

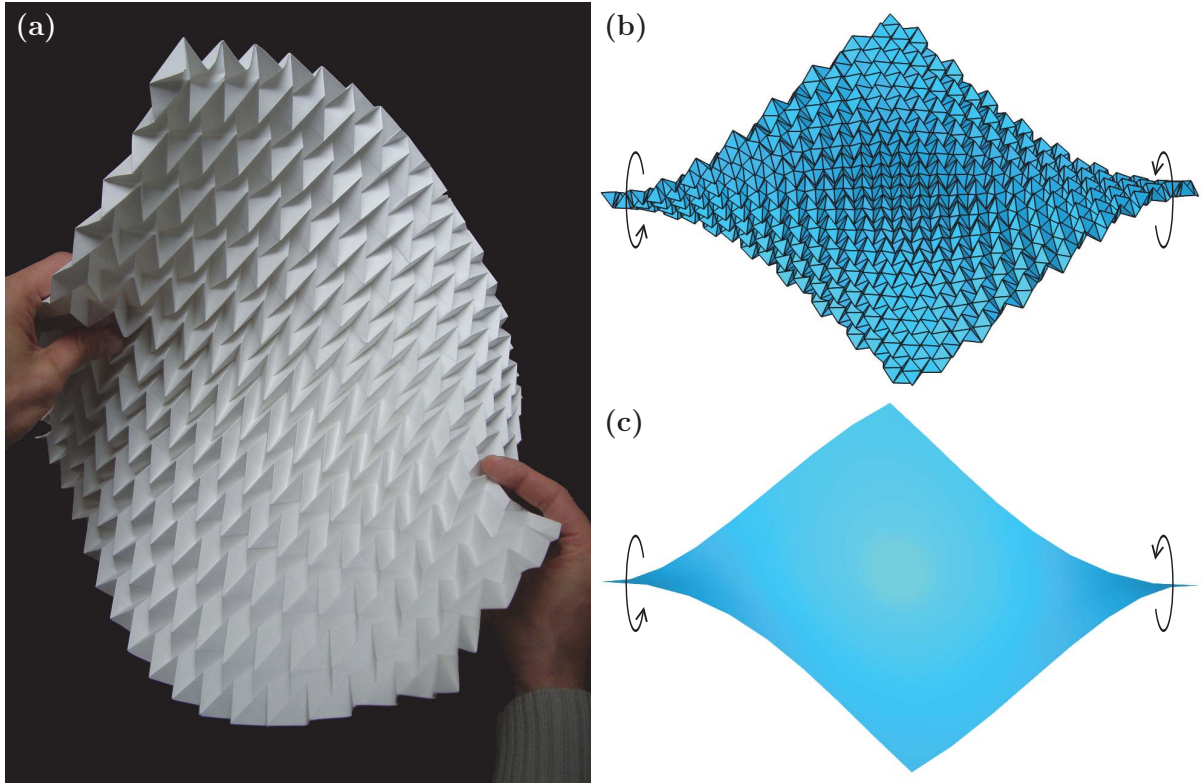
# Fitting surfaces with Miura ori tessellation

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## Abstract

Structured materials inspired from the art of paper folding, Origami, have proven useful in various fields spanning architecture, structural, aerospace and biomedical engineering as well as elastic and acoustic wave motion and control. Origami tessellations in particular offer numerous possibilities for the design of morphing shell structures. Indeed, their intricate folding and unfolding mechanisms are somehow organized and coupled on both local and global scales and are capable of bringing on large deformations and considerable changes in shape, curvature and elongation (Figure 1). These global deformation modes allow for origami tessellations to fit non-trivial curved surfaces even if made of an inextensible material, such as paper.



**Figure 1:** Large torsion of a Miura ori: (a) paper model, (b) discrete model, (c) continuous model.

The present work suggests an upscaling method which yields a macroscopic continuous de-

scription of the global deformation modes of the Miura ori tessellation and adapted from earlier work on the eggbox pattern (Nassar et al., 2017). The method characterizes in two steps the parametrization, metric and curvature of smooth surfaces that the initially discrete structure can fit. In the first step, we formulate a set of local conditions on whether or not an infinitesimal neighborhood of a surface can be fitted by the considered tessellation. Global conditions on whether or not a surface can be fitted in its entirety are formulated in a second step using standard results from the theory of surface geometry, namely, the Gauss-Codazzi-Mainardi equations. The proposed continuous model successfully predicts the existence of various fittings featuring large and finite changes in metric and curvature (Figure 1). Furthermore, it confirms the intuition that the Miura ori necessarily has a negative Gaussian curvature and can fit any and all ruled surfaces.

## References

Hussein Nassar, Arthur Lebé, and Laurent Monasse. Curvature, metric and parametrization of origami tessellations: theory and application to the eggbox pattern. *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 473(2197): 20160705, 2017. ISSN 1364-5021. doi: 10.1098/rspa.2016.0705. URL <http://rspa.royalsocietypublishing.org/lookup/doi/10.1098/rspa.2016.0705>.