

Continuum elasticity of Miura Tessellations

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Abstract

Origami tessellations are curved two-dimensional discrete shells folded out of a periodic crease pattern. Unlike solid shells, Origami tessellations can morph and access a space of configurations each characterized by the list of folding angles of all creases. Due to inextensibility constraints imposed by Origami kinematics, not all combinations of folding angles are admissible and so the space of admissible configurations, is a priori unknown [1]. In this talk, we present a model of Origami tessellations as continuum, rather than discrete, elastic shells. Most importantly, we suggest an asymptotic theory that translates the local constraints imposed on folding angles into global constraints weighing on the effective elongations and curvatures of the tessellation. Thus, the theory provides a characterization of the space of kinematically admissible configurations as the set of solutions to a system of nonlinear PDEs. Furthermore, the elastic strain energy required by each configuration is calculated. In conclusion, the elastostatic equilibrium of the tessellation is formulated as a constrained continuous energy minimization problem. The theory is exemplified in the case of the Miura tessellation. Various finite deformation modes are successfully predicted and constructed numerically under suitable boundary conditions.

Notwithstanding the costs of higher analytical complexity and lower accuracy, the suggested theory offers a deeper physical insight into the configuration space of Origami tessellations while significantly reducing calculation time. This compromise should therefore prove beneficial in time-sensitive applications, as for instance is the case when real-time control of Origami tessellations is desired.

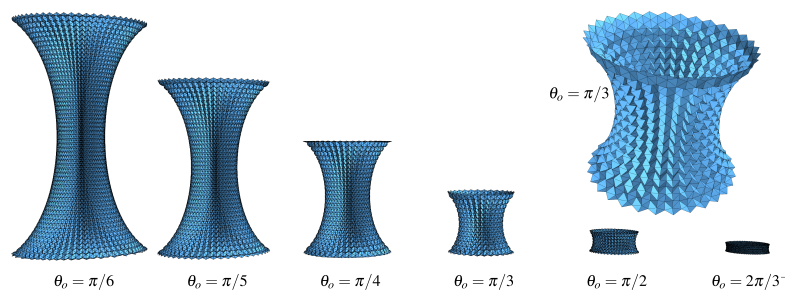


Figure 1: Example of axi-symmetric surfaces achieved with Miura ori

References

- [1] H. Nassar, A. Lebée, and L. Monasse, “Fitting surfaces with the Miura tessellation,” in *Origami 7th*, R. J. Lang, M. Bolitho, and Z. You, Eds., vol. 3. Tarquin, 2018, pp. 811–826.