

Origami Tessellations and Modulares: What they have in common and a new way of designing origami modulares

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Abstract

Tessellations and Modulares are well known abstract origami genres. Tessellations are relatively flat geometric origami tilings, composed of smaller repeating origami pieces also referred as molecules. They are not only entirely flat, but also can have some constant thickness that does not change with the addition of more molecules to the tessellation. Tessellations usually use single uncut sheets of paper, so the division into molecules is a bit imaginary, since all the molecules are connected without gaps. Modulares, on the other hand, are three-dimensional shapes composed of many separate pieces, also known as modules or units. Modulares tend to have some connection mechanism that allows the attachment of units one to another without using glue or other adhesives.

Although these two genres seem very different, it can be shown that they have much in common. Since tessellations consist of smaller molecules, you can draw an imaginary grid on the surface of the paper that would correspond to the borders of the molecules. You can choose the division into molecules in the way this grid would be either rectangular or rhombic. If the grid is triangular or hexagonal, it is possible to choose the division in a way the molecules become rhombic.

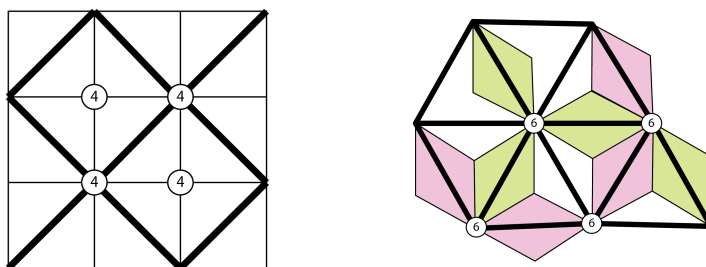


Figure 1: Two most common molecular divisions of a flat tessellation. The left one has nine square molecules and the right one is comprised of rhombic molecules.

The borders of the molecules in Figure 1 are indicated with thin black lines. The thick black lines define the 'edge' of the molecule. In the simplest case the edge is just the fold

line, although it can be more complex than a straight fold line. We can think of the surface then as a plane composed of those edges. Imagine that you cover the table surface with wooden matches. Playing with matches we can also construct 3-dimensional shapes including Platonic solids. Then the edges become the edges of platonic solids (Figure 2).

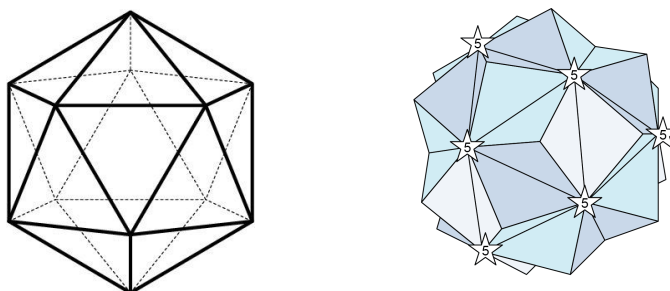


Figure 2: Icosahedron, one of the most common Platonic solids used for constructing modulars and the corresponding modular made from square molecules ‘taped’ together.

If we take a flat sheet of paper divided into those absolutely flat molecules and try to add or remove some molecules to ‘wrap’ it onto the polyhedron, we would get the results that already look like the most common Sonobe modular. The same procedure can be made with more complex, non-flat molecules resulting in very intricate shapes (Figure 3).

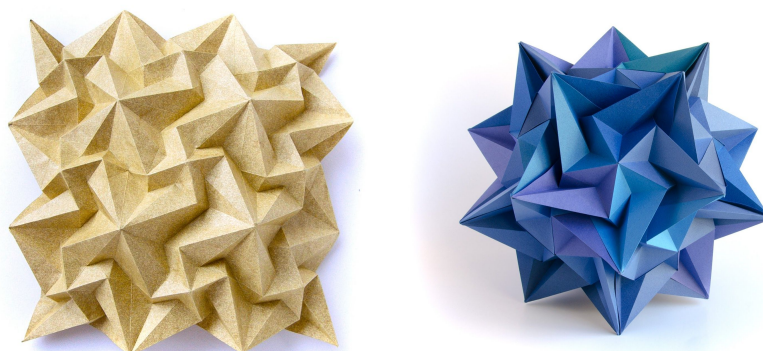


Figure 3: Paradigma: the example of a tessellation and a modular sharing the same molecule.

In fact, the molecules on the plane and the molecules wrapped to become the polyhedron can be absolutely the same. Not all kinds of molecules will allow this kind of transformation, and I will discuss which are the necessary conditions for the molecule to be able to both tile the surface and the polyhedron. New modulars can be discovered using this ‘wrapping’ technique. I will discuss in the paper how to organize the connections in these kind of modulars so that they can produce real foldable origami models.