Triskelion Block Families

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Abstract

We present families of construction blocks based on the classical iconographic pattern called a *triskelion*. The blocks have a unique way of connection that reminds us of a gymnastic pose of physically-balanced two persons and that also gives the blocks tiling properties and expressive power of constructing a variety of shapes. We fabricated prototypes and confirmed the basic connections and the possibility for creating various balanced objects.

1 Introduction

Geometric shapes and structures are frequently used to design construction blocks and related sculptures [1,2]. In this article, we focus on the iconographic pattern called a *triskelion* or a *triskele*. It is a classical iconographic pattern that consists of three spirals allocated with three-fold rotational symmetry. It is frequently used with a representation of three bent human legs, which are seen for example in the flags of Sicily and the Isle of Man in the Irish Sea shown in Figure 1 [3].

Figure 1: *The flag of the Isle of Man.*

In this study, we make use of this strange but dynamic and fascinating figure of triskelion as a motif for a new geometric construction blocks. Two basic plane figures we use are shown in Figure 2, which we call T_1 and T_2. Both figures have three legs with distinct (RGB) colors and have three-fold rotational symmetry, where the left one has no center triangle while the right one has, i.e., the yellow equilateral triangle. A common property of these figures advantageous for construction blocks is that a leg can be connected to the concave part between two legs as shown in Figure 3. This enables the figures to connect and expand to the three directions to make a variety of shapes. We also emphasize that the connected figures look just like the gymnastic pose of physically-balanced two persons shown in Figure 3, right, which should make the construction more entertaining and imaginative. These triskelion-like figures also have the functional properties of being able to tile the plane quite effectively. Lastly, when the figures are materialized, we found a unique sliding property of blocks which will be explained in Section 2.

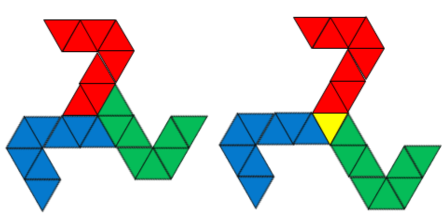


Figure 2: *Triskelion figures T_1 and T_2.*

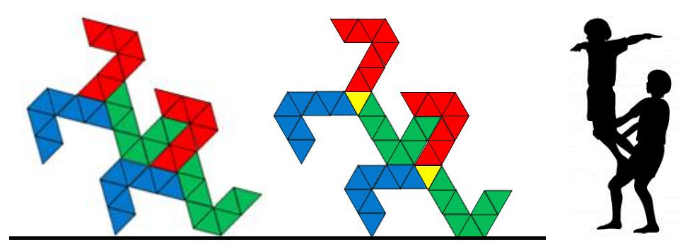


Figure 3: *Connections of T_1- and T_2-pairs, and a gymnastic pose.*

The figures T_1 and T_2 are extended to form families of figures by changing the length of the legs while keeping the geometric properties of three-fold symmetry, leg connectivity, and recursive tiling. We call them the T_1- and T_2-families. Then, we add depths to the figures, design the 3D models, and print them using 3D printers. We confirmed the basic connections and also confirmed through free-form assemblies that a variety of physically-balanced and visually-appealing constructions are actually possible.

The remaining sections of the paper are as follows: In Section 2, we show families of triskelion figures and their basic properties. In section 3, we state issues on 3D models and prototypes. In Section 4, some constructions using the prototypes are shown. Finally, concluding remarks are given in Section 5.

2 Basic Properties of Triskelion Figures

Exploiting the tiling property of T_1's and T_2's in Figure 3, six T_1's and six T_2's can be connected in a circular way as shown in Figure 4. The connections are radially extended from the center in a repeating way. Especially, T_1's can tile the whole plane.

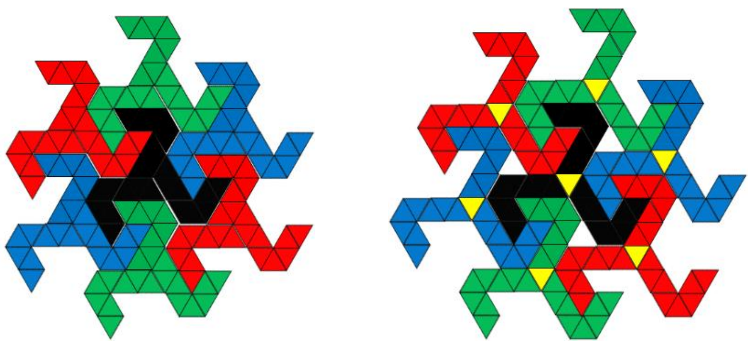


Figure 4: *Circular connections of T_1's and T_2's.*

Another somewhat surprising sliding property of these figures is that from the three-way interlocking situation in Figure 5, left, we can disassemble them by just sliding two of them, say, the green and blue ones. Then, the remaining red one slides out rather automatically without direct manipulation. Furthermore, this property is extended to the whole plane if the pieces are materialized and there is no friction. Namely, in such a tiling all the pieces slide out at a time when we seize two of them and pull them apart in different directions. We demonstrate this "auxetic" property using prototypes in Section 4.

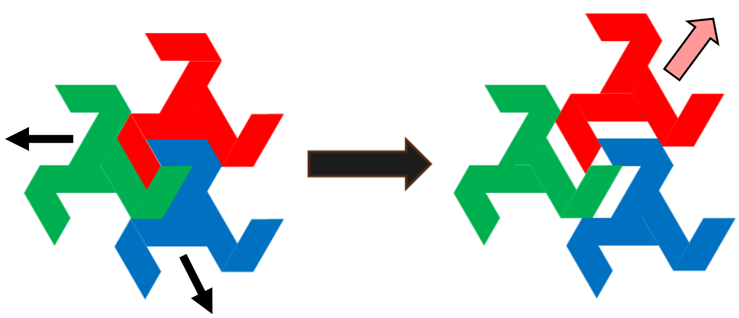
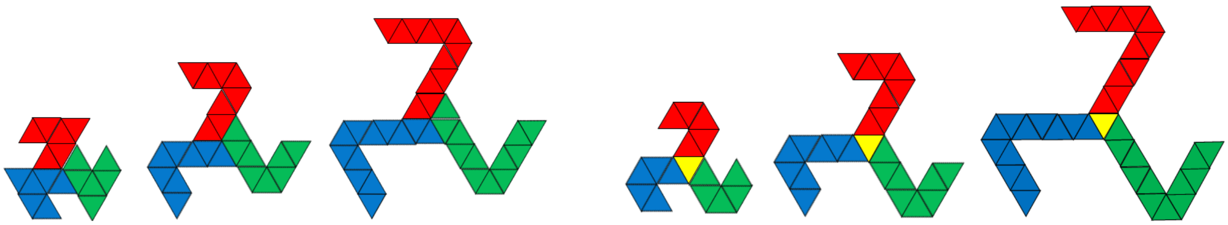


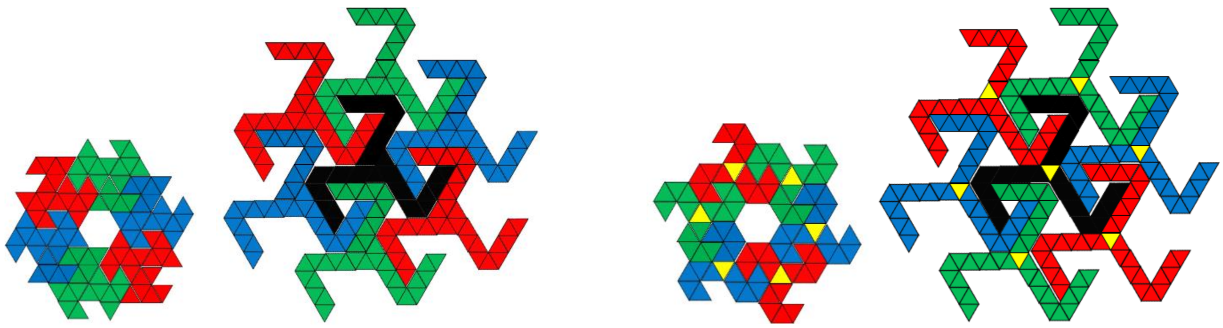
Figure 5: *Sliding property of T_1's (and also of T_2's).*

Now, we extend T_1 and T_2 to form families of triskelion figures by changing the lengths of legs while keeping the properties of three-fold symmetry, leg connectivity, and recursive tiling. The figures for the T_1- and T_2-families with leg length "1, 2, and 3" are shown in Figure 6. Here, we note that the figures with leg length 1 are rather exceptional with additional triangles at the ends and without the sliding property in Figure 5, but since they also have the above properties usable for constructions, we add them. For the figures with leg lengths 1 and 3, we show the circular connections in Figure 7.



(a) (b)

Figure 6: *Two families of triskelion figures related to (a) T_1 and (b) T_2 with leg length = 1, 2, 3.*



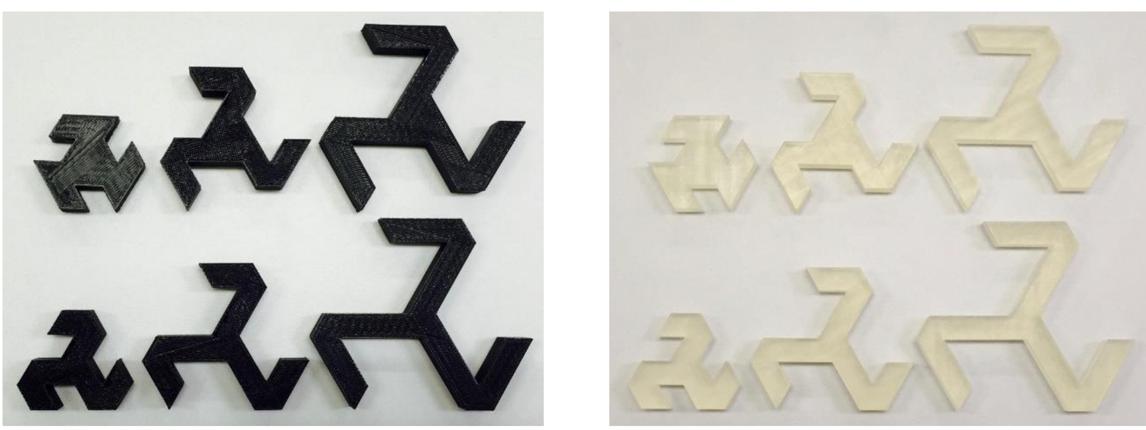
(a) (b)

Figure 7: *Circular connections for (a) T_1-family and (b) T_2-family with leg length = 1, 3.*

3 3D Modeling and Prototyping

The triskelion figures in the previous section are turned to 3D models by extruding them to a fixed thickness. A particularly convenient thickness value is $\cos\frac{\pi}{6} *$ (the edge lengths of the equilateral triangles) from which all these triskelions are formed since then parts with this thickness can be inserted to the blocks vertically and construction is extended to the third dimension.

All the 3D models were designed with the CAD system 123D Design and prototypes were printed using PLA resin by the 3D printer Replicator 2 of MakerBot and using acrylic resin by Projet 3500 of 3D Systems. The printed models are shown in Figure 8. The edge length of the equilateral triangle is 1 cm. The insides of the black and yellow blocks with PLA resin are almost hollow with some support pillars while the acrylic blocks are solid.



(a) (b)

Figure 8: *Printed blocks of T_1- and T_2-families using (a) PLA resin and (b) acrylic resin.*

4 Some Constructions with Triskelion Blocks

The basic connections corresponding to those in Figures 3, 4, and 5 are demonstrated in Figures 9, 10, and 11(a), respectively. Figure 11(b) shows the “auxetic” property of the triskelion blocks, where the tiling expands two-dimensionally when any two of the blocks are seized and pulled apart in different directions. Finally, Figure 12 shows some of the free-form assemblies using blocks of T_1- and T_2-families.

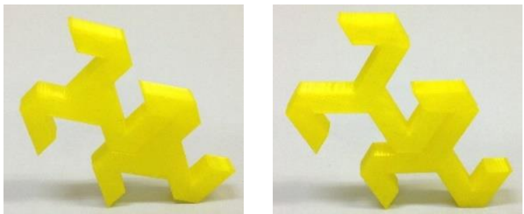


Figure 9: *Connections of T_1- and T_2-pairs.*

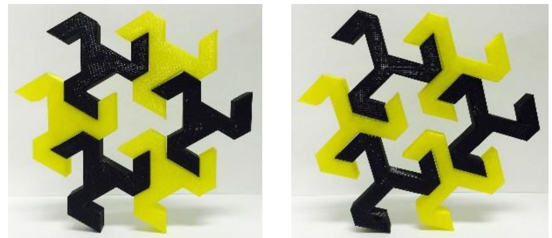
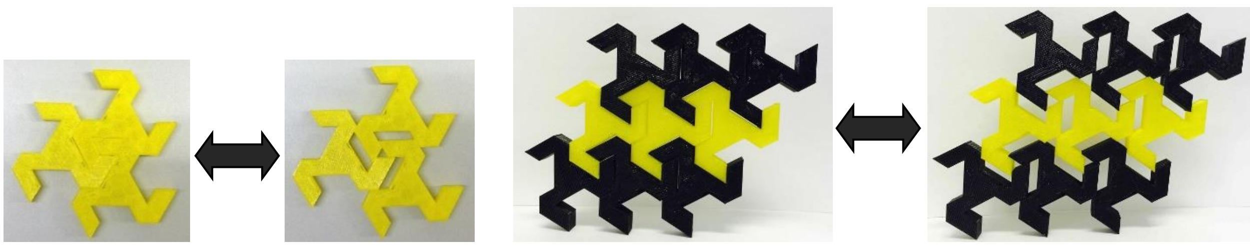


Figure 10: *Circular connections with six T_1- and T_2-blocks.*



(a) (b)

Figure 11: *Transitions by sliding two blocks: (a) three interlocked blocks (b) blocks in tessellation.*

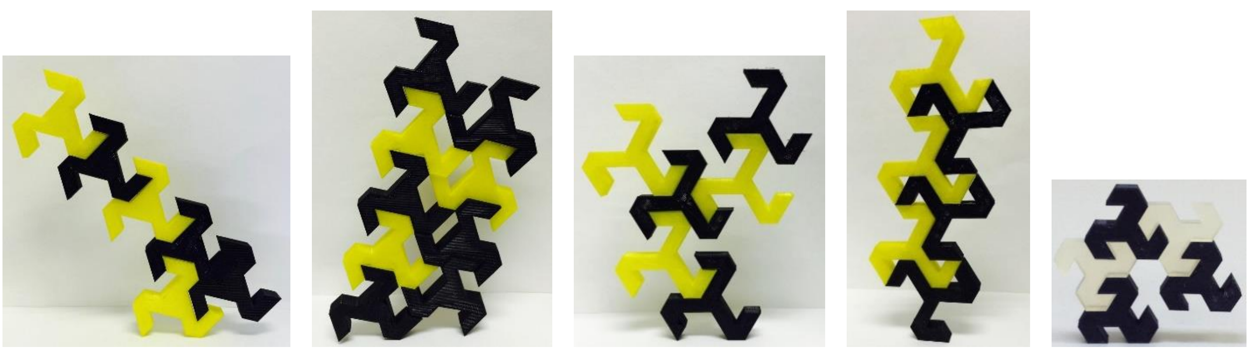


Figure 12: *Free-form assemblies using triskelion blocks of T_1- and T_2-families.*

5 Concluding Remarks

We presented families of geometric construction blocks with a motif of triskelion figures that enable us to create various constructions, many of which remind us of physically-balanced poses of humans. For future work, we plan to investigate materials, weights, and physical balance of the blocks and create art pieces. The related figures including the three-dimensional ones should be also promising.

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