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An Integration of Art and Mathematics

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Abstract

Mathematics and art are seemingly unrelated fields, requiring different skills and mindsets. Indeed, these disciplines may be difficult to understand for those not immersed in the field. Through art, math can be more relatable and understandable, and with math, art can be imbued with a different kind of order and structure. This project explores the intersection and integration of math and art, and culminates in a physical interdisciplinary product. Using the Padovan Sequence of numbers as a theoretical basis, two artworks are created with different media and designs, yielding unique results. Through these pieces, the order and beauty of number sequences can be visually observed and more easily conceptualized. Ultimately, two new pieces of artwork have been produced via the exploration of a mathematical concept.

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Completed Artworks

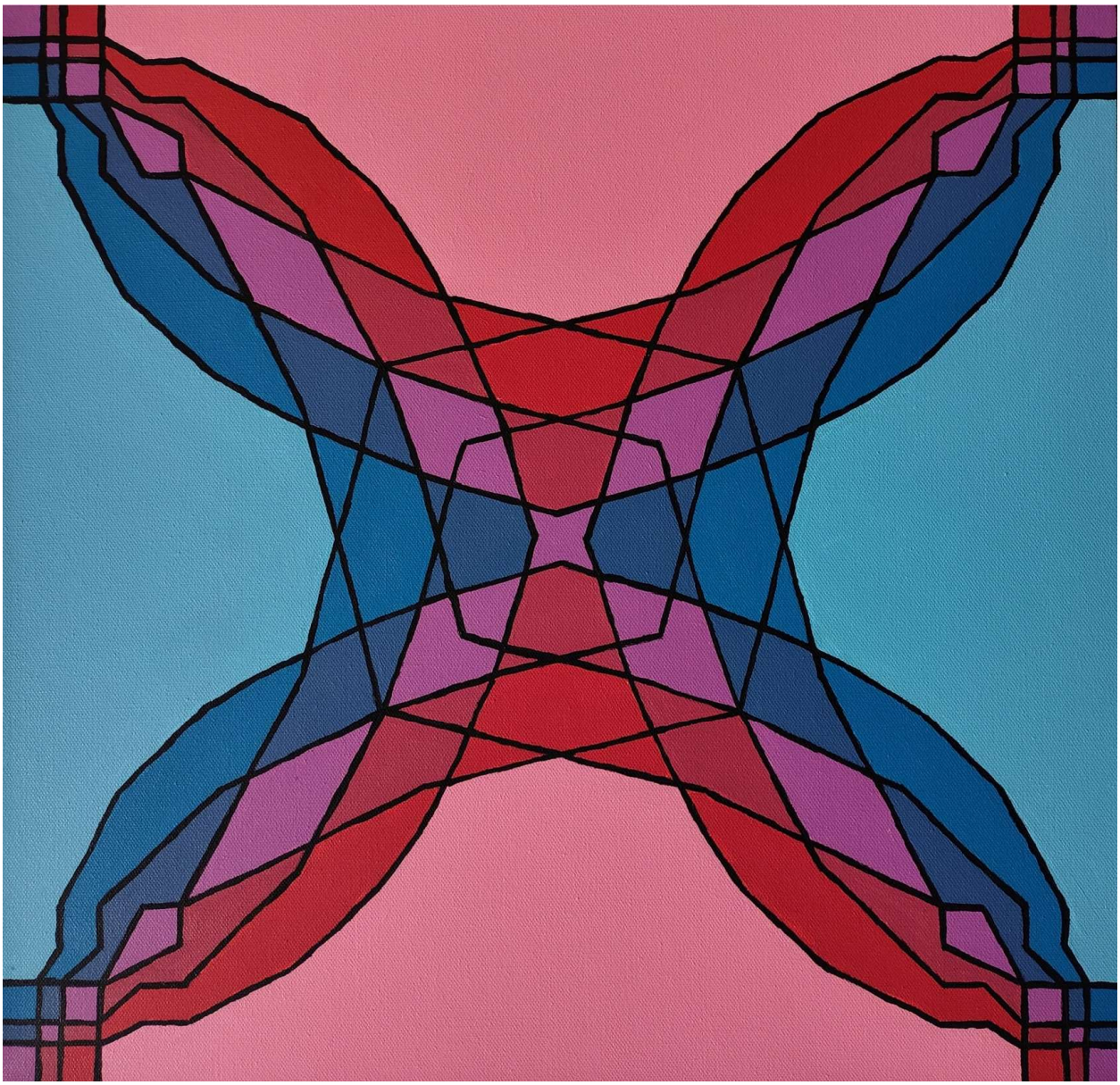

Fig. 1. Henry Jaakola, *Padovan Symmetry*. Acrylic on canvas, 20 x 20 in.

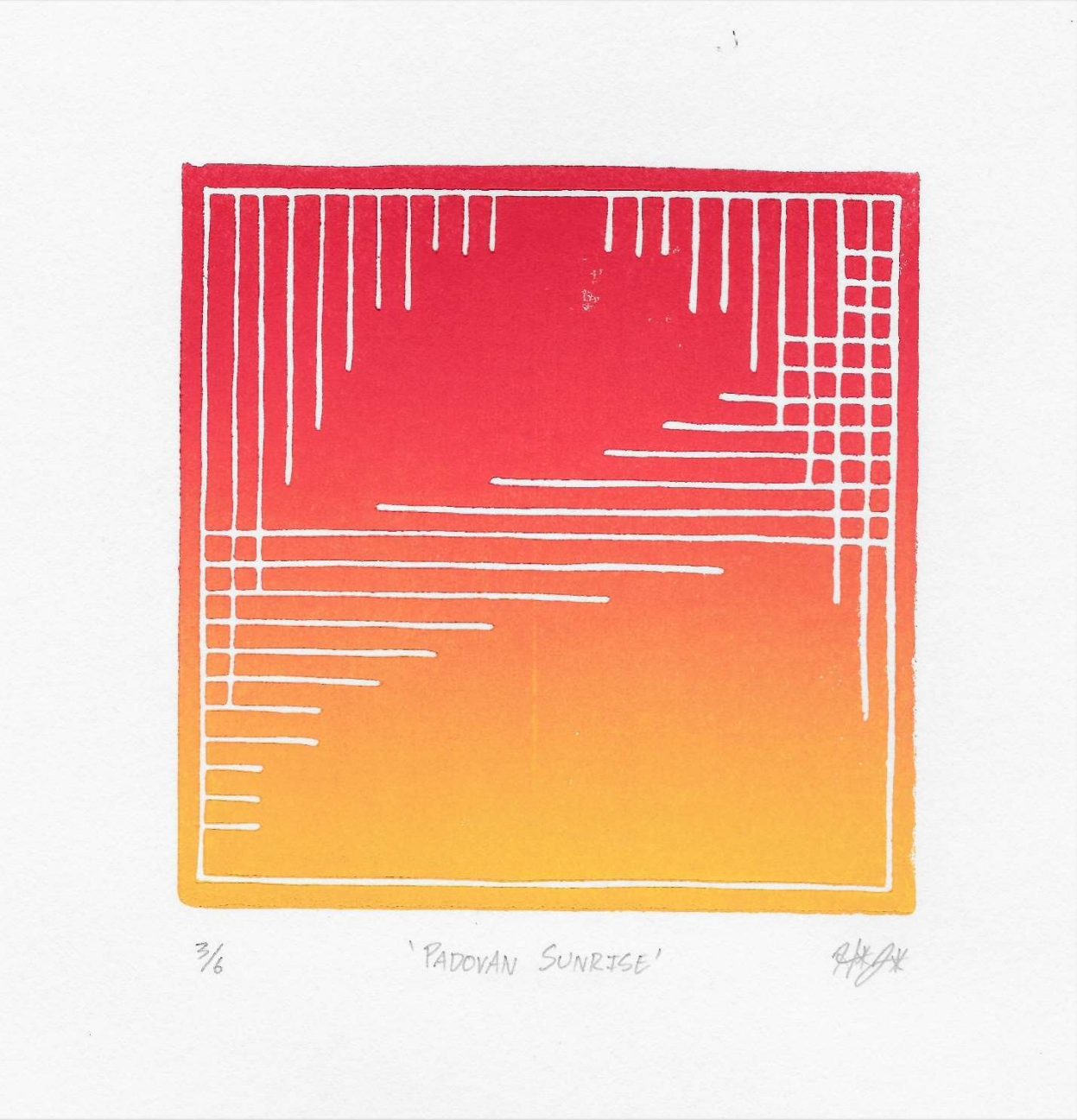

Fig. 2. Henry Jaakola, *Padovan Sunrise*. Block print on paper, 4 x 4 in.

Introduction

Art is everywhere in the modern world: from clothing and tattoos, to cars and movies, to the design of the latest smartphone. It makes everything we interact with more appealing, interesting, and desirable. Math, too, can be found everywhere. The construction and operation of those same smartphones and cars relies on mathematics, as does just about everything else. The combination of the two, though, is less obvious. With architecture being an easy example of art and mathematics working in tandem, other examples are hard to come by. When it comes to actual pieces of gallery art, math seldom makes an obvious appearance. However, when it does, the piece becomes ingrained with a whole new dimension.

The combination of mathematics and art is worthy of exploration because these are two areas that are vastly different, and critically misunderstood. Mathematics can be complex, beautiful, and stirring. Outside of the academic and professional communities, math is generally seen as either a daunting, painful exercise, or as a subject reserved for the less creative. Art can be structured and patterned, while still remaining attractive. This project will aid in not only bridging the gap between two seemingly opposite fields, but also help contextualize and make the content of both professions relatable for the average person.

The topic of this project is, put simply, to take a look at what happens when a piece of art is inspired by, or constructed from, an element of mathematics. With a select group of artists already using math as a component medium, it is relevant to examine both their artistic pieces and mathematical choices in order to gain a frame of mind as to the current confluence of the two fields. Practically, it makes sense to exercise this idea by creating,

from scratch, a unique piece of art that draws heavily on some aspect of mathematics for direction. The ultimate manifestation of this thesis is a pair of math-based artworks, with their respective mathematical theory and artistic methodology discussed in this paper.

Contemporary Overview

While the inclusion of mathematics in the artistic process is not altogether an outrageous idea, there are only a limited number of artists who have successfully used this approach as a defining feature, to both critical acclaim and positive audience feedback.

Michael Schultheis is a painter and sculptor with a bachelor's degree in economics from Washington State University, and a master's degree in labor economics from Cornell University. In his art he "paints layers of mathematical equations… that describe the form and motion of three-dimensional geometric shapes" (Schultheis). In addition to these painted pieces, he is an accomplished sculptor as well. His sculptures are elegant and simple, looping like parabolas and cycloids, and vary in size from tabletop pieces to massive outdoor installations. Schultheis incorporates a very literal integration of mathematics into his artwork. Figure 3, *Cardioid Limacons of Pythagoras*, displays actual mathematical equations interspersed with traced and shadowed geometric shapes. Clouds of color give depth and contrast, providing a background for superimposed mathematical notions.

Fig. 3. Michael Schultheis, *Cardioid Limacons of Pythagoras*. Acrylic on canvas, 48 x 72 in.

Dorothea Rockburne is a classically-trained painter inspired by math and geometry. Her pieces are bold and colorful, but precisely geometric. The artworks are "mathematically derived constructions made of geometrical shapes and painted in colors

that create a sense of vibrancy" (Rockburne). Figure 4, *Capernaum Gate*, displays both vivid colors and bold geometric shapes. Instead of utilizing equations, Rockburne relies on complementary geometry in her work. Colors are strategically chosen to show layering and texture between the various shapes.

Fig. 4. Dorothea Rockburne, *Capernaum Gate*. Oil and gold leaf on gessoed linen, 92 x 85 in.

Bathsheba Grossman is a sculptor taking inspiration from science and math. Utilizing mainly 3D-printed metal, laser-etched glass, and cast glass, her pieces vary from representations of pure math to exact representations of biological proteins (Grossman). Figure 5 represents one of her larger pieces, *Eltanin*. Here, the angular geometry and precise fabrication are reflective of actual mathematical shapes, which have been manifested into a large piece of sculptural art.

Fig. 5. Bathsheba Grossman, *Eltanin*. Silicon bronze, 106 x 70 x 70 in.

Mathematical Theory

In mathematics, a number sequence is a sequence of numbers that can be developed out by iterating according to a unique rule. Additionally, an initial number or set of numbers is defined to begin the sequence. For instance, if the integer 2 is given as an initial condition, and the next number in the sequence can be obtained by adding 3 to the previous number, then the resultant sequence is 2, 5, 8, 11, and so on.

One of the most well-known number sequences is the Fibonacci sequence, which observes the following form (Wolfram):

$$F(n) = F(n-1) + F(n-2)$$

$$F(0) = 0, F(1) = F(2) = 1$$

This means that any given integer in the sequence is equal to the sum of the two integers immediately previous to it. Additionally, the first three terms are given as 0, 1, 1. The Fibonacci numbers then are 0, 1, 1, 2, 3, 5, 8, 13, and so on.

The number sequence of specific interest to this project is the Padovan sequence, which is given by the following conditions (OEIS):

$$P(n) = P(n-2) + P(n-3)$$

$$P(0) = P(1) = P(2) = 1$$

This gives the sequence of 1, 1, 1, 2, 2, 3, 4, 5, 7, 9, 12, and so on. This sequence was named after the architect Richard Padovan, though the origin of who first discovered the sequence is unclear (OEIS).

While various properties and relationships exist about the Padovan sequence, the most notable is how it can be derived using Pascal's triangle. Similarly to the Fibonacci

sequence, the numbers in the Padovan sequence can be found by summing diagonally across the triangle (Anatriello, et al.). Figure 6 illustrates how both the Fibonacci and Padovan sequences are related to Pascal's triangle.

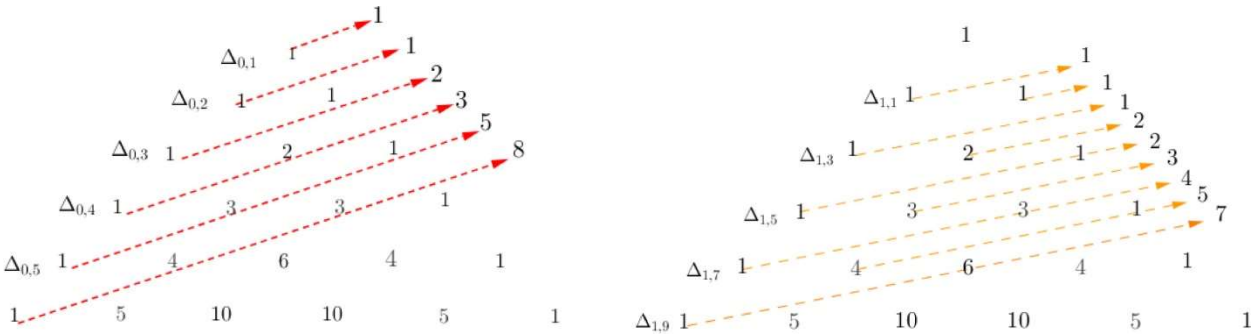

Fig. 6. The integers in the Fibonacci (left) and Padovan (right) sequences can be derived by summing across Pascal's triangle at specific diagonals (Anatriello, et al.).

Artistic Process

Both of the artworks created for this project use the Padovan sequence of numbers as a mathematical basis. This means that not only is the number sequence the inspiration for the pieces, but its pattern is also exactly represented within the lines and shapes making up the art. Existing visual representations of the Padovan sequence, such as the spiraling triangles shown in figure 7, exist to emphasize the ratios of successive terms and the growth rate of the numbers. The goal of this project, however, is to create an artistic representation of the sequence.

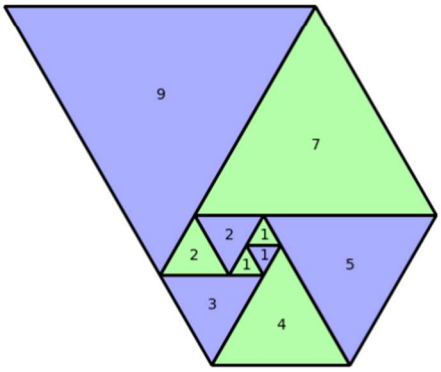

Fig. 7. Each term in the Padovan sequence is represented by a triangle with side length equal to the integer value of the term (Sivaraman).

The first piece created, *Padovan Symmetry*, uses the plotted version of the sequence to create a design by scaling, rotating, and flipping the plot across and around various axes. Figure 8 illustrates the step-by-step approach to creating the final pattern.

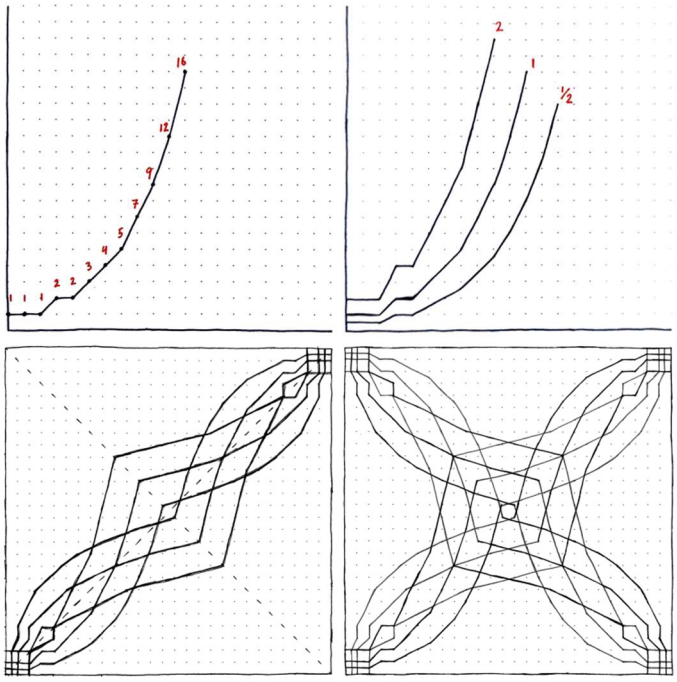

Fig. 8. The step-by-step process used to create the design for *Padovan Symmetry.*

The initial step is to plot the magnitude of the integers sequentially, at one-unit intervals. These points are connected to form a continuous line. Next, this line is scaled vertically by powers of 2 and ½. The three lines are now reflected across the lines $y=x$ and $y=27-x$, which divide the

overall square design into four parts, from corner to corner. The final step is to rotate the design 90 degrees and replicate it. This creates a highly symmetrical pattern, completely based on the Padovan number sequence.

A square canvas 20 inches in each direction is selected to impart a sense of scale on the viewer, and fully display both the finer details as well as the overall movement of the mathematically-based lines. The colors are chosen to show a merging gradient from blue to pink as they progress from one edge of the painting to the other.

Though the second piece, *Padovan Sunrise*, still uses the Padovan sequence as a structural basis, is not as rigidly defined by symmetry or equations as the first. The increasing sequence of numbers is represented by bars of growing magnitude, and these bars are then scaled, rotated, and placed according to visual preference instead of mathematical rules. Figure 9 shows various sketched designs that were generated during this creative process.

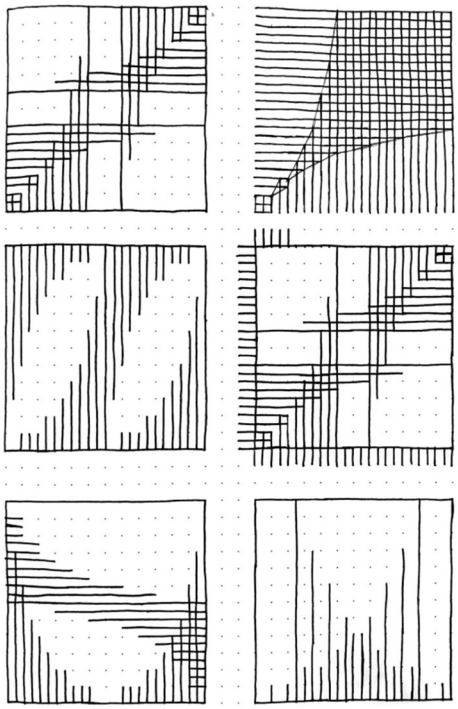

Fig. 9. Various designs using the Padovan sequence as a basis. Note that the bottom left design ultimately became *Padovan Sunrise*.

Ultimately, the final design was chosen for its aesthetically pleasing balance of straight and curved shapes, and a distinct use of negative space. The design resembles a sun, partially obscured by the horizon. The name of the piece is a direct result of this interpretation. In order to explore a new medium, a hand-carved linoleum block print was selected as the medium for this piece. The colors of red and yellow, blended in a gradient, reflect the natural colors present in a sunrise.

Exhibition

Both artworks were shown to the public in early 2022. From January 21 to February 19, *Padovan Symmetry* was displayed in Gallery One in Ellensburg, WA as part of the annual Members' Exhibition. Later, from April 1 to 30, *Padovan Sunrise* was exhibited at Gallery One as part of the Central Washington University Student Art Club show. Neither piece was sold as part of their exhibition.

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