Modelling entanglement in curly hair: numerical, theoretical and experimental approach

Postdoc 2024

Supervisors Florence Bertails-Descoubes[1] (INRIA Grenoble), and Victor Romero[2] (INRIA Grenoble)

Hosting team Elan Team (INRIA & LJK, Université Grenoble Alpes), https://team.inria.fr/elan/

Practical details: Postdoc position at Inria, starting between October 2023 and March 2024 (flexible dates). Duration of 12 months (renewable), possible extensions afterwards.

Context Over the last 30 years the graphics community has actively worked on the simulation of dense fibrous assemblies such as human hair or animal fur. Whether it is for the realistic animation of characters by the entertainment industry, for its applications in cosmetology, or for the design of mechanical structures, simulating accurately such kinds of systems remains challenging and computationally costly. Furthermore, a rich underlying phenomenology arises from the interaction between fibers, driven by the interplay between geometry, frictional contact, and elasticity. Due to the large number of degrees of freedom and the strong coupling between the length-scales at which fibers interact, innovative approaches are crucial.

Figure 1: Simulating the combing of a curly hair wisp with frictional contact ©Elan team at Inria, 2023.

Recent developments for the simulation of frictional fibers [2, 5, 8, 4] have made possible the efficient simulation of tens of thousands interacting fibers producing visually appealing images. However, these simulators remain limited to fibers with small natural curvature, making them unable to retrieve the rich phenomenology observed for highly curly fibers. Additionally, in many cases, the underlying model for the simulation is not systematically tested for its validity.

To bring a breakthrough on the realistic simulation of frictional fibers, we believe that a combined effort between computer simulation, physics and mechanics is required. While computer simulation has developed a large amount of knowledge to efficiently solve large-scale problems numerically, physics and mechanics have a long-standing culture to model and analyse complex systems through controlled experiments and theoretical developments. Progressively, these communities are joining their forces to, on the one end, produce more realistic physics-based simulators [2, 1, 5, 6, 3], and on the other end, find model configurations to study the physical validity of simulations [10] and advance the understanding of physical systems with enhanced complexity [11, 12].

Objective While studies exist regarding the mechanics and shape characterisation of a single curly hair [9, 7], extensions to the understanding and modelling of a full collection of curly filaments in 3D remains scarce. The objective of this postdoc position is to combine our current numerical and experimental works on fiber assemblies to better understand and model, at the macro-scale, some remarkable collective phenomena appearing in curly hair due to the mixed effects of elasticity/geometry and frictional contact at the fiber scale. This work will take advantage of the numerical Kirchhoff models for rods, contact detection, and frictional contact solvers developed by the Elan team, and additionally, we expect for this study to have an important experimental component to conceive novel setups and collect data to compare with simulations.

Skills required Candidates should hold (or be about to hold) a Ph.D., either:

- in a computer simulation related topic (Computer Sciences, Computer Graphics, Engineering, or Applied Mathematics) with strong expertise in numerical simulation, mathematical modelling, and software development; taste and skills in physical modelling and experiments will be appreciated.

[1] florence.descoubes@inria.fr
[2] victor.romero-gramegna@inria.fr

- in a mechanics related topic (Mechanics, Physics, or Engineering) with expertise either in experimental or theoretical research; taste and skills in programming will be appreciated.

All candidates should have a good understanding in numerical analysis (modelling, discretisation of ODEs and PDES for mechanical systems, finite elements, optimisation) and algorithms. We expect for the candidates to have a minimum of understanding in C/C++ and Python/Matlab. In addition, we are looking for candidates interested in application of numerics for physics and mechanics (e.g. Computer Graphics, Virtual Prototyping, or more fundamental problems in elasticity/geometry/contact/friction), capable to work alongside in real physical experiments, and curious to discover the links between Physics and Computer Graphics. Finally, candidates are expected to have good written and oral communication skills (at least in English, French is a plus) and strong motivation to work with other researchers and students, in a pluridisciplinary environment.

How to apply Applications must be sent to florence.descoubes@inria.fr and victor.romero-gramegna@inria.fr. Please include an extended CV and a motivation letter explaining your scientific interests, expectations for this position, as well as at least two reference contacts. If available, please provide your PhD and defence reports.

Contract conditions and benefits Inria is a leading edge public institution, with high quality working conditions and a vibrant and innovative environment. The successful candidate will be hosted at the Elan team at Inria's University Grenoble-Alpes center, and will be under fix-term contract for 1 year, with the option to extend to a second year. The net monthly salary is 2200 €, and comes with a strongly developed welfare state (French social security, health care, child care, free education, etc.) along with a privileged lifestyle in Grenoble, the capital of the French Alps (ideal spot for both scientific emulation and outdoors activities like mountaineering and skiing). Extensions to a variety of positions (either as permanent or non-permanent scientist) at Inria may be envisioned at the end of the postdoc and can be discussed with the successful candidate.

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