EPFL
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Actuation of Surface-based Inflatables

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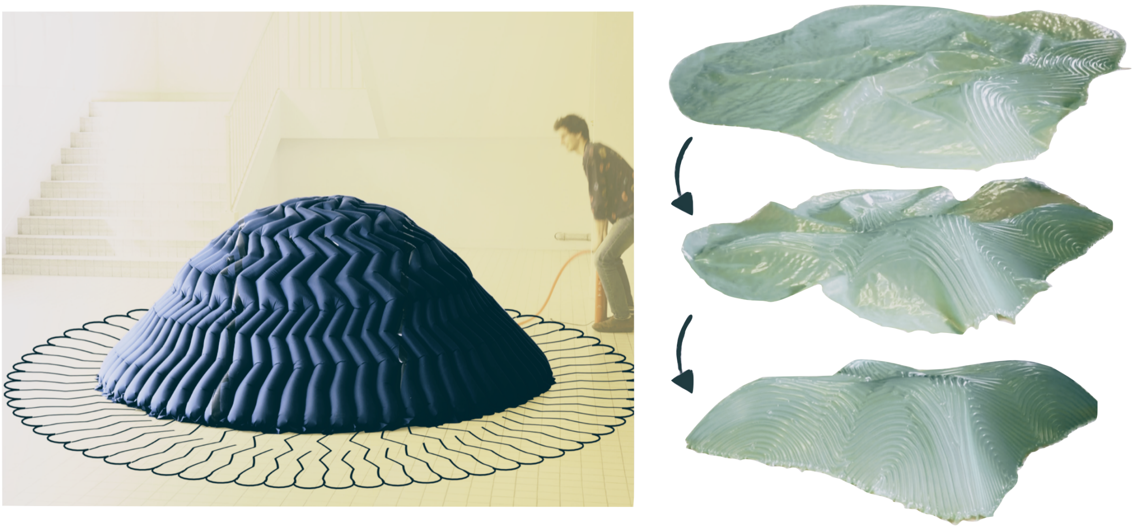

Figure 1: Left: Surface-based inflatable structure with zigzag pattern from [3]. Right: The inflation process of an inflatable that approximates a freeform surface from [2].

Description

Surface-based inflatables are composed of two thin sheets of nearly-inextensible materials fused at a set of fusing curves [3]. When inflated, the in-plane contraction of the material varies depending on the fusing curves' shape, orientation and position. Existing research has shown that this simple material system can form a large range of freeform surfaces with both positive and negative Gaussian curvatures and exhibit interesting material properties [1, 2]. The goal of this project is to explore the actuation and dynamics of surface-based inflatables using our existing quasi-static simulation methods. There are several methods to actuate inflatable structures:

- Adjust the pressure values to change the shape of the structure: inflate and deflate in a certain sequence to cause the structure to deform dynamically.
- Adjust inflatable regions: define individually controlled chambers and inflate different parts of the structure at different steps.
- Combine more layers of multi-stable inflatables: stack two or more surface-based inflatables to form more volumetric shells. Inflatable layers with different fusing curves will have different preferred deformation states. When a new inflatable layer is activated (inflated),

the incompatibility of the target shapes for different layers can cause the whole structure to deform further.

The starting point of the project is running simulation experiments on surface-based inflatables with different fusing lines. The main goal will then be defining an actuation strategy using the methods above or potentially new ideas to achieve some target sequence of deformations or locomotions.

We can adapt the project for Bachelor student projects (8 or 12 credits), Master student projects (8 or 12 credits), or a Master thesis. Knowledge of at least one programming language is required. Strong background in linear algebra, physics-based simulation, and optimization will be preferred.

References

[1] Gao, T., E. Siéfert, A. DeSimone, and B. Roman (2020). Shape programming by modulating actuation over hierarchical length scales. *Advanced Materials 32*(47), 2004515.

[2] Panetta, J., F. Isvoranu, T. Chen, E. Siéfert, B. Roman, and M. Pauly (2021). Computational inverse design of surface-based inflatables. *ACM Transactions on Graphics (TOG) 40*(4), 1–14.

[3] Siéfert, E., E. Reyssat, J. Bico, and B. Roman (2020). Programming stiff inflatable shells from planar patterned fabrics. *Soft Matter 16*, 7898–7903.