2017-00096 - Optimizing support structures for freeform architecture

Contract type: Public service fixed-term contract
Level of qualifications required: Graduate degree or equivalent
Function: Internship Research

About Inria

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.

Context

This internship position is part of the \( \text{DP} \) project funded by the European Research Council (ERC). This 5-year project aims at developing a new generation of 3D modeling tools that allow designers to create 3D objects by drawing. This internship could be extended to a PhD, for which we have secured funding.

Assignment

Freeform architecture refers to the creation of buildings made of curved surface patches. Several low-cost manufacturing techniques exist to produce temporary freeform buildings, such as self-supporting surfaces made of bricks, inflatable surfaces and elastic surfaces.

Designing such buildings is very challenging because architects need to anticipate the physical behavior of the construction materials to achieve the desired shape. For example, self-supporting surfaces must not collapse under their own weight, while inflatable and elastic surfaces must deform to a desired shape subject to external forces. The goal of this internship is to propose novel computer-aided design tools that assist architects in this task.

Main activities

Several methods have been recently proposed to help designers create and fabricate freeform surfaces [1,2,3]. In particular, interactive systems provide real-time simulation feedback to help users quickly evaluate different design alternatives, or optimize design parameters to best reproduce a target shape. However, most of these methods assume that the overall structure of the building is provided as input. For example, [1] requires the position of support points (pillars), [2] asks users to draw the seams between inflatable patches, while [3] asks users to draw elastic rods that will support the deformable surface.

Our goal is to automatically define the overall structure of such surfaces. We will focus on similar elastic surfaces defined by rods as in [3], although we hope that our approach will later generalize to self-supporting and inflatable surfaces. The method would take as input a target 3D shape, and jointly optimize the structure of the elastic rod network and its parameters to best reproduce the shape in the physical world. The main challenge of this research is that the support structures correspond to discrete degrees of freedom (existence or absence of an elastic rod at a point), which result in a very large number of potential solutions. We plan to combine geometric heuristics, stochastic optimization and fast simulation to explore this solution space efficiently and find a good balance between surface quality and complexity of the support.

- [1] Designing Unreinforced Masonry Models
  Daniele Panozzo, Philippe Block, Olga Sorkine-Hornung
  http://igl.ethz.ch/projects/masonry/

- [2] Designing Inflatable Structures
  Melina Skouras, Bernhard Thomaszewski, Peter Kaufmann, Akash Garg, Bernd Bickel, Eitan Grinspun, Markus Gross
  https://www.disneyresearch.com/project/designing-inflatable-structures/

  Jesus Perez, Miguel Otaduy, Bernhard Thomaszewski
  http://www-labs.iro.umontreal.ca/~bernhard/Projects/KPS/KPS.html

General Information

- Theme/Domain: Interaction and visualization
- Scientific computing (BAP E)
- Town/city: Sophia Antipolis
- Inria Center: CRI Sophia Antipolis - Méditerranée
- Starting date: 3/1/18
- Duration of contract: 6 months
- Deadline to apply: 1/31/18

Contacts

- Inria Team: GRAPHDECO
- Recruiter: Bousseau Adrien / adrien.bousseau@inria.fr

The keys to success

Candidates should have strong programming and mathematical skills as well as knowledge in computer graphics, geometry processing and physical simulation.

Conditions for application

Defence Security:

This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST). Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy:

As part of its diversity policy, all Inria positions are accessible to people with disabilities.

Warning: you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.
Skills
C++, numerical optimization, OpenGL

Benefits package
- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

Remuneration
Gross salary: 1480€ per month