PhD thesis proposal

Contacts

Jonàs Martínez (jonas.martinez-bayona@inria.fr) and Sylvain Lefebvre (sylvain.lefebvre@inria.fr) at INRIA Nancy Grand-Est.

Title

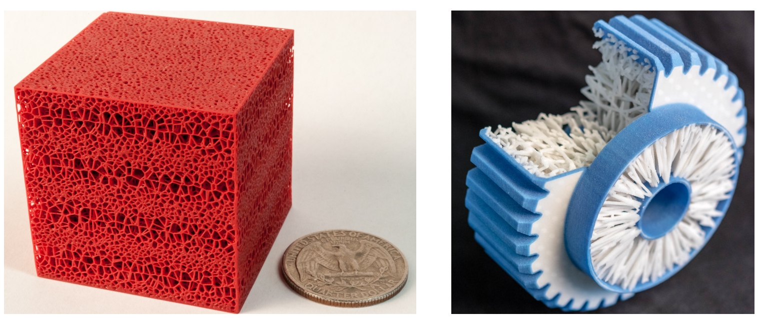
Procedural, stochastic, and fabricable microstructures.

Context

Additive Manufacturing (AM) technologies are now capable of fabricating microstructures at the scale of microns, therefore enabling to precise control of the macroscopic physical behavior. This control empowers a wide range of industrial applications by bringing high-performance customized materials. In particular, a promising venue lies in the optimization of material properties such as rigidity or impact absorption.

Microstructures for AM will play a decisive role in the factory of the future, but several challenges remain aside [1]. The dimension of the objects being printed increases, and concurrently, the available printing resolution becomes finer. Thus, the geometry size of microstructures is drastically escalating. From a computational viewpoint, explicitly storing the microstructure geometry (e.g in an STL file), will eventually render infeasible the whole computational pipeline (numerical simulation, visualization, and computational design of microstructures). From a material science viewpoint, it remains a challenge to properly embed and grade microstructures within an object, and to ensure that they can be directly fabricated with AM processes.

State of the art methods consider periodic microstructures [8, 6, 7], offering compact storage, efficient display, and simulation of the macroscopic physical behavior. However, due to their constrained global structure, periodic microstructures exhibit a poor grading behavior, specially when targeting anisotropic material properties that follow an arbitrary orientation field.



(a) Isotropic elasticity [3]. (b) Orthotropic elasticity [4].

Figure 1: Procedural microstructures with controlled elastic behavior.

Subject

The objective of the thesis is to tackle the aforementioned interdisciplinary challenges by considering procedural, stochastic, and fabricable microstructures, with a controlled macroscopic physical behavior. We have recently contributed novel techniques in this area of research [3, 4] (see Figure 1). The main guiding principles the PhD thesis will follow are:

Procedural. A procedural microstructure is defined as a function $\mathcal{F} : \mathbb{R}^n \rightarrow \{0, 1\}$ (0 being void, and 1 solid matter) which is evaluated at every point in space, at the desired resolution, in constant time and constant memory computational complexity. A procedural function will scale with future additive manufacturing technologies [5], as it is algorithmically independent of the output microstructure geometry size and complexity.

Stochastic. A stochastic formulation enables an easier grading of material properties, and conforming to a surface. Compared to periodic tilings, the lack of global organization and periodicity enables for better gradation of stochastic microstructures. The absence of regularity affords for a simple approach to grade their geometry – and thus their mechanical properties – within a target object and its surface (see Figure 2)

Controllable macroscopic physical behavior. Microstructures allow to precisely control of the macroscopic physical behavior [2]. In particular, controlling material elasticity plays an important role in many industrial applications. Another important goal of the PhD will be to precisely determine the relation between the microstructure parameters and the corresponding macroscopic behavior.

Fabricable. There is a high interest about microstructures that can be directly fabricated with AM devices, without requiring any finishing operations that may take place following printing. For instance, being able to print without requiring any support structure. In summary, this PhD topic will tackle the algorithmic and fabrication challenges for the fast and scalable synthesis of procedural microstructures, that can be freely graded and embedded into volumes.

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Required qualifications

MSc in computer science.

General information

- Duration: 3 years.
- Starting date: 1st September 2018 (or before, if a suitable candidate is found).
- Applications to be sent as soon as possible.

How to apply

Send the following documents to jonas.martinez-bayona@inria.fr in a single ZIP file:

- CV.
- A motivation letter describing your interest in this topic.
- Your degree certificates and transcripts for Bachelor and Master (or the last 5 years if not applicable).
- Master thesis (or equivalent) if it is already completed, or a description of the work in progress, otherwise.
- Publications, if any (it is not expected that you have any).

In addition, at least one recommendation letter from the person who supervises(d) your Master thesis (or research project or internship) should be sent. At most two other recommendation letters may be sent. The recommendation letter(s) should be sent directly by their author to jonas.martinez-bayona@inria.fr.

Help and benefits

- Monthly net salary of 1600 €. Medical insurance included.
- Possibility of free French courses.
- Help for finding housing.
- Help for the resident card procedure and for husband/wife visa.
- Lunch cost at INRIA is 2,78 €.

About us

INRIA, the French National Institute for computer science and applied mathematics, promotes "scientific excellence for technology transfer and society". Graduates from the world's top universities, INRIA's 2,700 employees rise to the challenges of digital sciences. With its open, agile model, INRIA is able to explore original approaches with its partners in industry and academia and provide an efficient response to the multidisciplinary and application challenges of the digital transformation. INRIA is the source of many innovations that add value and create jobs.

The INRIA Nancy - Grand-Est center conducts sustained activity in the sector of information science and technologies, including computer science, applied mathematics, control engineering and multidisciplinary themes situated at the crossroads between information science and technologies and other scientific areas, including life sciences, physics and human and social sciences. We also have strong commitments linked to technology transfer. Our establishment at the heart of a major cross-border region, together with our industrial and university partnerships, constitute a major advantage in achieving these commitments.

References

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