

Thick Rigid Origami with Parallel Double Creases

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Abstract

To apply origami mechanisms to practical systems, various thickening methods for rigid origami have been proposed. The typical problem of thick origami is to treat the thick version of an interior vertex of the crease pattern as forming a spherical linkage, which is overconstrained if creases are shifted to avoid intersection of thickened panels. Here are the major approaches for thick origami. (a) First, we can use a special type of spatial linkage for a vertex, so that it is a mechanism even if that axes are non-concurrent [1,2]. This allows for a crease to fold 180° completely. The method applies to a limited family of rigid origami patterns. Also, the assembly is potentially complicated because of non-concurrent hinges, and this leaves a hole at the corner. Alternately, (b) we can keep the positions of the crease unchanged, but trim the volume of panels [3,4]; this sacrifices the ability to fold up to 180° but is general enough to be applied to any rigidly foldable pattern using all creases. If tapered panels are used, there will be no

hole at the corner. Finally, (c) a crease pattern can be preconditioned before applying method (b) by replacing a crease with two parallel creases [5,6,7]. This allows one to split the fold angle into two smaller ones, so that we can virtually construct a mechanism that folds up to 180° (Figure 1).

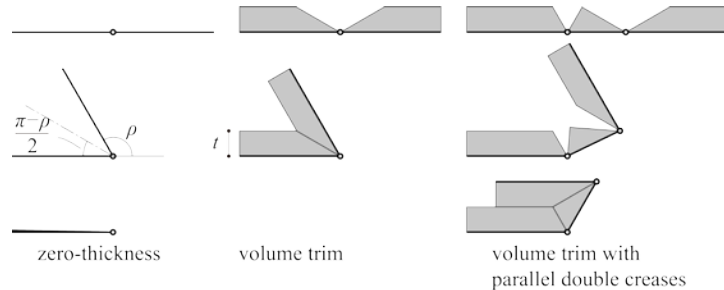


Figure 1: Thickness by parallel double creases

In this paper, we investigate on type (c), i.e., the preconditioning method by parallel double creases, and extend the work of [6]. We show that any developable degree-4 vertex can be converted into double-crease version without losing its rigid foldability (Figures 2 and 3). This also gives a new interpretation of mechanism of developable degree-4 vertex represented as the summation a pair of fold angles where the tangents of the half angles are proportional to each other. The double creases method allows for removing the material on one side, so that the hinges can live on one side of the panel. This technique also allows for thickening a non-manifold origami composed of multiple sheets by gluing the non-thickened sides of origami.

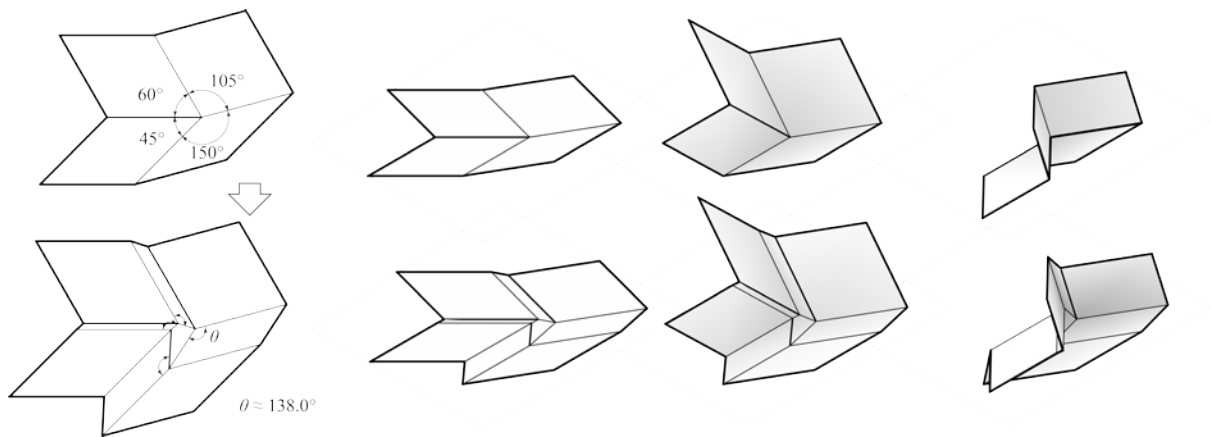


Figure 1: Generic degree-4 vertex (top) converted to parallel double creases version (bottom).

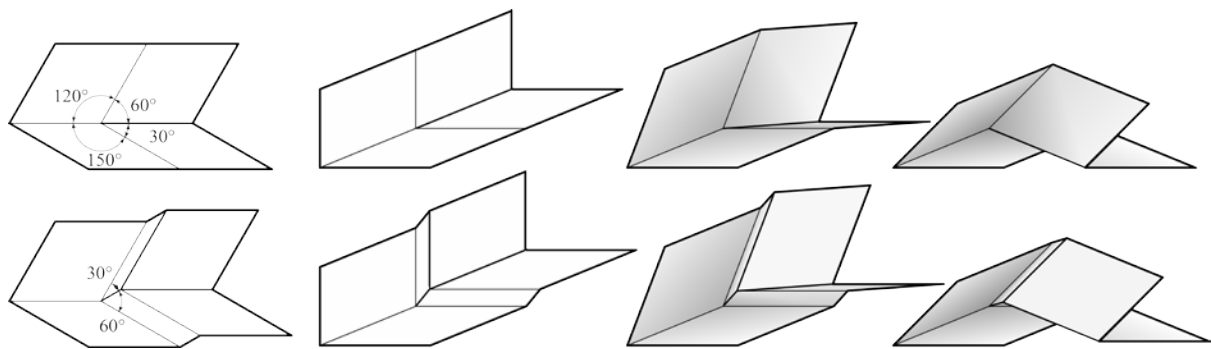


Figure 2: Degree-4 vertex with aligned creases (on top) converted to parallel double creases version (bottom).

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