Origami Tessellations for Double-Curved Sandwich Structures

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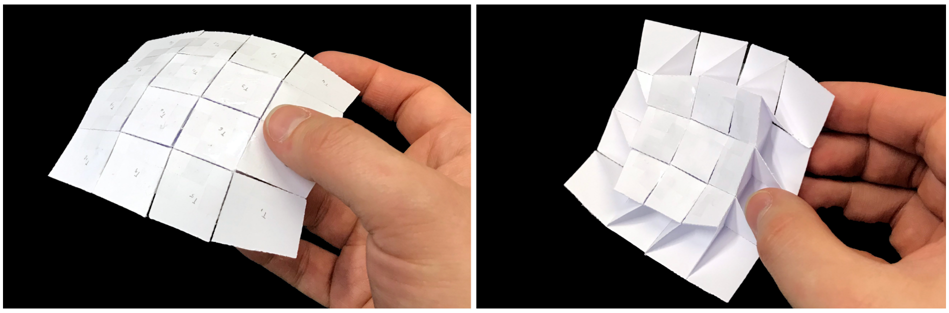

Figure: Double-curved sandwich structure generated on a target surface from a single sheet of paper.

Abstract

The design and fabrication of curved, multi-layered sandwich structures are often limited by the geometry and developability of the outer surfaces and the complexity of the inner core. While folded core structures as shown by Klett [1] already demonstrate the advantages of achieving high strength to weight ratios, these systems are usually made by assembling individually produced three parts, namely, the core and two skin surfaces, and were not constructed from one single material. In contrast to that, some origami patterns like the Octet Truss by Lang [2] can be folded into closed sandwich structures from a single sheet of paper yet are currently only explored for flat plate geometries [3]. The application of one-sheet folding strategies to curved sandwich structures requires either a generalization of the pattern or another approach that provides more control over the design process. In this paper, the authors will present an experimental process that enables the generation of origami patterns on specific target surfaces. Instead of a mathematical generalization, this approach is based on the idea of constraining a digital 3D model of the origami sandwich on a curved surface to a developed 2D pattern to make them isometric to each other. The investigated pattern is a Kirigami-version of the Octet Truss that features local cutouts to replace the tetrahedra. We employ a dynamic-relaxation-based optimization method to keep the isometry between the 2D and 3D representations of the model. The developed 2D pattern and 3D form can change their edge lengths while maintaining its topology and developability constraints. The change in length is informed and cross-linked between the geometries of 2D and 3D models, which can freely change its shape in between two target surfaces. The edges of both models are defined as springs that equalize their lengths during the convergence process. An equilibrium in both models should therefore lead to a foldable double-curved sandwich model with closed top and bottom surfaces.

References

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[2] R. Lang, Artist, *Octet Truss, Opus 652.* [Art]. 2014.

[3] A. Adachi and T. Tachi, "Dual Tiling Origami," *Journal for Geometry and Graphics,* vol. 22, no. 2, p. 269281, 2018.