

Symmetrical Design in Interlocking Origami Polyhedron

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Abstract

Symmetry never goes out of style, referring to a sense of harmonious, beautiful proportion and balance. In origami, symmetry can be extremely significant for completing a model and even performing a specific transformation, which then might be used to contract the total volume, change the shape and absorb energy. In fact, symmetry can even contribute to design the origami structure with strong support capacity, characterized the feature of interlocking. Here, interlocking is not just about insertion but also with the concept of closed form. And the interlocking origami mechanism should be strong and robust. This paper focuses on the interlocking origami polyhedron with several symmetrical units.

It is well known that a regular dodecahedron can be made using Tom Hull's PHiZZ (Pentagon-Hexagon Zig-Zag) modular origami units. Each PHiZZ unit is front-to-rear symmetry, (which means rotating about the central line of the unit with 180 degrees, the shape remains unchanged.) and can be assembled into an integrated dodecahedron by inserting one flap into next unit's pocket created by the folding process, as shown is Figure 1.

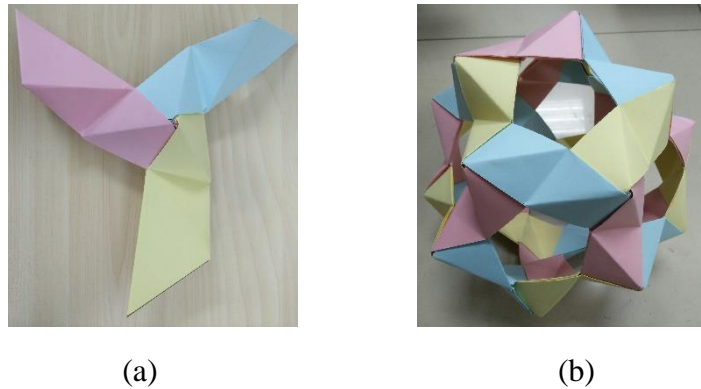


Figure 1: (a) three PHiZZ units form a corner of the dodecahedron. (b) PHiZZ dodecahedron

Since its symmetrical characteristic, using PHiZZ units to make various polyhedral which is composed of pentagon or hexagon faces is possible. For example, a truncated icosahedron (aka soccer ball). In fact, there are various types of penultimate modules making a ball or polyhedral. However, most of them are hollowed-out, i.e., only the edges of polyhedral are visible. Moreover, for PHiZZ units, they tend to buckle when forced to make square faces. As a result, this paper presents design and analysis of a solid cube origami using a fascinating and extremely simple unit, characterized by front-to-rear symmetry, as shown in Figure 2. These units fall into the category of modular origami units whose locking mechanism is based on an

accordion pleat. And the short ends of the accordion pleat become the flaps, and the layers at the sides created by the accordion folds become the pockets.

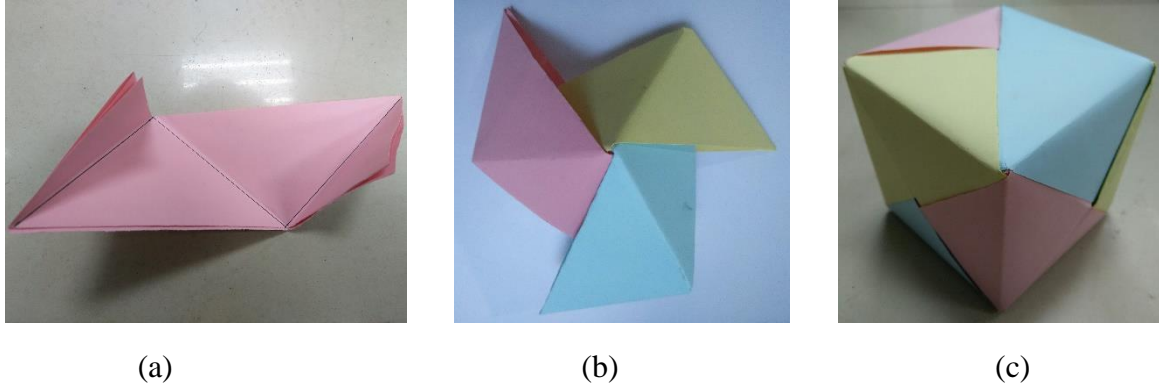


Figure 2: (a) front-to-rear symmetric unit for cube. (b) three units form a corner of the cube. (c) final interlocking cube

As we know, a cube is composed of 6 square faces and a total of 12 edges. Each symmetrical unit will form one edge of the cube so it will need 12 square pieces of paper. Three identical units can be linked together as a cubic corner with degree 3. The difference from the PHiZZ unit lies at the lines of Zig-Zag decreases to three, and only one third of the rectangle pleat is actually functioned as part of the faces, the rest of that is for interlocking. There is no doubt that the cube is particularly strong.

To make the cube, first slide the end of one unit into the side of another. The flap should go in between the pleat of papers, and crease lines should line up. Then, slide the third unit into the second unit, and slide the first into the third for interlocking. Every three units can make a corner of the cube. continue adding units onto the first three, and remember only the middlemost part is visible, which also means that the second crease is shown as the edge of the cube.

Based on the theory of symmetry, it is possible to design some other unit characterized with symmetry and then to be locked together (Figure 3). However, the number as well as the length of creases influences the capacity of being interlocked.

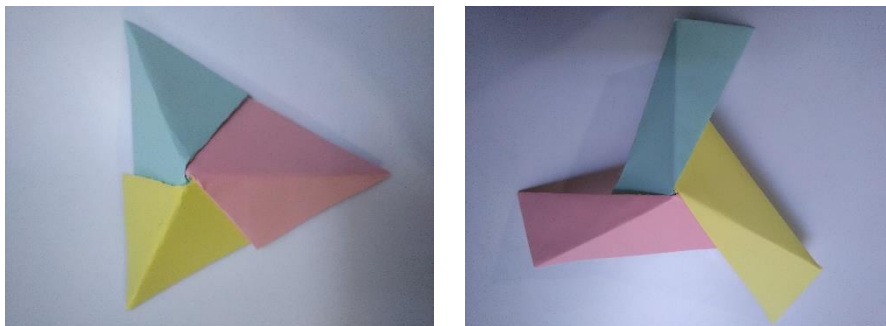


Figure 3: examples of symmetry design in origami unit.