Computational Design of Freeform Structures

MSc internship proposal, October 2017

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Context

Recent advances in digital fabrication and material science raise various exciting new research challenges in computer science with applications to product design, architecture, medicine and art. One of them relies on the fact that 3D printing technologies, coming along with increasing computational capabilities, nowadays allow to realize more complex geometries and even to control the deformation behavior. Similar research challenges originate from architecture or structural engineering where creative structural design is linked with material realization. A common approach is to mimic material and fabrication constraints by suitable *geometric representations*, which are more easily translated into numerical algorithms. Successful examples include developable surfaces as a geometric representation able to mimic behavior of materials such as paper, garments or thin metal.

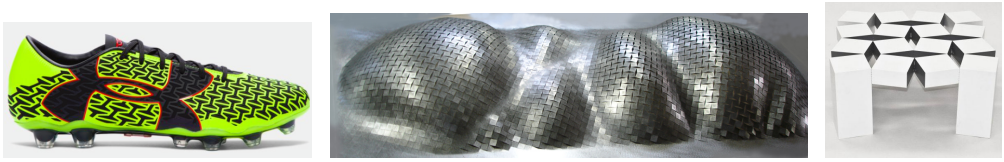

Figure 1: auxetic fabric (UnderArmor sportswear), xSurface in steel from H. Lavani, table from T. Cecil

Research Goal

In this internship we focus on a new class of surfaces, which is given by a geometric structure able to mimic deformable materials [2]. Figure 1 shows examples of such structures applied to sports wear, art and furniture.

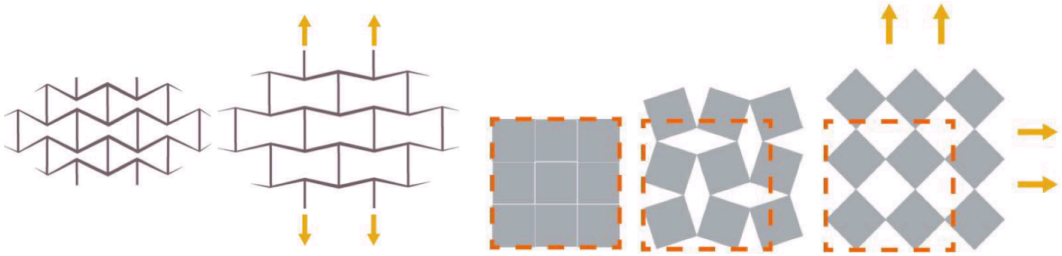

Figure 2: Two examples of structures, from [2]

The goal of this internship is to develop a 3D modeling system that allows to design or approximate doubly-curved shapes only by using flat flexible structures that can stretch up to a certain extend, see Figure 2. Inspired by the recent works of Kodovic et al. [1] (where auxetic rotating triangle units were used to fit a doubly curved surface) or Jiang et al. [4], Tang et al. [3], our approach is to consider other existing auxetic geometric structures in order to derive suitable geometric representations. We further propose to develop either a computational approach to approximate a given shape or to develop intuitive and interactive modeling and deformation algorithms dedicated to mimic auxetic material. The resulting interactive geometric and computational design system shall provide intuitive user control over the shapes. Physical realization of a designed model using a 3D printer can also be investigated.

Requirements

The candidate should have good knowledge in geometric modeling and numerical algorithms and solid experience in computer graphics programming.

References

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[2] R. Naboni, L. Mirante: Metamaterial computation and fabrication of auxetic patterns for architecture, in Blucher Design Proceedings, pp. 129-136 (2015)

[3] Jiang, C., Tang, C., Vaxman, A., Wonka, P., Pottmann, H.: Polyhedral Patterns, ACM Trans. Graphics (TOG) 34 (6) (2015).
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