Determine Distinct Shapes of Rigid Origami

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Abstract

Rigid origami is a class of origami whose entire surface remains rigid during folding except at crease lines. In this work, we explore the idea of determining distinct shapes that can be realized by a given crease pattern. Typically, crease pattern is designed with a single target shape in mind. However, as the advances in material science and robotics engineering enable the realization of self-folding rigid origami [Ryu et al. 2012; Ahmed et al. 2013; An et al. 2011], it is desirable to create a crease pattern that can fold into multiple shapes. Traditionally such a crease pattern is created by combining the crease patterns designed for each of the target shapes. The main limitation of such an approach is the complexity of combined crease, which often prohibits the implementation of self-folding origami due to the geometric, kinematic and material constraints. Therefore, we propose to take an approach that attempts to take an existing crease pattern and discover most distinct k foldable shapes. Our hope is that we can match one of the k distinct foldable shapes to the given target shapes, and only modify the crease pattern locally to better approximate the target shapes.

We say that two foldable shapes (origami) s and s' are distinct if their folding paths from a flat sheet are in different homotopy classes and the distance between s and s' is greater than a user defined value. Our method proceeds by creating a random foldable shape s and keeping s if s is distinct from the existing distinct shapes S. This process iterates until S has k elements. More specifically, we model the rigid origami as a kinematic system with closure constants and solve the foldability problem through a randomized method and determine the distinctness of shapes by careful foldability analysis. Fig. 1 illustrates this idea. Our experimental results show that the proposed method successfully determines distinct shapes from several types of rigid origamis.

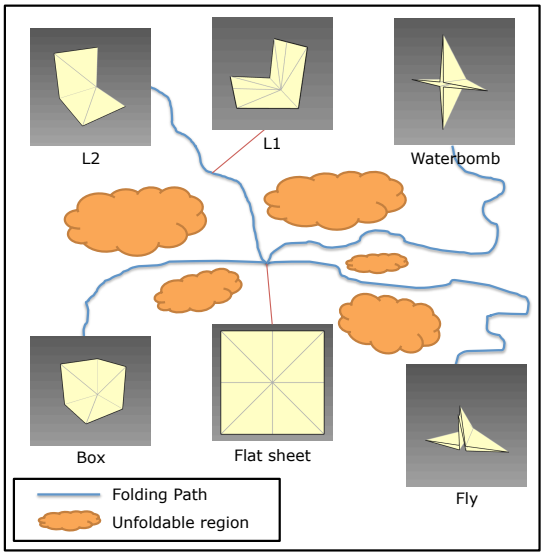

Figure 1: *This figure illustrates the ideas of determining the distinct shapes from a given crease pattern. Each folding path in this figure is obtained from different homotopy classes.*

References

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