Plain Woven Objects

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Plain weaving is one of the most beautiful and widely used geometric forms. In plain weaving, a set of distinct threads (or yarns) are interlaced with each other to form a fabric or cloth where each thread crosses the other threads (or themselves) by going over one, then under the next, and so on. We have recently developed a method to create plain weaving over arbitrary manifolds. We call the resulting objects plain woven objects, which are linked knots that cover any given surface. Figure 1 shows an example of a plain woven object: plain woven Enneper’s surface.

Knots and links are interesting structures that are widely used for tying objects together and creating beautiful shapes such as woven baskets. In mathematics, knots are 3D embeddings of one circle and links are 3D embeddings of more than one circle. We will use the term linked knots since each cycle in a link can be a knot. Linked knots can be used to represent weaving structures such as fabric, cloth or baskets. There exist a wide variety of weaving methods. Among them, the most popular is plain weaving, which consists of threads that are interlaced by each thread alternatively going over and under the other threads (or themselves). To create a plain weaving on a manifold surface, we need to create cycles that cross other cycles (or itself) in even numbers by going under and above in equal numbers. If this condition is not satisfied, the result is not really a plain weave. We have recently proven that it is possible to create plain weaving cycles from any given manifold mesh by twisting all of the edges of the orientable manifold mesh.

Fig. 1 Enneper’s Surface created by using planar hexagons. Model courtesy of Wenping Wang.

Fig. 2 Enneper’s plain woven surface that is created by using the mesh shown in Figure 1.
Plain weaving theoretically corresponds to Celtic knots [1,2,3], but unlike Celtic knots or in some weaving patterns such as sparse triaxial weaving, our goal is to cover the underlying surface to create a tightly woven object. We have also developed a method to control the size of gaps such that we can obtain both sparse and dense plain weaving. Using this method, we can cover the original manifold surface, with almost no gaps, with ribbons whose unfolded versions are wavy as shown in Figure 3 and 4.

Fig. 3. Sparsely woven sphere surfaces.  
Fig. 4. Dense woven sphere surfaces
We have developed a system that converts any manifold mesh to a plain woven basket. Our system converts the mathematical knots to 3D thread structures where the shapes of the threads can be interactively controlled with a set of parameters. These 3D structures can cover the original surfaces without having large gaps. Most importantly, with this system we can create a wide variety of plain weaving patterns. The system allows us to cover the surface either ribbons or yarns. The Figures 1, 2 and 3 show objects that are covered with ribbons. On the other hand, the cover image shows an object covered with yarns. Figure 5 shows the five distinct links of the plain woven object in the cover image. This structure is very fascinating but it can be more interesting to use only one knot. We have also proven that it is possible to cover any surface using only one knot which has plain weaving property.

Fig. 5. The image in the cover consists of 5 links. Each link is a knot as shown in this the computer rendered images. They together form the plain woven object in the cover. Renderings courtesy of Christine Liu.
Of course, these 2D images cannot completely capture the full visual richness without hyperseeing the object, i.e. by walking around the sculptural forms to view it from all sides. Our ribbon models can be cut using laser cutting and physically constructed. We are currently planning to create large sculptures in collaboration with architects. We are also planning to create 3D sculptures with some of our plain woven yarn objects by using a rapid prototyping machine.

References


Fig. 6. This image shows that by carefully coloring each link, it is possible to get interesting patterns and color combinations.
Prize Winners

The art exhibit at the 2009 JMM in Washington, DC, January 5-8, 2009, was quite successful with a large audience of appreciative viewers. The exhibit was juried and curated by Robert Fathauer and Anne Burns. Reza Sarhangi and Nat Friedman were also jurors. This year an anonymous donor provided $1000 for prizes. The four judges were also anonymous. The first place prize of $500 went to Goran Konjevod for the origami sculpture *Wave (32)* shown in Figure 1.

Figure 1. Goran Konjevod, *Wave (32)*, 2006, 10 x 10 x 5 inches, one folded square sheet of paper.

The wave is one of the pleat tessellations that continues to amaze me even years after I first folded it. The peculiar symmetry and the tension caused by locking the edges causes two of the corners to buldge in opposite directions, while the remaining two corners
remain fairly flat. The pleat sequences all begin at the edges and proceed towards the center of the sheet. All horizontal pleats are oriented the same way, and similarly all the vertical pleats. GK.

The second prize of $300 went to Carlo Séquin for the bronze sculpture *Figure_8 Knot* shown in Figure 2. The *Figure_8 Knot* is the second simplest knot, which can be drawn in the plane with as few as four crossings. When embedded in 3D space, it makes a nice constructivist sculpture. This particular realization has been modeled as a B-spline along which a crescent-shaped cross section has been swept. The orientation of the cross section has been chosen to form a continuous surface of negative Gaussian curvature. CS.

![Figure 2. Carlo Séquin, Figure_8 Knot, 2007, 9 inches tall, bronze.](image)

![Figure 3. Robert Fathauer, Twice-Iterated Knot No. 1, 2008, 19 x 12 inches, Digital Print.](image)

The third prize went to Robert Fathauer for the digital print *Twice-Iterated Knot No. 1* shown in Figure 3.

The starting point of this knot is a nine-crossing knot that has been carefully arranged to allow seamless iteration. Four regions of this starting knot are replaced with a scaled-down copy of the full starting knot, incorporated in such a way that the iterated knot is still unicursal. These same four regions are then replaced with a scaled-down copy of the iterated knot, resulting in a complex knot possessing self-similarity. RF.
Additional Works

A small selection of four additional works with statements by the artists Radmila Sazdanovic, Ghee Beom Kim, Bradford Hansen Smith, and Vladimir Bulatov are shown in Figures 4, 5, 6 and 7.

![Figure 4. Radmila Sazdanovic, Caught In A Dual Net, 2008, 16 x 16 inches, Printed graphic.](image1)

![Figure 5. Ghee Beom Kim, Valley of Serenity, 2007, 12 x 12 inches, Digital Print.](image2)

This computer graphic represents three superimposed tessellations. The edges of a tessellation (6,6,7) are hidden below two nets consisting of tessellations (7,7,7) and (3,3,3,3,3,3,3), both dual to the original one. RS.

Valley of Serenity has been created using semicircles based on a fractal concept with a touch of Op Art element. Within a semicircle two smaller semicircles fit in. This process(iteration) continues on until it is visually meaningful. The resulting image conjures up an extraterrestrial terrain of a faraway planet. The smaller semicircles bear a resemblance to a horizon by giving the effect of perspective. GBK.
Figure 1. Maria A. Hall, Olympia, 2008, 76 h x 80 w x 58 d inches, stainless steel, Adelphi University, Garden City, New York.

"My sculptures are abstract works concerned with the interrelationship of form and space. I try to develop strong, simple sculptural images that are dynamic compositions, which move one emotionally. The proportion, scale, and progression of the different elements are intended to create an enigmatic, yet complete whole."

M.A.H.

Introduction

Maria Andriopoulos Hall's work was previously discussed in [1]. She lives in Slingerlands, NY, a suburb of Albany, and we have been sculpture colleagues since 1971. She has been creating impressive geometric sculpture in stainless steel for over thirty years. Her recent sculpture Olympia, shown in Figure 1, is a striking work that contains

Forty circles have been folded, reformed to an in/out variation of a truncated tetrahedron, then octahedronally joined in pairs, and arranged in an icosahedron pattern. This revealed an interesting form of the icosadodecahedron with open pentagon stars. In this case twelve circles were reformed and added to suggest mouth-like openings found in sea anemones or in opening flower buds. This gives function to the opening pentagons. Much of what I explore with folding circles are the structural functions of geometry found in life forms that correlate to the movement forms of folded circles. B H-S.

The basis of this sculpture is a rhombic dodecahedron (polyhedron with 12 rhombic faces with cubical symmetry). Each of the 12 faces was transformed into a curved shape with 4 twisted arms, which connect to other shapes at vertices of valence 3 and 4. The boundary of the resulting body forms a quite complex knot. VB.

The complete exhibit may be seen at the SIGMAA-ARTS website http://myweb.cwpost.liu.edu/aburns/sigmaa-arts/exhibits.html
Maria A. Hall: Olympia at Adelphi

Nat Friedman
artmath@albany.edu

Figure 1. Maria A. Hall, Olympia, 2008, 76 h x 80 w x 58 d inches, stainless steel, Adelphi University, Garden City, New York.

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several significant ideas. In particular, the main lines are diagonals that give the sculpture a very distinctive look. The diagonal orientation was first used in her work Passages II, 1989, shown in Figure 7, [1]. Also here the cross section is triangular rather than square as in Passages II. The triangular cross section has a certain lightness and partners well with the diagonal lines.

We are grateful to Professor Richard Vaux of Adelphi University for providing the variety of images in this article.

Alternate Views

A number of alternate views will now be considered. In Figure 2, a more frontal view is shown. One can also appreciate the three-dimensional movement of the form in space.

![Figure 2. Olympia, alternate view.](image)

![Figure 3. Olympia, alternate view.](image)

A side view is shown in Figure 3. In this case the sharp edges of the triangular cross sections are sharply defined by light and shadow. The three-dimensional movement of the form toward the viewer is felt strongly from this viewpoint. With this in mind, we recall Eduardo Chillida’s classic statement on sculpture:

*Only one of the three dimensions is active (the one that comes toward me from far to near) but all three must be in power, alternating their activity.*

A corner view to the right of Figure 3, the side opposite of Figure 2, is shown in Figure 4. A further view to the right is shown in Figure 5. The last view shown in Figure 6 is between Figures 1 and 2. In conclusion, Olympia is an exciting sculpture to hypersee and we have only touched on a small number of possible views.
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Introduction

Benigna Chilla’s previous work is discussed in [1] and consisted of three-dimensional three-layer geometric paintings with two layers of painted screen over one layer of painted canvas. The resulting optical effects are quite striking. In these recent intaglio prints on paper, Chilla creates geometric prints using line as the ultimate two-dimensional element in order to create a layered three-dimensional illusion through repetition. An intaglio print consists in incising lines on a plate, inking the plate, wiping off the surface ink so ink only remains in the incised lines, and then running the plate through a press to transfer the inked lines onto paper.

“These prints evolved during my residency at The Fine Arts Work Center, Provincetown, MA, in the spring of 2008. Throughout the year, these pieces were reprinted on a larger format through repetition, overlapping, rotation, and overprinting. I chose to keep the pieces monochromatic, only printing with different kinds of black ink.

I was looking for a new approach to create a three-dimensional illusion on a two-dimensional surface. Every piece is unique, there are no editions, and thus they are monoprints.

All plates consist of rectangular geometric shapes with parallel lines. These, when printed, create line patterns, line surfaces with interrupted formations, crossing and missing lines. I used one, two, or more plates for each print. Some pieces were run through my intaglio press up to 30, 40, or 50 and more times.” BC

Chilla created a large number of monoprints and the ten shown below were chosen as representatives of the various possibilities. The descriptive comments are Chilla’s. All pieces are 30 x 22 inches except numbers 1 and 2 which are 11 x 15 inches.
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Number 1. One plate was used: a square with a cut out negative shape, printed four times while rotated to the right within the rectangle, always lining up the 90 degree corner of the plate with the 90 degree corner of the paper.

Number 2. A variation of number 1: the plate was turned 90 degrees from the left hand corner and then mirror reversed.

Number 3. Four squares within a square, overlapping a cut hexagon, so each corner or side would touch the square.

Number 4. Four open hexagons rotated 180 degrees within a square, repeated while turned 90 degrees and then repeated six times.
Number 5. The same plate that was used in numbers 1 and 2 was printed four times within a square, rotated into each corner of the square, and then repeated six times, (the plate was printed 24 times for this piece)

Number 6. The same hexagon plate as in number 2 was printed on six squares of diagonal lines. The open hexagons were rotated in different directions and again printed four times within a square. Two vertical columns are touching at the corner point and creating a zigzag movement.

Number 7. Two squares were rotated in the center of one or two sets of diagonal lines of a square. Each rotating square consists of four linear triangles either parallel to the square or lines moving to the center of the square. This causes a Moire effect.

Number 8. Two rhomboids overlapped eight times within each square. These were printed 48 times on six squares with vertical lines. The rhomboids are always touching at the corners of each square.
Number 9. A playful combination of squares and spaced through equilateral triangles, printed again and again and again.
Number 10. A variation of number 9.

Reference

Spiritual Pentagons
Mehrdad Garousi
Freelance fractal artist, painter and photographer; No. 153, Second floor, Block #14; Maskan Apartments, Kashani Ave; Hamadan, Iran
E-mail: mehrdad_fractal@yahoo.com; http://Mehrdadart.deviantart.com

As traditional painters and photographers have been loving mathematics and geometry so much, I have recently focused my artistic activity strongly on mathematical image making and especially on fractal art. Fractals have amazing geometrical shapes and provide new perspectives which would not be possible to obtain without them or without the help of modern computers.

Most of my works are different presentations of interwoven and complex fractals. I am mainly interested in bridges between fractal mathematics and Euclidean geometry. Therefore, my most lively works of art are those which provide new connections between these two basically different areas of mathematics.

So I have selected one of my newest illustrations entitled Spiritual Pentagons to speak about, which would reflect this property more clearly (Figure 1). This image is basically a complex and disordered fractal form, which has resulted from simultaneous running of different fractal formulas and equations. But the main pattern, on which the image is formed, is an ordered mixture of some similar pentagonal forms.

![Figure 1. Spiritual Pentagons (2008; © Mehrdad Garousi)](image1)

![Figure 2. A simple show of the evident and hidden pentagons in the artwork.](image2)

This fractal artwork is a clear representation of connections between fractal and Euclidean geometries. This basically fractal image contains several pentagons some of which are clearly evident but some hidden. Three of the evident ones which you can find easily are: the pentagon appearing by connecting five outer or inner globes, the violet pentagon that is located between the larger and smaller globes, and finally that one surrounding the central globe. But a closer look at the image will disclose that, for
example, all globes are surrounded separately in some other pentagons or that the smaller globes are placed also inside another pentagon. You can find out this better by inspecting figure 2 in which all the evident and hidden pentagons are shown.

On the other hand, all the globes are good examples of tiling the hyperbolic disk with hyperbolic triangles. The basic pattern of the hyperbolic tessellation of the artwork’s central globe is made clear by white lines in figure 3.

However, one can also look at the complementary triangles and it is really wonderful that among triangular patterns of the globe you can also find many other new different patterns. It is true about all other globes of the image; the reason is the coloring method of the image. It is clearer in the outer globes, so that, for example, if you turn off the colors of them you will see completely different patterns than the first ones, which are clearly displayed in figure 4.

Coloring has played a key role in creating this work, because it is in a 2D area, but due to the use of colors, it seems to be a 3D image. Indeed, coloring in this image has played the role of the lighting processes in 3D image making and provides some 3D global views of flat 2D tessellations for us. It should also be mentioned that green gates placed on the sides and vertices of the pentagons and the relative brightness of the central globe, create a centripetal force that reminds us of the spiritual processes of Yantric paintings.
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Figure 3. A magnified view of the central globe with white lines on it which depict the hyperbolic tessellation pattern.

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**GRAPH THEORIST'S CHRISTMAS**

**FIGURE:**

This year, we had a Christmas graph instead of a Christmas tree.

**ERGUN AKLEMAN-**
PLATONIC LOVE
SO WHAT DO YOU THINK OF THEIR MUSIC?

IT'S KIND OF ONE-DIMENSIONAL

YEAH, BUT THEY ONLY HAVE ONE EDGE

EVEN THAT IS JUST A HALF-TWIST

I THINK IT'S VERY EDGY

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*Double Star, 1959-2001, aluminum and stainless steel, 27 1/2 x 23 x 20 1/4 in., 69.9 x 58.4 x 51.4 cm*
The Journal of Mathematics and the Arts is a peer reviewed journal that focuses on connections between mathematics and the arts. It publishes articles of interest for readers who are engaged in using mathematics in the creation of works of art, who seek to understand art arising from mathematical or scientific endeavors, or who strive to explore the mathematical implications of artistic works.

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The Bridges Conferences, running annually since 1998, bring together practicing mathematicians, scientists, artists, educators, musicians, writers, computer scientists, sculptors, dancers, weavers, and model builders in a lively atmosphere of exchange and mutual encouragement. Important components of these conferences, in addition to formal presentations, are hands-on workshops, gallery displays of visual art, working sessions with artists who are crossing the mathematics-arts boundaries, and musical/theatrical events in the evenings.

The conference will feature presentations of regular, plenary, and short papers, as well as several workshops. The program for the conference is composed from a combination of submitted and invited presentations.

Regular Papers: submissions are due by February 1, 2009. (4, 6, 8 pages)
Short Papers: submissions are due by March 15, 2009. (2 pages)
Workshop Papers: submissions are due by March 1, 2009. (2, 4, 6, or 8 pages) See below.

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All papers are to be submitted properly formatted as they would appear in the conference proceedings. See the formatting instructions and template (also in the menu on the left). Papers that ignore the formatting guidelines or the length limits will not be entered into the reviewing process.

In order to have as diverse a representation of authors as possible and to keep the proceedings to a reasonable size, conference participants can be the main author and presenter on only one paper. The main author on each submitted paper should be identified with an asterisk: “*”. This rule includes all contributions: short and regular papers as well as workshop papers.

The regular presentations will be given a 30 minute time slot; short presentations will be given a 15-minute time slot.
Purpose
The main purpose of ISAMA 2009 is to bring together persons interested in relating mathematics with the arts and architecture. This includes teachers, architects, artists, mathematicians, scientists, and engineers. As in previous conferences, the objective is to share information and discuss common interests. We have seen that new ideas and partnerships emerge which can enrich interdisciplinary education. In particular, we believe it is important to begin interdisciplinary education at an early age so one component of ISAMA 2009 will be teacher workshops for K-12 in addition to college level courses. Talks will be on June 22-24 and workshops on June 25. Registration details are at www.isama.org.

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ISAMA 2009 will focus on the following fields related to mathematics: Architecture, Computer Design and Fabrication in the Arts and Architecture, Geometric Art, Sculpture, Music, Dance, Mathematical Visualization, Tesselations and Origami. These fields include graphics interaction, CAD systems, algorithms, fractals, and graphics within mathematical software (Maple, Mathematica, etc.). There will also be associated teacher workshops.

Call For Papers
There will be a Conference Proceedings. Papers should be submitted in Word and should follow the same format as in the 2008 Conference Proceedings, which may be seen at www.isama.org/hyperseeing/, May/June 2008 issue. This is the same as the Bridges format. The presentation should be primarily visual and contain at least 10 images. Reading a paper is not acceptable. Papers are due March 1 and should be emailed to Nat Friedman at artmath@gmail.com and submitted https://www.eASYchair.org/login.cgi?conf=isama09. Requested revisions will be sent by April 1 and revised papers are due May 1. Submission details are at www.isama.org.

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