Triblock Origami Spheroid Workshops

Keh-Ming Lu, Alan S Tsaur, and Feng-Tse Chuang
Department of Computer Science and Information Engineering
Asia University
500 Liu-Feng Road, Wu-Feng, Taichung, 41354, Taiwan
E-mail: klu@asia.edu.tw, mNemonix@mac.com, and jfz926@gmail.com

Abstract

An origami spheroid is here defined as the symmetric assemblage of multiple copies of paper building blocks without holes. Four examples with the octahedral and dodecahedral wireframes of Platonic solids, Johnson solid #17 wireframe, and the pentagonal antiprism wireframe symmetry are presented. These consist of multiple pieces of Triblock paper building blocks, with folding and adhesives. In this study, we will describe the folding and assembly processes of spheroids in details.

Introduction

The concept of constructing unit origami that came from Fuse's idea [1] is useful for realizing the mathematical computation in the fields of combinatorics. An origami spheroid is here defined as the symmetric assemblage of multiple copies of building blocks without holes. A Triblock origami spheroid is a non-manifold complex assembled by attaching edge to edge and vertex to vertex of the models. We will use multiple pieces of the frustum of a tetrahedron and the socket boat of Triblock building blocks models to assemble origami spheroids. We may prefabricate non-manifold module, attach it to the wireframes of Platonic solids [2], antiprism [3], and Johnson solids [4] - [6] to construct the origami spheroids. A method similar to the modules including a one-piece icosahedron and other triangulated polyhedra can be found in John Montroll's book [7].

Folding and Assembly Processes of Spheroids

In this study four examples of origami spheroids with the octahedral and dodecahedral wireframes of Platonic solids, Johnson solid #17 wireframe, and the pentagonal antiprism wireframe are presented. These consist of multiple pieces of Triblock paper building block, with folding and adhesives.

Case 1: Octahedral Spheroid. An octahedral spheroid is a non-manifold complex that consists of eight (8) frusta of tetrahedron models. Apply pieces of a small portion of tape to adhere three base edges from the inside and a few drops of white glue onto the frustum portion. Please refer to Figure 1 for the folding process of the frustum of a tetrahedron.

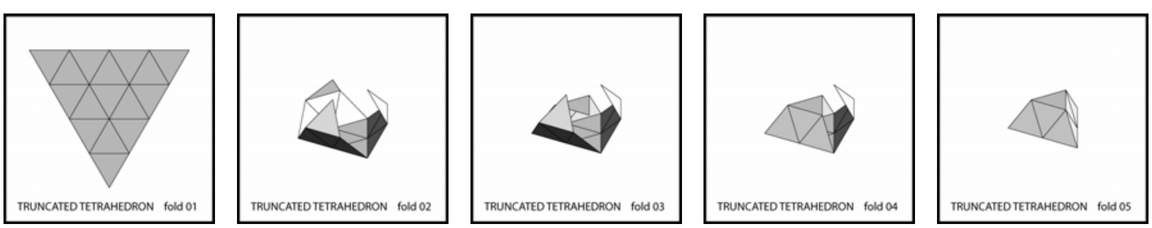

Figure 1: *Folding process of frustum of a tetrahedron*

In order to assemble the octahedral spheroid, apply white glue to the edges of six units in the form of a ring. You may need tape to affix the ring of six units until the glue has set. At this time, the edges of the top and bottom empty space should exactly form a triangle. Please refer to Figure 2 for the assembly process of the octahedral spheroid.

Figure 2: *Assembly process of octahedral spheroid*

Case 2: Johnson Solid #17 Spheroid. A Johnson solid #17 spheroid is a non-manifold complex that consists of sixteen (16) pieces of the frustum of a tetrahedron. In order to assemble the Johnson solid #17 spheroid, apply white glue to the edges of eight units in the form of a ring. You may need tape to affix the ring of eight units until the glue has set. At this time, the edges of the top and bottom empty space should exactly form a square. Please refer to Figure 3 for the assembly process of the Johnson solid #17 spheroid.

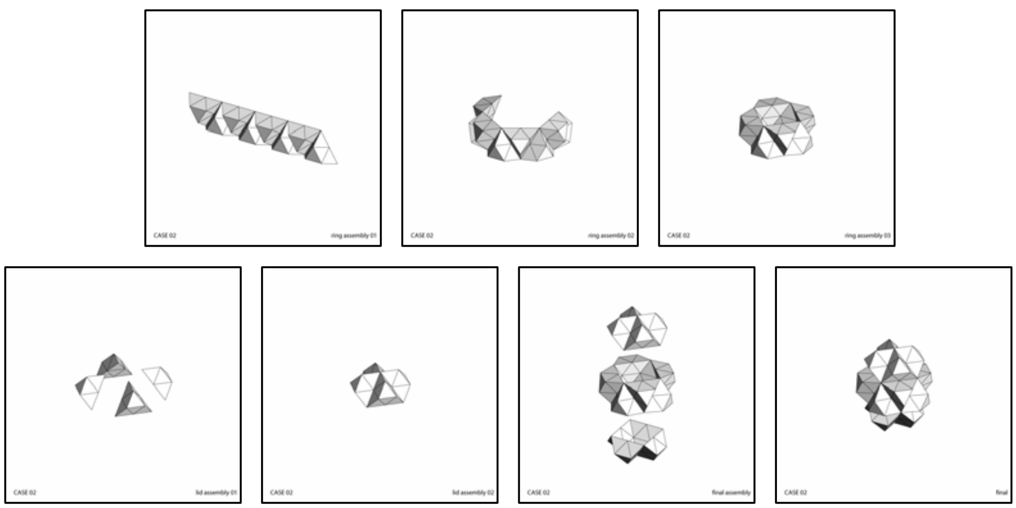

Figure 3: *Assembly process of Johnson solid #17 spheroid*

Case 3: Pentagonal Antiprism Oblate Spheroid. A pentagonal antiprism oblate spheroid is a non-manifold complex that consists of twenty (20) pieces of the frustum of a tetrahedron. Among these twenty pieces, ten pieces will be put onto the wireframe of the pentagonal antiprism and one pair of five pieces each will be put onto the wireframe of a Johnson solid #2. In order to construct the pentagonal antiprism oblate spheroid, apply white glue to adhere the edges of ten units in the form of a ring. You may need tape to affix the ring of ten units until the glue has set. At this time, the edges of the top and bottom empty space should exactly form a pentagon. Please refer to Figure 4 for the assembly process of the pentagonal antiprism oblate spheroid.

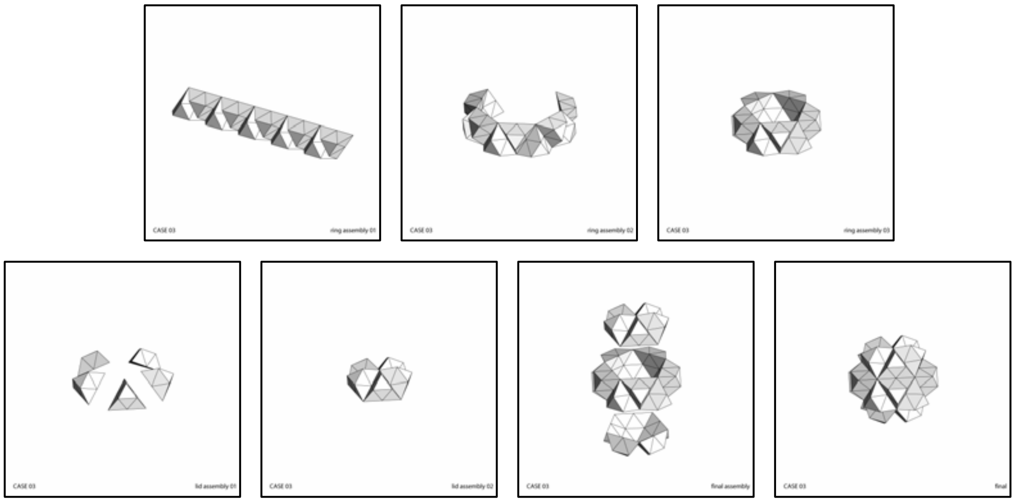

Figure 4: *Assembly process of pentagonal antiprism oblate spheroid*

Case 4: Dodecahedral Spheroid. A dodecahedral spheroid is a non-manifold complex that is comprised of twelve (12) pieces of pentagon models consisting of five units of the socket boat model. In order to construct the socket boat model, apply a small portion of tape to adhere the convex head and the concave tail of the socket boat model from inside, as in Folds 05 and 07 respectively. Please refer to Figure 5 for the folding process of the socket boat model.

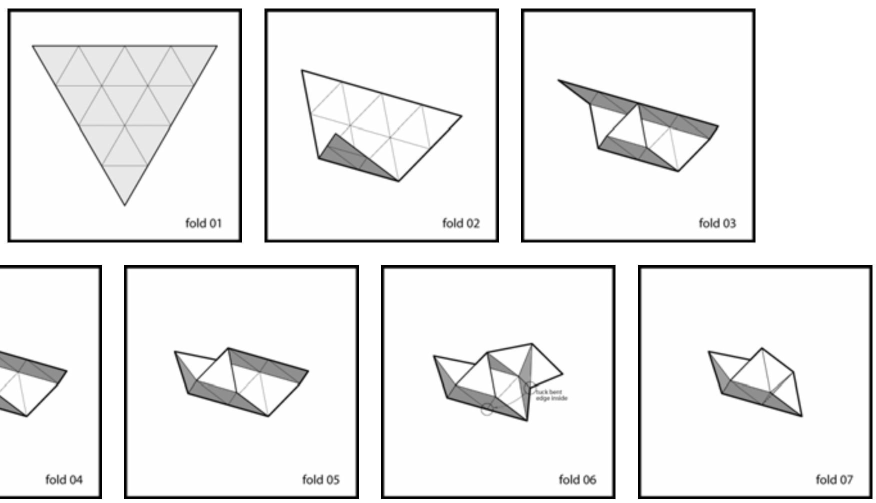

Figure 5: *Folding process of the socket boat model*

While assembling a pentagon, apply a few drops of white glue to the convex head of the socket boat model and insert it into the concave tail of the second socket boat model. You will have to repeat this process five times to form a ring of five units before the glue has set. Please note that the construction process of a pentagon is only an approximation, not geometrically exact. Upon completion of the six units of pentagon models, we then construct one of the two hemispheres of the dodecahedral spheroid. Apply white glue to the two edges of each and connect the six pentagon models. You may need to use tape on the outside of the hemisphere to hold the position until the glue has set. In the last construction stage, you may need tape to connect the two hemispheres temporarily. Apply white glue to ten edges from outside this time. Remove excess glue. Please refer to Figure 6 for the folding and the assembly process of a pentagon and the assembling process of the dodecahedral spheroid.

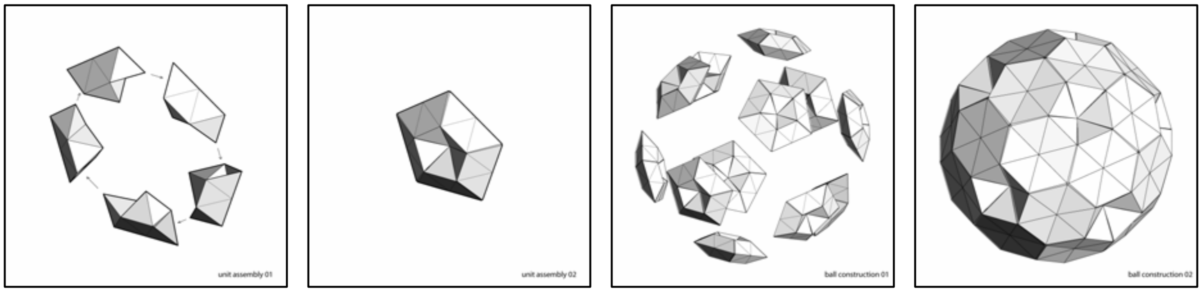

Figure 6: *Folding process of a pentagon and assembly process of a dodecahedral spheroid*

Discussion and Conclusion

In this study, we built three spheroids by 8, 16, and 20 units of the frustum of a tetrahedron and a dodecahedron spheroid by 60 units of the socket boat model. We have applied the octahedral and dodecahedral wireframes of Platonic solids in Case 1 and 4, Johnson solid wireframes in Case 2, and the pentagonal antiprism wireframe in Case 3.

In a future study, we will continue working on putting multiple pieces of the frustum of tetrahedrons onto the Johnson solid wireframes or the combinations of Johnson solid and the antiprism wireframes. Similar to the Johnson solid #17, we will work on putting 6, 10, 14, and 12 pieces of the frustum of tetrahedrons onto the wireframes of Johnson solids #12, #13, #51, and #84, respectively [6]. Similar to Case 3: pentagonal antiprism oblate spheroid, we plan to use both Johnson solids #1 and #2 to replace the square and pentagon plate wireframes by the wireframes of 4 and 5 pieces of triangles, respectively.

Without abiding by the rules of unit origami [8] and modular kirigami [9] stipulating no glue, we constructed these spheroids with multiple pieces of paper, with folding and adhesives. However, the field is open for others to develop further and joint designs are possible. We expect to see an explosion of ideas in the future, as inexpensive cutting, folding, and gluing workshops mushroom all over the world.

References

[1] Tomoko Fuse, "*Unit Origami- Multidimensional Transformations*" Tokyo and New York: Japan Publication, Inc. p.228, 1990.
[2] http://en.wikipedia.org/wiki/Platonic_solid
[3] http://en.wikipedia.org/wiki/Antiprism
[4] V. Zalgaller, *Convex Polyhedra with Regular Faces*. New York: Consultants Bureau, 1969.
[5] N. W. Johnson, "Convex Polyhedra with Regular Faces." *Canad. J. Math.* 18, 169-200, 1966.
[6] http://mathworld.wolfram.com/JohnsonSolid.html
[7] John Montroll, *"A Plethora of Polyhedra in Origami"*, Dover Publications, February 26, 2002.
[8] http://en.wikipedia.org/wiki/Modular_origami.
[9] G. Hart, "Modular Kirigami", Proceedings of *Bridges Donostia*, San Sebastian Spain, 2007, pp. 1-8.