of the inverse problem can be reduced, for each unknown quantity (parameter or force) at play. Both the equilibrium condition and the stability criterion of the equilibrium are leveraged towards this goal. On the theoretical side, we have recently shown that a given 3D curve always matches the centerline of an isotropic suspended Kirchhoff rod at equilibrium under gravity, and that the natural configuration of the rod is unique once material parameters (mass, Young modulus) are fixed [1]. On the practical side, we have recently devised a robust algorithm to find a valid natural configuration for a discrete shell to match a given surface under gravity and frictional contact forces [3]. Unlike rods however, shells can have multiple inverse (natural) configurations. Choosing among the multiple solutions based on some selection criteria is an open challenge. Another open issue, in all cases, is the theoretical characterization of material parameters allowing the equilibrium to be stable.

3.3.3. Dynamic inversion of physical objects from geometrical poses

To refine the solution subspaces searched for in the static case and estimate dynamic parameters (e.g., some damping coefficients), a dynamic inversion process accounting for the motion of the object of interest is necessary.

In contrast to the static case where we can afford to rely on exact geometrical poses, our analysis in the dynamic case will have to take into account the imperfect quality of input data with possible missing parts or outliers. One interesting challenge will be to combine our high-order discretized physics-based model together with the acquisition process in order to refine both the parameter estimation and the geometrical acquisition.

3.3.4. Experimental validation with respect to real data

The goal will be to confront the theories developed above to real experiments. Compared to the statics, the dynamic case will be particularly involving as it will be highly dependent on the quality of input data as well as the accuracy of the motion predicted by our physics-based simulators. Such experiments will not only serve to refine our direct and inverse models, but will also be leveraged to improve the 3D geometrical acquisition of moving objects. Besides, once validation will be performed, we shall work on the setting up of new non-invasive measurement protocols to acquire physical parameters of slender structures from a minimal amount of geometrical configurations.

4. Application Domains

4.1. Mechanical Engineering

Many physicists and mathematicians have strived for centuries to understand the principles governing those complex mechanical phenomena, providing a number of continuous models for slender structures, granular matter, and frictional contact. In the XX$^{\text{th}}$ century, industrial applications such as process automatization and new ways of transportation have boosted the fields of Mechanical Engineering and Computer-Aided Design, where material strength, reliability of mechanisms, and safety, standed for the main priorities. Instead, large displacements of structures, buckling, tearing, or entanglement, and even dynamics, were long considered as undesirable behaviors, thus restraining the search for corresponding numerical models.

Only recently, the engineering industry has shown some new and growing interest into the modeling of dynamic phenomena prone to large displacements, contact and friction. For instance, the cosmetology industry is more and more interested in understanding the nonlinear deformation of hair and skin, with the help of simulation. Likewise, auto and aircraft manufacturers are facing new challenges involving buckling or entanglement of thin structures such as carbon or optical fibers; they clearly lack predictive, robust and efficient numerical tools for simulating and optimizing their new manufacturing process, which share many common features with the large-scale simulation scenarii traditionally studied in Computer Graphics applications.

4.2. Computer Graphics

In contrast, Computer Graphics, which has emerged in the 60's with the advent of modern computers, was from the very beginning eager to capture such peculiar phenomena, with the sole aim to produce spectacular images and create astonishing stories. At the origin, Computer Graphics thus drastically departed from other scientific fields. Everyday-life phenomena such as cloth buckling, paper tearing, or hair fluttering in the wind, mostly ignored by other scientists at that time, became actual topics of interest, involving a large set of new research directions to be explored, both in terms of modelling and simulation. Nowadays, although the image production still remains the core activity of the Computer Graphics community, more and more research studies are directed through the virtual and real prototyping of mechanical systems, notably driven by a myriad of new applications in the virtual try on industry (e.g., hairstyling and garment fitting). Furthermore, the advent of additive fabrication is currently boosting research in the free design of new mechanisms or systems for various applications, from architecture design and fabrication of metamaterials to the creation of new locomotion modes in robotics. Some obvious common interests and approaches are thus emerging between Computer Graphics and Mechanical Engineering, yet the two communities remain desperately compartmentalized.

4.3. Soft Matter Physics

From the physics-based viewpoint, since a few decades a new generation of physicists became interested again in the understanding of such visually fascinating phenomena, and started investigating the tight links between geometry and elasticity [2]. Common objects such as folded or torn paper, twined plants, coiled honey threads, or human hair have thus regained some popularity among the community in Nonlinear Physics [3]. In consequence, phenomena of interest have become remarkably close to those of Computer Graphics, since scientists in both places share the common goal to model complex and integrated mechanical phenomena at the macroscopic scale. Of course, the goals and employed methodologies differ substantially from one community to the other, but showcase some evident complementarity: while computer scientists are eager to learn and understand new physical models, physicists get more and more interested in the numerical tools, in which they perceive not only a means to confirm predictions afterwards, but also a support for testing new hypothesis and exploring scenarios that would be too cumbersome or even impossible to investigate experimentally. Besides, numerical exploration starts becoming a valuable tool for getting insights into the search for analytic solutions, thus fully participating to the modeling stage and physical understanding. However, physicists may be limited to a blind usage of numerical black boxes, which may furthermore not be dedicated to their specific needs. According to us, promoting a science of modeling in numerical physics would thus be a promising and rich avenue for the two research fields. Unfortunately, very scarce cooperation currently exists between the two communities, and large networks of collaboration still need to be set up.

5. New Software and Platforms

5.1. Argus-distribution

KEYWORDS: Frictional contact - Cloth dynamics - Mesh adaptation

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[2] In France this new trend was particularly stimulated by the work of Yves Pomeau, who convinced many young scientists to study the nonlinear physics of common objects such as paper, plants, or hair [24].

[3] It is however amusing to observe that research in these areas is quite successful in obtaining the IG Nobel prize [5], [27], thus still being considered as an exotic research topic by physicists.

SCIENTIFIC DESCRIPTION: The Argus-distribution software exactly replicates all the results published in the SIGGRAPH 2018 paper entitled "An Implicit Frictional Contact Solver for Adaptive Cloth Simulation", by Li et al. This paper presents the first method able to account for cloth contact with exact Coulomb friction, treating both cloth self-contacts and contacts occurring between the cloth and an underlying character. The key contribution is to observe that for a nodal system like cloth, the frictional contact problem may be formulated based on velocities as primary variables, without having to compute the costly Delassus operator. Then, by reversing the roles classically played by the velocities and the contact impulses, conical complementarity solvers of the literature can be adapted to solve for compatible velocities at nodes. To handle the full complexity of cloth dynamics scenarios, this base algorithm has been extended in two ways: first, towards the accurate treatment of frictional contact at any location of the cloth, through an adaptive node refinement strategy, second, towards the handling of multiple constraints at each node, through the duplication of constrained nodes and the adding of pin constraints between duplicata. This method allows to handle the complex cloth-cloth and cloth-body interactions in full-size garments with an unprecedented level of realism compared to former methods, while maintaining reasonable computational timings.allows to simulate cloth dynamics subject to frictional contact.

FUNCTIONAL DESCRIPTION: Adaptive cloth simulation in the presence of frictional contact. Reference software for the paper "An Implicit Frictional Contact Solver for Adaptive Cloth Simulation", Li et al. 2018, ACM Transactions on Graphics (SIGGRAPH'18).

- Participants: Jie Li, Gilles Daviet, Rahul Narain, Florence Descoubes, Matthew Overby, George Brown and Laurence Boissieux
- Partners: Department of Computer Science and Engineering, University of Minnesota - IIT Delhi
- Contact: Florence Descoubes
- Publication: An Implicit Frictional Contact Solver for Adaptive Cloth Simulation
- URL: http://www-users.cselabs.umn.edu/~lixx4611/contact_friction.html

6. New Results

6.1. Inverse design of a suspended elastic rod

Participants: Florence Bertails-Descoubes, Victor Romero.

In collaboration with Alexandre Derouet-Jourdan (OLM Digital, Japan) and Arnaud Lazarus (UPMC, Laboratoire Jean le Rond d'Alembert), we have investigated the inverse design problem of a suspended elastic subject to gravity. We have proved that given an arbitrary space curve, there exists a unique solution for the natural configuration of the rod, which is independent of the initial framing of the input curve. Moreover, this natural configuration can be easily computed by solving three linear ODEs in sequence, starting from any input framing. This work has been published in Roy. Soc. Proc A [1] and physical aspects of this study have been communicated about in a mechanical congress [4].

6.2. Simulation of cloth contact with exact Coulomb friction

Participants: Florence Bertails-Descoubes, Laurence Boissieux.

In collaboration with Gilles Daviet (Weta Digital, New Zealand) and Rahul Narain's group (University of Minnesota and IIT Delhi), we have developed a new implicit solver for taking into account contact in cloth with Coulomb friction. Our key idea stems from the observation that for a nodal system like cloth, and in the case where each node is subject to at most one contacting constraint (either an external or self-contact), the frictional contact problem may be formulated based on velocities as primary variables, without having to compute the costly Delassus operator; then, by reversing the roles classically played by the velocities and the contact impulses, conical complementarity solvers of the literature may be leveraged to solve for compatible velocities at nodes. To handle the full complexity of cloth dynamics scenarios, we have extended this base algorithm in two ways: first, towards the accurate treatment of frictional contact at any location of the cloth, through an adaptive node refinement strategy; second, towards the handling of multiple constraints at each node, through the duplication of constrained nodes and the adding of pin constraints between duplicata. Our method proves to be both fast and robust, allowing us to simulate full-size garments with an unprecedent level of realism compared to former methods, while maintaining similar computational timings. Our work has been published at ACM Transactions on Graphics (ACM SIGGRAPH 2018) [2].

6.3. Inverse design of thin elastic shells

Participants: Mickaël Ly, Florence Bertails-Descoubes, Laurence Boissieux.

In collaboration with Romain Casati (former PhD student of F. Bertails-Descoubes) and Mélina Skouras (EPI IMAGINE), we have proposed an inverse strategy for modeling thin elastic shells physically, just from the observation of their geometry. Our algorithm takes as input an arbitrary target mesh, and interprets this configuration automatically as a stable equilibrium of a shell simulator under gravity and frictional contact constraints with a given external object. Unknowns are the natural shape of the shell (i.e., its shape without external forces) and the frictional contact forces at play, while the material properties (mass density, stiffness, friction coefficients) can be freely chosen by the user. Such an inverse problem formulates as an ill-posed nonlinear system subject to conical constraints. To select and compute a plausible solution, our inverse solver proceeds in two steps. In a first step, contacts are reduced to frictionless bilateral constraints and a natural shape is retrieved using the adjoint method. The second step uses this result as an initial guess and adjusts each bilateral force so that it projects onto the admissible Coulomb friction cone, while preserving global equilibrium. To better guide minimization towards the target, these two steps are applied iteratively using a degressive regularization of the shell energy. We validate our approach on simulated examples with reference material parameters, and show that our method still converges well for material parameters lying within a reasonable range around the reference, and even in the case of arbitrary meshes that are not issued from a simulation. We finally demonstrate practical inversion results on complex shell geometries freely modeled by an artist or automatically captured from real objects, such as posed garments or soft accessories. Our work has been published at ACM Transactions on Graphics (ACM SIGGRAPH Asia 2018) [3] and has been selected for a Press Release of the ACM.

7. Partnerships and Cooperations

7.1. European Initiatives

7.1.1. FP7 & H2020 Projects

7.1.1.1. GEM

Title: from GEometry to Motion, inverse modeling of complex mechanical structures

Programm: H2020

Type: ERC

Duration: September 2015 - August 2021

Coordinator: Inria

Inria contact: Florence BERTAILS-DESCOUBES

With the considerable advance of automatic image-based capture in Computer Vision and Computer Graphics these latest years, it becomes now affordable to acquire quickly and precisely the full 3D geometry of many mechanical objects featuring intricate shapes. Yet, while more and more geometrical data get collected and shared among the communities, there is currently very little study about how to infer the underlying mechanical properties of the captured objects merely from their geometrical configurations. The GEM challenge consists in developing a non-invasive method for inferring the mechanical properties of complex objects from a minimal set of geometrical poses, in order to predict their dynamics. In contrast to classical inverse reconstruction methods, my proposal is built upon the claim that 1/ the mere geometrical shape of physical objects reveals a lot about their underlying mechanical properties and 2/ this property can be fully leveraged for a wide range of objects featuring rich geometrical configurations, such as slender structures subject to frictional contact (e.g., folded cloth or twined filaments). To achieve this goal, we shall develop an original inverse modeling strategy based upon a/ the design of reduced and high-order discrete models for slender mechanical structures including rods, plates and shells, b/ a compact and well-posed mathematical formulation of our nonsmooth inverse problems, both in the static and dynamic cases, c/ the design of robust and efficient numerical tools for solving such complex problems, and d/ a thorough experimental validation of our methods relying on the most recent capturing tools. In addition to significant advances in fast image-based measurement of diverse mechanical materials stemming from physics, biology, or manufacturing, this research is expected in the long run to ease considerably the design of physically realistic virtual worlds, as well as to boost the creation of dynamic human doubles.

7.2. International Initiatives

7.2.1. Inria International Partners

7.2.1.1. Declared Inria International Partners

- Long-term partnership with Rahul Narain (University of Minnesota, USA, and IIT Delhi, INDIA) and Rahul Narain’s PhD student Jie Li (University of Minnesota, USA).
- Long-term partnership with Alexandre-Derouet-Jourdan (OLM Digital, JAPAN).

8. Dissemination

8.1. Promoting Scientific Activities

8.1.1. Member of the Conference Program Committees

- Florence Bertails-Descoubes, member of the ACM SIGGRAPH Technical Program Committee in 2018 and 2019, and the Eurographics Technical Program Committee in 2018 and 2019.

8.1.2. Journal

8.1.2.1. Reviewer - Reviewing Activities

- Florence Bertails-Descoubes, Reviewer in 2018 for ACM Transaction on Graphics, ACM SIGGRAPH Asia 2018, Soft Matter, Royal Society Open Science.

8.1.3. Invited Talks

- Florence Bertails-Descoubes, invited talk at IUSTI, Marseille, June 2018 (contact: O. Pouliquen, équipe Écoulements de Particules).

8.2. Teaching - Supervision - Juries

8.2.1. Teaching

Licence : Raphaël Charrondière, Calcul matriciel et fonctions de plusieurs variables, 36h éq TD, L2, Université Grenoble Alpes

Licence : Florence Bertails-Descoubes, Méthodes Numériques, 18h éq TD, L3, ENSIMAG 1A, Grenoble INP.

8.2.2. Supervision

PhD in progress : Mickaël Ly, Static inverse modelling of cloth, 01 octobre 2017, Florence Bertails-Descoubes and Mélina Skouras.

PhD in progress : Haroon Rasheed, Inverse dynamic modeling of cloth, 01 novembre 2017, Florence Bertails-Descoubes, Jean-Sébastien Franco, and Stefanie Wuhrer

PhD in progress : Raphaël Charrondière, Modeling and numerical simulation of elastic inextensible surfaces, 01 septembre 2018, Florence Bertails-Descoubes and Sébastien Neukirch.

8.2.3. Juries

Florence Bertails-Descoubes, member (Rapportrice) of Ph.D. Thesis committee of E. Cottenceau (10 avril 2018), ENSAM Lille (directeur de thèse : O. Thomas)

Florence Bertails-Descoubes, member (Rapportrice) of Ph.D. Thesis committee of S. Salamone (4 juillet 2018), Institut Charles Sadron à l'Université de Strasbourg (directeur de thèse : T. Charitat)

Florence Bertails-Descoubes, member (Rapportrice) of Ph.D. Thesis committee of S. Poincloux (15 octobre 2018), Laboratoire de Physique Statistique de l'ENS Paris (directeurs de thèse : F. Léchenault et M. Adda-Bedia).

8.3. Popularization

8.3.1. Articles and contents

- Interview about our past work on hair and cloth for a press article in Dauphiné Libéré des Enfants in November 2018.
- Press interview about our SIGGRAPH Asia paper on inverse shell design for an ACM Press Release in November 2018.

9. Bibliography

Publications of the year

Articles in International Peer-Reviewed Journals

[1] F. Bertails-Descoubes, A. Derouet-Jourdan, V. Romero, A. Lazarus. *Inverse design of an isotropic suspended Kirchhoff rod: theoretical and numerical results on the uniqueness of the natural shape*, in "Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences", April 2018, vol. 474, n^{o} 2212, pp. 1-26 [*DOI :* 10.1098/RSPA.2017.0837], https://hal.inria.fr/hal-01827887

[2] J. Li, G. Daviet, R. Narain, F. Bertails-Descoubes, M. Overby, G. Brown, L. Boissieux. *An Implicit Frictional Contact Solver for Adaptive Cloth Simulation*, in "ACM Transactions on Graphics", August 2018, vol. 37, n^{o} 4, pp. 1-15 [*DOI :* 10.1145/3197517.3201308], https://hal.inria.fr/hal-01834705

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International Conferences with Proceedings

[4] V. ROMERO, F. BERTAILS-DESCOUBES, A. DEROUET-JOURDAN, A. LAZARUS. *Inverse design of a suspended Kirchhoff rod: From theory to practice*, in "ESMC10 2018 - 10th European Solid Mechanics Conference", Bologne, Italy, July 2018, vol. 25, 184302 p. , https://hal.inria.fr/hal-01778474

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