

# 1-DOF Structure Folding into Multiple Polyhedra

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## Abstract

The study on a common unfolding of polyhedra [1,2] is a potential source of design for reconfigurable systems such as transformer robots and self-assembly blocks, as it can fold into different forms by just actuating the corresponding set of creases. However, there is a typical difficulty in realizing self-folding system using common unfolding due to the high degrees of freedom (DOF) of the mechanism where each edge can independently fold. That would require multiple actuators independently controlled.

In this paper, we propose the design of common unfolding of multiple polyhedra which can fold along one-DOF mechanism. We synchronize the folding angles by adding the *synchronization gadget*, a wall-like structure connecting the desired creases through a sequence of degree-4 non-developable vertices (Figure 1). The gadget is designed to be compatible to both the flat unfolded and the final polyhedral states, which can be achieved by trimming each corner of the polyhedron by a plane and extrude the section along the direction perpendicular to the plane. The extrusion generates a rectangular strip, which is compatible with the flat unfolded state.

To allow for the structure to fold into more than one configurations, we use common unfolding where the two set of creases properly intersect each other, so that the actuation of one set of creases suppresses that of the other. Figure 2 shows a common unfolding of the regular tetrahedron and a tetramonohedron synchronized using the proposed method. Here, we used the tiling property of tetramonohedron [3,4] to produce the common unfolding with properly intersecting creases. The combination of synchronization gadgets and the proper intersection of crease patterns enables the configuration space with exactly two branches of one-DOF mechanisms. Such a mechanism is easily controllable with a small number of actuators.

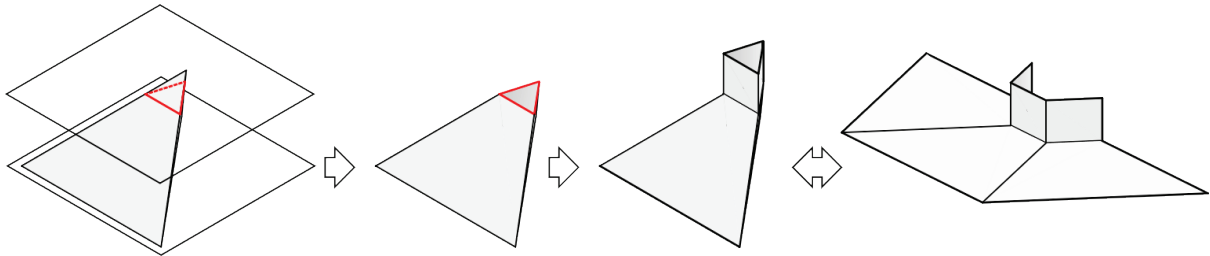


Figure 1: The construction of synchronization gadget to synchronize the creases forming a corner: slicing by a plane and extruding perpendicularly (left three figures). The rectangular strip is compatible with the flat state of the unfolding (right).

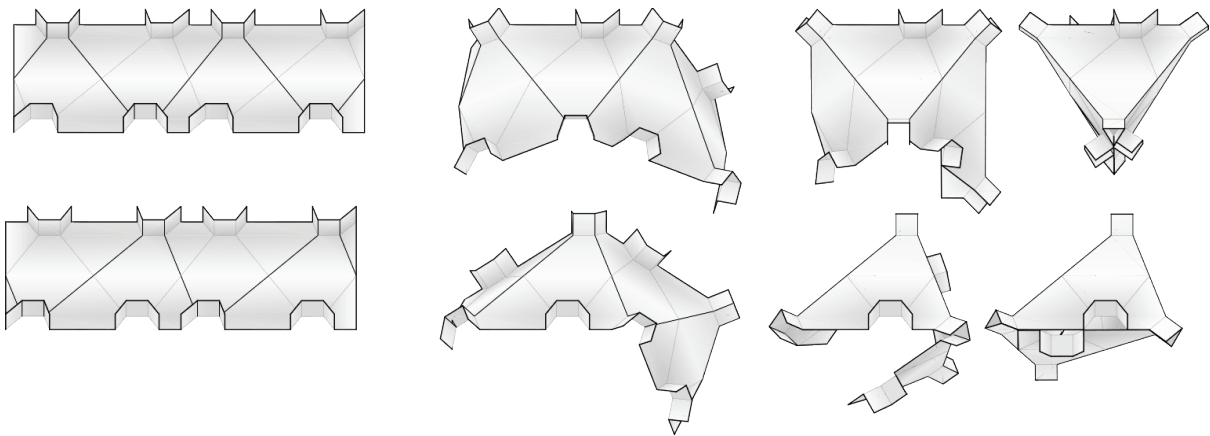


Figure 2: A common unfolding that folds (left) into the regular tetrahedron (right top) and a tetramonohedron (right bottom). Due to the synchronization gadgets, each folding motion is one-DOF.

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