

Designing Self-Blocking Systems with Non Flat-Foldable Degree-4 vertices

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Abstract

Non flat-foldable rigid origami patterns are potentially useful to make mechanisms that self-block at desired three-dimensional folded states. In this paper, we show a design approach for making self-blocking one-DOF mechanisms using the geometry of non flat-foldable degree-4 origami vertices. We identify the crease patterns from three-dimensional self-blocked state in use, by use of simple spherical trigonometry and the trigonometric inequalities.

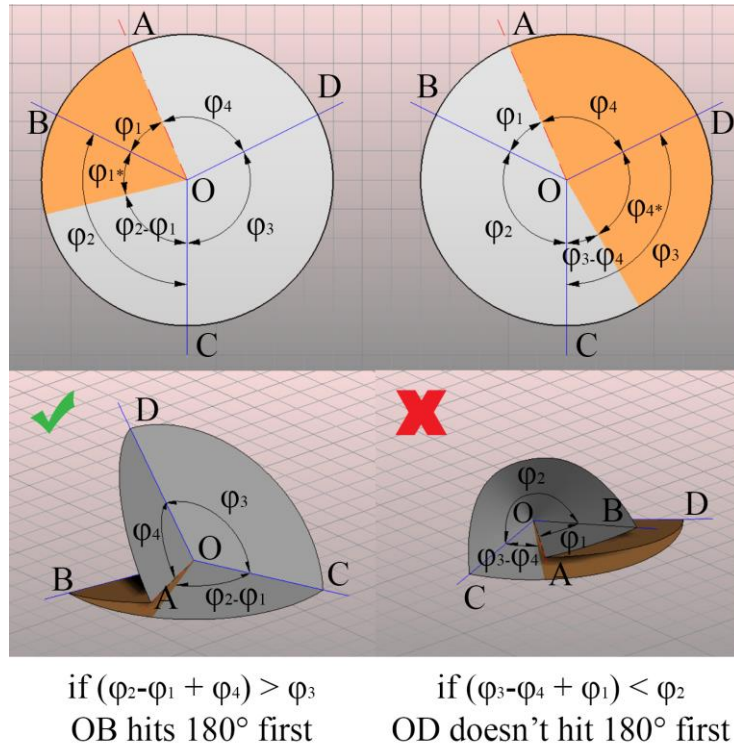


Figure 1: non-flat foldable 4-degree single vertex analysis

A developable, non-flat-foldable degree-4 vertex forms a one-DOF mechanism from a flat unfolded state to a blocked state; at the blocked state, one of its fold lines hit 180 degrees first. A rather complicated algebraic expression of this kinematics is shown by Huffman [Huffman 1976]. We show a simpler way to identify the self-blocking crease for each of two kinematic modes of the mechanism using spherical trigonometry and triangle inequality. We also show constructive design of deployable systems based on the geometry of the self-blocked state. We

claim that this constructive geometric approach is more manageable by professionals with no mathematical and computer science background than algebraic expression. Lastly, we present two designs as case studies: a foldable stair and a foldable chair. These examples show practical applications of the proposed methods into a real design pipeline.

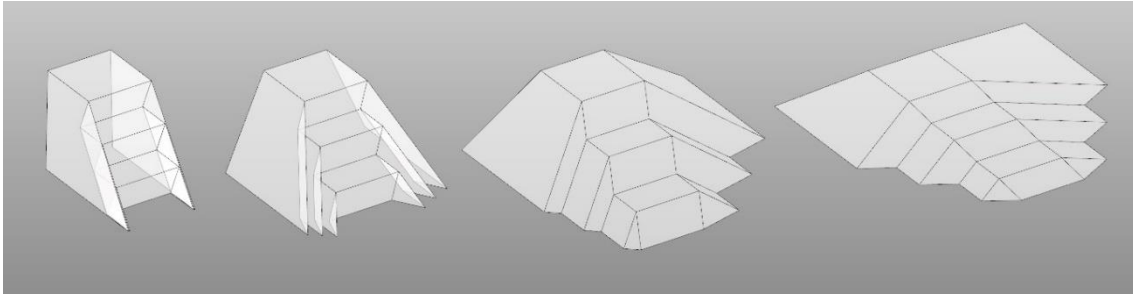


Figure 2: Self-blocking rigid origami stair - unfolding

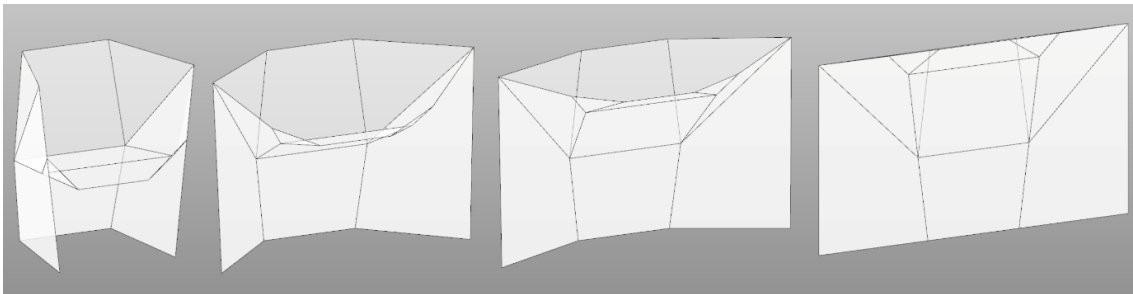


Figure 3: Self-blocking rigid origami chair - unfolding

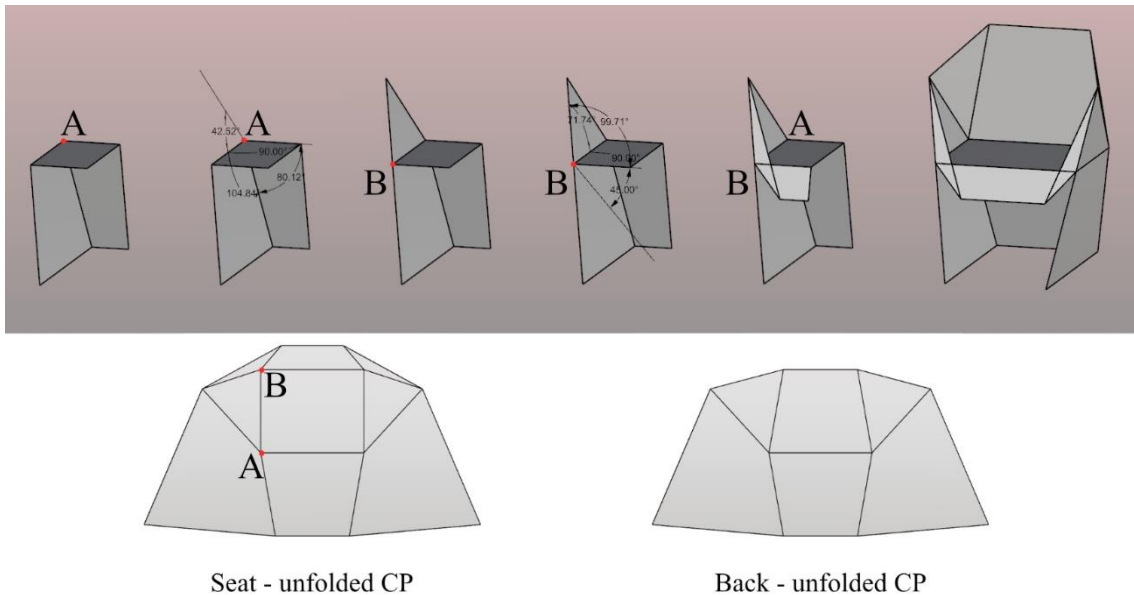


Figure 4: The constructive geometrical process of self-blocking rigid origami chair with synchronized blocking vertices.