The Story of *Gyrangle*

A Novel Piece of Mathematical Art at Towson University

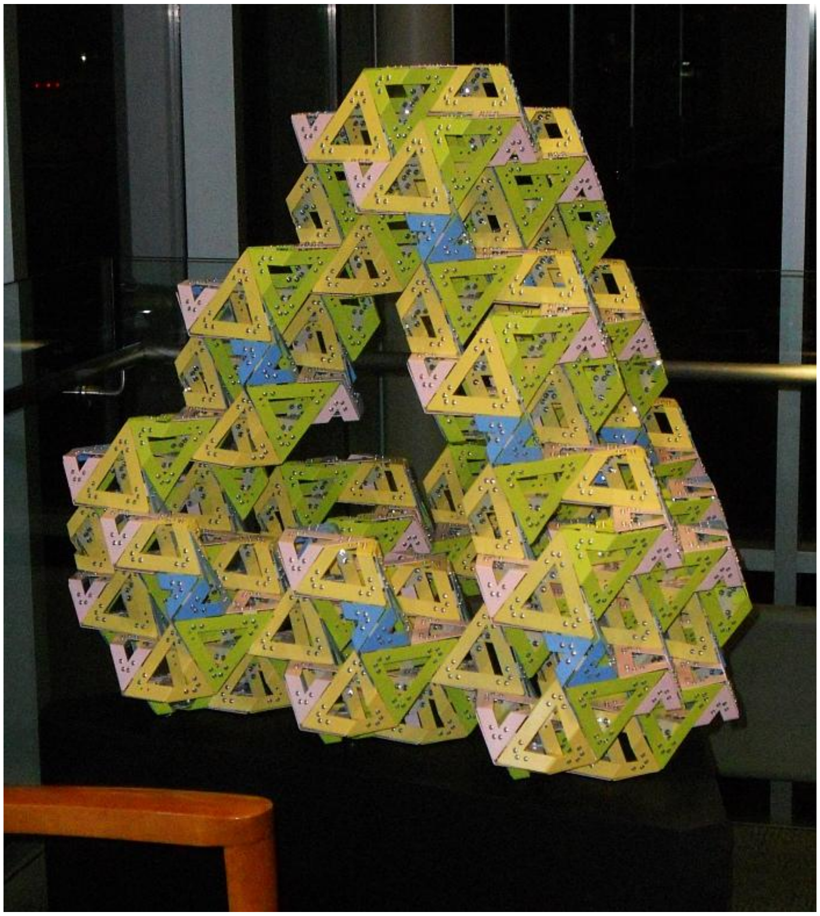

Figure 1: *Gyrangle*

The first USA Science and Engineering Festival was a call by President Obama to invite the nation to the National Mall at Washington DC for a celebration of science and engineering achievements and their contributions to our society. For two beautiful sunny days, Saturday and Sunday October 23-24, thousands of people attended the festival at the National Mall and enjoyed talking to scientists and engineers to learn about their new inventions and discoveries. People of all ages played with scientific toys and machines, and participated in interesting and exciting activities presented in hundreds of booths located all over the mall.

Mathematicians appeared in this national celebration by presenting mathematical ideas and activities at several booths, including ones for the American Mathematical Society (AMS) and the Mathematical Association of America (MAA). The award-winner mathematics writer Ivars Peterson, who currently directs the publications for journals and communications at the MAA, was among the hosts in the MAA booth. One gift from the MAA booth was a folded one-sheet booklet, A Field Guide to Math on the National Mall, highlighting mathematical aspects of some interesting sites in Washington DC area.

The sculptor, mathematician and computer scientist George Hart (PhD, EE&CS, M.I.T., 1987, the author of *Multidimensional Analysis*, Springer Verlag, 1995, and *Zome Geometry*, Key Curriculum Press, 2001) led a public sculpture barn-raising of his latest work, *Gyrangle*, at the AMS booth. The 38" high sculpture consists of hundreds of laser-cut steel units bolted together in a novel way. To be exact, there are 490 flat or folded hollow equilateral triangles in four colors. It illustrates a discrete version of the gyroid surface, made entirely from equilateral triangles.

The gyroid is a smooth, infinite, triply periodic, minimal surface discovered by Alan Schoen in 1970. Channels run through it in many directions and connect at an angle to other channels. The direction of connection spirals along each tunnel, giving rise to the name "gyroid". The following figure from the Wikipedia illustrates a cubical portion of the infinite gyroid surface.

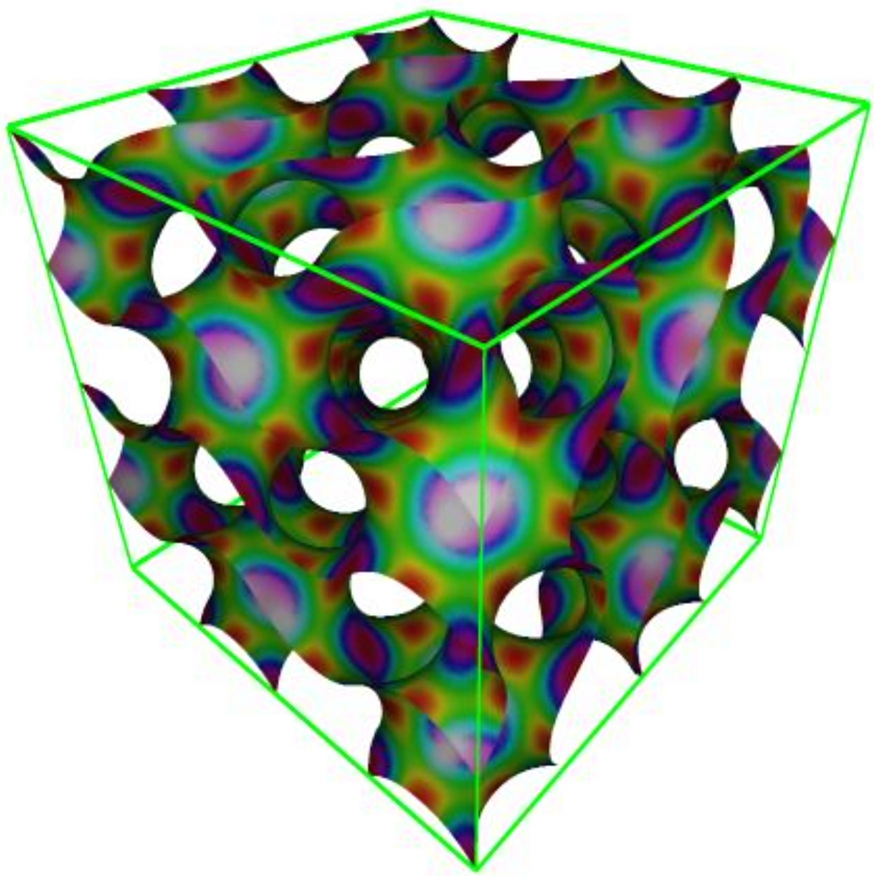

Figure 2: *Gyroid surface*

The gyroid is a smooth surface, but Hart discovered a way to triangulate it entirely with equilateral triangles. His construction is “uniform on the faces” and “uniform on the vertices.” Although the gyroid itself contains no straight lines, Hart’s triangular discretization contains infinite straight lines embedded in various directions. It divides all space into two congruent, but mirror-image volumes. Another interesting property is that the faces do not meet edge-to-edge, but instead each triangle shares six half-edges with six neighboring triangles. The construction is previously unpublished, so the sculpture serves as the first presentation of this discovery. As it illustrates a gyroid made of triangles, Hart coined the term *Gyrangle* for it.

The full infinite surface would be visually repetitive (and infinitely large) so is not itself suitable for a sculpture. Instead, Hart chose a tetrahedral portion of space as the outer form of the sculpture, and inhabited it with the Gyrangle surface as a kind of 3D texture. To seal off the edges he introduced a folded triangle unit that closes off the boundary. For visual and mathematical interest, the 100 pounds of laser-cut steel triangles are painted in four colors according to the direction of their normal vector. It is one of a series of many sculptures Hart has created to for assembly at a “sculpture barn-raising”. He prepares the components and invites the public to participate in the construction.

During this barn-raising at the Mall, Hart helped hundreds of children and adults to screw pieces together. At the same time, he continuously answered questions about the mathematics, computer science algorithms, and fabrication aspects of the design. The AMS representatives at the booth were Annette Emerson and Michael Breen. They patiently helped children to successfully fasten screws and connect pieces together, while also answering their very interesting but occasionally difficult questions such as “why are we making this thing?” and “What is it used for?” The public often sees mathematics only as something useful, but here the goal was to show another aspect of mathematics: mathematics is beautiful!

Mathematical sculpture is a rich area of visual art that is approached in various ways. Some sculptors have no formal background in mathematics, yet their artworks present patterns or structures that make sense to mathematicians. On the other hand, there are mathematicians that use techniques from computer science or the arts to visualize abstract mathematical forms. This gives the public an opportunity to “see” mathematical properties that were previously accessible only to specialized mathematicians. In either approach, sculpture may present harmony and balance in a new way, and bring an appreciation of mathematics to the public, in a way similar to how we enjoy music and feel its importance in our lives.

Figure 3: (Left) *George Hart*, (Right) *Annette Emerson and Michael Breen*

The AMS financially supported the construction of this beautiful piece of mathematical art donated this unique artwork to the Department of Mathematics at Towson University, Towson, Maryland. The department is known for education activities concerning mathematical connections to the arts and culture. The President of the Bridges Organization, the author, is a faculty member of this department. Bridges Organization is a non-profit organization, which runs the international Bridges conferences on mathematical connections in art, music, and science (www.BridgesMathArt.org). Several faculty members from both colleges of “Jess and Mildred Fisher College of Science and Mathematics” and “College of Fine Arts and Communication” participate in the annual international Bridges conferences that are held around the world. Hart is on the Board of Directors of the Bridges Organization.

Hart, after serving as a faculty member at Columbia University and Stony Brook University recently decided to find another venue for pursuing his thirst of discovery and creation. He is now Chief of Content at The Museum of Mathematics, which will open in New York City in 2012. As a sculptor, Hart’s work is recognized around the world for its mathematical depth and creative use of materials. He is a pioneer in using computer technology and solid freeform fabrication in the design and fabrication of sculpture. Examples of his artwork can be seen at major universities, such as M.I.T., U.C. Berkeley, and Princeton University. He has received praise and awards in numerous exhibitions, including a New York State Council for the Arts Individual Artist's Award. He has been invited to lecture and show his art across the country and around the globe, including many major universities.

The project was more ambitious than Hart realized. After two days of hard work to assemble *Gyrangle* at the Mall, only two-thirds of the work was completed. Therefore, on Sunday evening, the half-built structure was carried to the glass lobby at the third floor of 7800 York Road building, the Department of Mathematics at Towson University. The base for the artwork was already built by Jim Paulsen, an Art professor at Towson University, and was located in its permanent place.

George and now new volunteers, Towson University faculty and students, worked hard to complete the structure. In the afternoon of Monday October 25, he delivered a talk about the structure, and after that, he and more volunteers continued with final touches into the evening.

Thank you George and American Mathematical Society for your great gift to Towson University!

Figure 4: Finishing the construction at Towson University

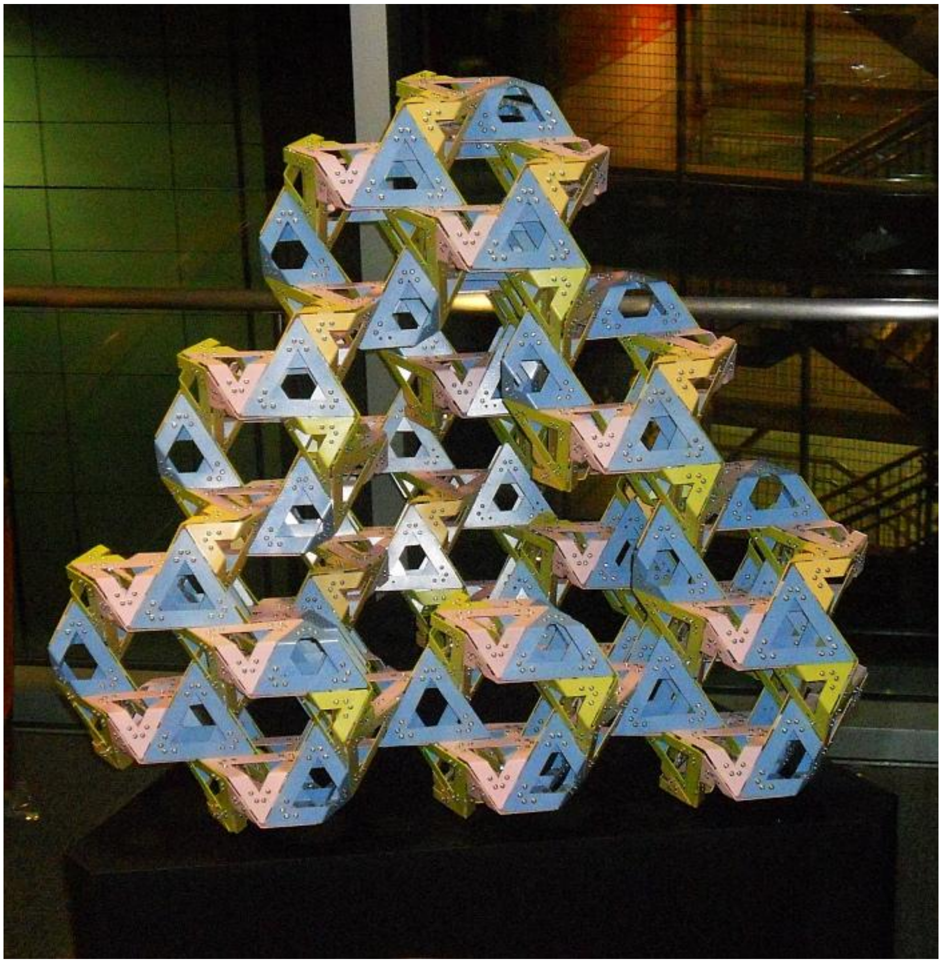

Figure 5: A view of *Gyrangle* showing some of its hexagonal tunnels.

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October 2010