Yturralde: Impossible Figure Generator

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ABSTRACT

This research highlights José María Yturralde's most significant involvement and contributions to early computer art from 1968 to 1973. Yturralde collaborated with artists and scientists to expand and redefine his understanding of shapes, and explored ways that the mainframe computer could be used as a tool for complementing his art practices. He is known for developing a mathematical model with which he was able to create a highly sophisticated program where Penrose geometries could be recombined algorithmically. However, there is limited evidence and access to the code of the actual software. The authors' goal is to further understand Yturralde's contribution by developing a re-significance of his model, which they have accomplished through a modern interpretation of manuscripts.

Introduction

This paper revisits the art of José María Yturralde, an artist who was an early adopter of computational methods used to produce aesthetic forms. Yturralde's departure from constructivist and optical tendencies as a painter led him to explore the use of mathematical models to visualize multi-dimensional figures.

Yturralde's experience in painting, developed through a life-long career, is largely recognized internationally for its characteristic representations of enigmatic visual designs enhanced with color (Figure 1). Perhaps one of his most significant contributions was made during his participation in a seminal moment of computer art. In 1968, following the computer's arrival in Spain, a series of academic seminars began at the Centro de Cálculo de la Universidad de Madrid (CCUM) [1]. From 1968 to 1973, Yturralde and other key artists explored the use of mainframe computers as tools for creating art at CCUM. This interdisciplinary effort was accomplished through an academic seminar experience called *Generación Automática de Formas Plásticas* (GAFP): Automatic Generation of Plastic Forms.

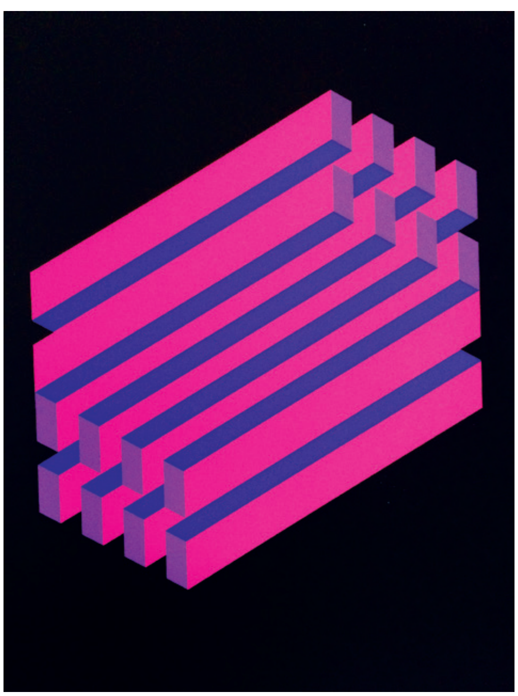

Figure 1. Figura Imposible, 25" x 33", 1972. Screenprint on cardboard. © 1972 José María Yturralde.

Our motivation for this study was to understand Yturralde's desire to incorporate computers and work with scientists to complement his artistic intent. We were particularly interested in a project developed through the GAFP seminar that Yturralde completed in collaboration with computer scientist Isidro Ramos Salavert and architect

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Guillermo Searle. The result of this collaboration was a computer program that recombined Penrose geometries algorithmically. While the software description is documented in a series of manuscripts and artifacts from various authors, there are few remains of the actual program (Figure 2). There is also no way in which to access the full code through modern computers and programming languages, leaving limited proof of its existence and little room for further investigation.

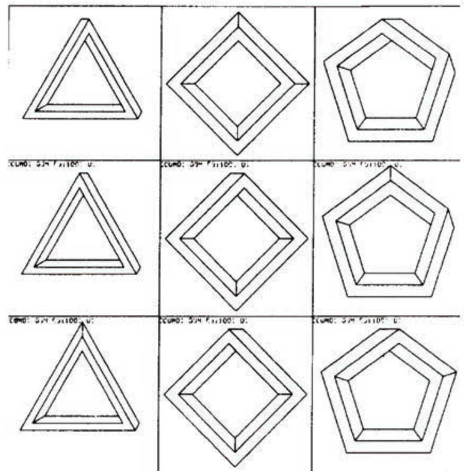

Figure 2. A possible output of the impossible figure generator found in Castaños Alés' dissertation [2]. © 1971 José María Yturralde.

Methodology

For this paper, we interviewed Yturralde about his arrival in the field of computer art as well as the process involved in the creation of the impossible figure generator. Additionally, we gathered a sample of secondary sources including dissertations, articles, newsletters, news-clippings and screen prints in which the project is directly referenced. The majority of these documents were translated from Spanish for this investigation. Our goal is to share our mutual inspiration from Yturralde's art with a larger community of scholars, media archaeologists, artists, designers, scientists and mathematicians.

Media Archaeology and the Re-Significance of Media Art

A possible starting point for the study of early computer-mediated works could be Erkki Huhtamo and Jussi Parikka's concept of "Media Archaeology." Media archaeology is a branch of "historically oriented media studies" [3] that "rummages textual, visual, and auditory archives as well as collections of artifacts, emphasizing both the discursive and the material manifestations of culture" [4]. Andres Burbano has furthered the study of media archaeology through his work "Re-significance of Media Technology." According to Burbano, the re-signification of media technology encompasses studying the media artifacts as well as inspecting the researcher's own attempt to recreate and update technologies of the past [5]. We explore Burbano's model as a methodology to gain a deeper understanding of Yturralde's contribution.

Through this research we aim to reconstruct an algorithm devised by the team Yturralde-Ramos-Searle at the GAFP. Additionally, this paper illustrates the historical context from which the algorithm emerged. In an interdisciplinary manner similar to the one at CCUM, the authors of this paper collaborated, bridging art and mathematics. We have created a modern-day impossible figure generator that will allow new generations to access and understand the computational methods used for the development of this early framework. With a historical mindset, we documented and preserved Yturralde's original materials through a contemporary interpretation of this model. A similar attempt at reinterpreting art through modern code is the Software Structures project by Casey Reas, in which the wall drawings by Sol LeWitt were visualized using the Processing language [6]. In contrast, we are reconstructing the algorithm that was used in the process, rather than recreating images that resemble the finished artworks.

Before Computer Art

José María Yturralde was an emerging artist in Valencia, Spain, around 1964. In the late 1950s, that area fostered an active interest in geometric abstraction. Many avant-gardes explored a constructivist aesthetic, one of them being the Arte Normativo movement from Valencia. The approach of the Arte Normativo artists was comparable to the concurrent Minimalist (or early conceptualist) tendencies that occurred in the United States, where paintings and sculptures were created based on strict sets of rules. The intention was to reduce the expressionist values in favor of a more rationalized composition [7]. Vicente Aguilera Cerni, who was a key member of the Arte Normativo group, later collaborated with Yturralde and others to found the new Antes del Arte group in 1967.

In addition to normative characteristics, Antes del Arte (Before the Art) embraced perceptualism in order to democratize the artistic experience. Antes de Arte believed also in the fusion of science and the arts [8]. In a recent interview, Yturralde recalled his participation in this group: "We wanted to find the geometrical, the mathematical and the intellectual basis of our work and we wanted to do it in a systematic way" [9]. Both Valencian avant-gardes were very influential for Yturralde, who started to use computers as part of a process to rationalize form.

CCUM

In 1966, IBM donated a 7090 computer to the Universidad de Madrid. This was Spain's first-ever mainframe computer. The 7090 had been recently decommissioned by CERN, a center for the study of elemental particles in Switzerland. Although this computer was donated, it was not significantly older or less powerful than those that were at MIT and other research institutions around the world at that time [10]. The university had to build a new building in which to host this computer and founded the Centro de Cálculo de la Universidad de Madrid (CCUM), a center for research in computing. To accelerate research, the director Florentino Briones and sub-director Ernesto García Camarero formed interdisciplinary groups through an initiative of public meetings called seminars [11]. Yturralde recalls:

> In respect to the computer, nobody knew what to do with it. I had an acquaintance with one of the scientists [at CCUM] who was also related to the world of art. We decided to create a group called Automatic Generation of Plastic Forms, and we initiated that seminar. We started to embrace musicians, architects, a painter, and, of course, scientists. [12]

The seminars took the form of regular meetings. The first Automatic Generation of Plastic Forms (GAFP) meeting occurred in December 1968 [13]. Yturralde and Vicente Aguilera Cerni came from Valencia to Madrid to participate and meet with the interdisciplinary group. In an interview, Yturralde states, "We talked about the importance that working with computers could have. We also talked about how artists and scientists should work closely together. This is an idea that has never left me" [14].

At the meetings, open discussions led to different types of efforts and collaborations. Some sessions included planning activities for events and writing articles for the Boletín CCUM, a newsletter-type publication with reflections and even computer code prototypes for artists. From 1969 to 1973 there were constant exhibitions organized by the CCUM, which grew exponentially greater in size and reach. The outreach plan was very successful in raising the awareness of computer art to the general public, making it also visible to an international community of computer artists. In 1972, the CCUM organized the largest exhibit of computer art ever done in Spain, which included some of the most important computer artists from Europe, America and Japan, in addition to the GAFP participants. The exhibit, entitled "Impulsos: arte y ordenador," brought together about 90 artworks by diverse pioneers of the field, such as Kenneth Knowlton, Charles Csuri, Frieder Nake, Michael Noll, and Manfred Mohr, to name a few. During the month-long exhibit, there was a conference cycle that invited keynote speakers to discuss the role of computers in art. One of the fathers of computing, Konrad Zuse, gave a lecture on 28 February 1972 [15].

This experience led to a crossover of Spanish artists in subsequent installments of international exhibits of computer art such as Tendencije 5 in Zagreb, Croatia [16]. After the 1972 exhibit, the GAFP group began a slow process of dissolution, with various generations of members and rotating participants. By the time Tendencije 5 opened in 1973, the GAFP seminar had dissipated.

According to some, the GAFP seminar experience was overwhelming and there was a gradual loss of interest amongst the participants. In the early days of mainframe computers, display terminals were uncommon and, therefore, the programmatic visualizations could only be seen when they were plotted. This was frustrating for many artists because they could not get immediate visual results (if any), while other times having extenuating deliberations about computers. Creating programs was a painstaking process that included many steps, from the formulation of a problem, to its translation into computer code, to the perforation of cards to finally be able to run the program. Manuel Barbadillo recalled that the whole process could take about three months [17]. Barbadillo left the group around 1971 because he felt that he could make greater progress in his art by working without computers [18]. In contrast, Yturralde's memory of this time was very positive and exciting. He remembers getting a lot of support from the CCUM and IBM [19]. He also participated continuously throughout the duration of the seminars, from 1968 to 1973.

Resistance to Computers in Art

The exhibitions received a lot of publicity, however not all the responses were positive. The art critics of the time did not embrace the practice of computer-aided art. According to Yturralde: "The art press messed around with us, they wrote very negative reviews," and critics "were sublevated against the idea of any attempt at rationalizing art" [20]. In the early stages of computer art, artists felt alienated by the idea of using computers.

Yturralde points out that this period was a time of social and cultural transformations [21]. He recalled the student and worker movements of Paris in May 1968, the hippie movement, and the final years of General Francisco Franco Bahamonde's dictatorship. It was a polarizing moment for a new generation that was fed up with Franco's more than repressive regime. For some reason, computers were in Spain a symbol of this brutal regime, and comparisons were drawn between machine and state. Early computer artists received harsh criticism for using computers as a tool for their creative practice and were called "Cyber-Fascists" during the 1972 conference [22]. The role of computers in art was often criticized in the arts scene as a form of escapism for not being engaged directly with the immediate social and political problems [23]. For those who opted to work with computers, these unfair claims had little to do with the reality of working with a computer. There was an intricate creative process needed to decompose the artistic process in a number of steps and constraints.

Impossible Figure Generator

Yturralde's interest in understanding the underlying structure of impossible figures led him to join efforts with Isidro Ramos Salavert and Guillermo Searle. Impossible figures have been a long-standing theme of research, dating back to the golden age of Islamic mathematics around the ninth century. These traditional patterns continue to inspire artists, designers and mathematicians.

In the West, the design of an "impossible triangle" became popularly known as the Penrose triangle after its publication in a scholarly journal in 1958 [24]. Although the original design of the impossible triangle, by Oscar Reutersvärd, dates back to 1934, Penrose and Penrose's article references M.C. Escher's steps series from the 1950s instead of Reutersvärd's as a point of departure for their study. José María Yturralde takes a similar starting point, inspired by Escher [25]. He collaborated with a team to produce a program that was designed to compute all the possible combinations of Penrose shapes of three, four and five sides. Yturralde recalls that the plotting process was slow, and that they spent full nights looking at how those "strange-type" [26] pens plotted the images. Hundreds of designs were generated algorithmically.

Yturralde studied the plotted shapes and chose the ones that seemed more appealing to him. After the computer designs were on paper, he was able to reproduce them at his studio in the form of paintings on wood, screen prints and lithographs [27]. There was also an additional system that determined the color mixtures of each plane, which he later made manually, as there were no color printers at the time.

Re-Significance of the Model

Yturralde's manuscripts about this project [28] serve as the foundation for the re-significance of the Impossible Figure Generator. However, our approach to Yturralde's figures uses ideas from analytic geometry and graph theory. A *graph* is a sketch where we represent the elements of some set *V* (known as the vertex) as circles, and represent a binary relationship by arrows between those circles [29].

One particular kind of graph is called the *cycle*. A cycle follows the principle that if the arrows of the graph are followed beginning at one vertex, eventually the end vertex will be the same as the beginning vertex: all arrows will have been used, and all vertices will have been visited exactly once. In Figure 3, we see an example of cycles with three, four and five vertices. We can generate Yturralde's impossible figures if we start with cycles and at each vertex of the cycle we assign a label of one of four letters (A, B, C, D). Indeed, this labeled cycle has all of the information needed in order to generate an impossible figure, so we can think of this cycle as another representation of the same object. This representation is particularly useful for working with a computer. Figures 3 and 5 illustrate examples of the labeled cycles.

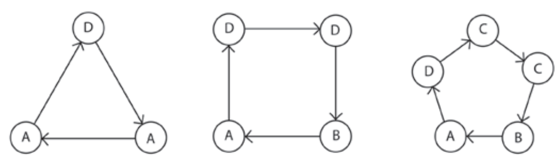

Figure 3. Labeled cycles of regular figures. © 2015 Esteban García Bravo and Jorge Garcia.

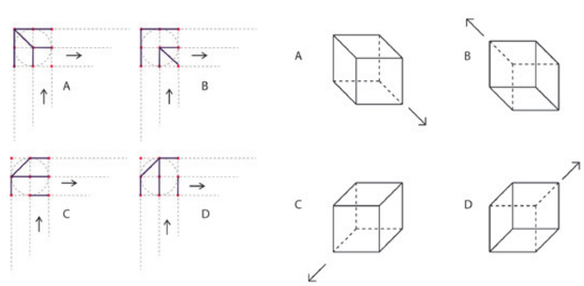

Figure 4. Example of the 4 variable vertices and the 4 types of shearing. © 2015 Esteban García Bravo and Jorge Garcia.

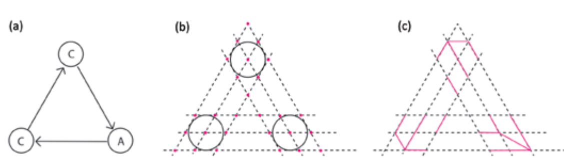

Figure 5. Example of the geometric process in 3 steps. © 2015 Esteban García Bravo and Jorge Garcia.

Implementation

Given a labeled cycle, we can assign coordinates in a plane to each of its points. For convenience we will adhere to the terminology used in Yturralde's manuscripts published by CCUM [30]. So, for a reason that will become apparent, we shall call the vertices *variables* and we shall call the edges *invariables*. Every variable in a cycle will always have two distinct neighbors [31]. For simplicity, we will add the restriction that the variable and its two neighbors cannot lie along the same line [32]. If we think of the variables as circles of radius r, then for every line we can create another two parallel lines at distance r from the given line—one above it and one below it. These three lines are the invariables. Now, at every variable we have two invariables converging. Because these two sets of intersecting lines are not parallel, the invariables have 3 x 3 = 9 intersection points, shown in red in Figures 4 and 5b. That is, every variable defines nine points due to its two invariables. We define a way to connect the points on the variables, depending on their labels, as the four cases shown in Figure 4. These cases are not arbitrary; they arise as the four possible ways to shear a cube to its four corners [33].

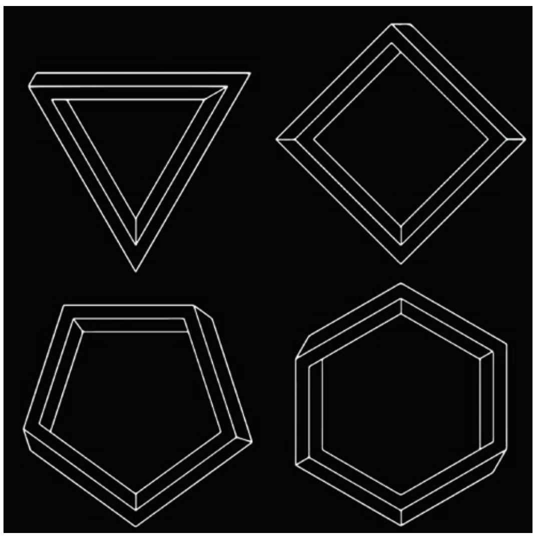

Figure 6. An iteration of our software implementation displaying 4 impossible shapes—available at <www.snebtor.org/yturralde>. © 2015 Esteban García Bravo and Jorge Garcia.

Finally, in order to generate the impossible figure we connect the variables and the invariables as we see in the complete process illustrated in Figure 5. Now that we have a procedure to go from the labeled cycle to the impossible figure, in order to reproduce the results of the program made by Yturralde, Ramos and Searle, we must generate all possible labeled cycles of size three, four and five. This enumeration generates not only the impossible figures but also the possible figures with the given size. As explained in Yturralde's manuscripts, with this model, there can be 4^V figure combinations, where V is the number of vertices of each shape. Yturralde observed that the algorithm could generate repeated, or even "possible," geometries, which he discarded by only focusing on the new and impossible designs [34].

Our implementation was made in Processing 2.0. Using this language makes the model more easily available to a wider audience of programmers with diverse levels of expertise. Processing's philosophy of bridging the gap between artists and programmers aligns with the original mission of the GAFP seminar. Additionally, we implemented a Processing code through a JavaScript interface to make it readily available for interaction and download at www.snebtor.org/yturralde (Figure 6).

In the future, we plan to be able to change the positions and the radii of the invariables to be able to generate forms beyond the ones generated by Yturralde. Additionally, a deeper analysis of the braids generated by the figures can lead to the automatic shading of those figures. The value of this is not only aesthetic, but can also lead us to further insight about the connection between the figures and their underlying labeled cycles. With these additions, we could allow users to experience Yturralde's studio practice, which included the fragmentation and coloring of the impossible shapes originally rendered by the software (Figure 7). However, the focus of this paper is to document the original software developed in the GAFP seminar.

Figure 7. Figura Imposible, 25” x 33”, 1972. Screenprint on cardboard. © 1972 José María Yturralde.

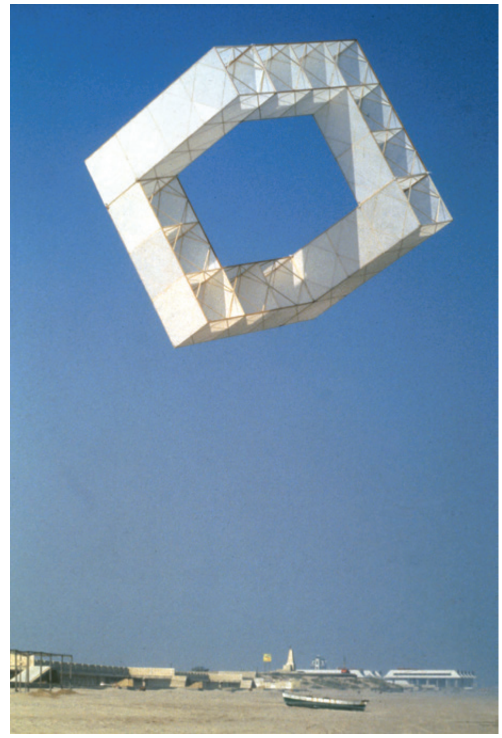

Figure 8. Estructura Volante, 80” x 80” x 80”. Balsa wood, nylon and Japanese paper. A flying structure from the cube series flying over the Saler beach in Valencia. © 1977 José María Yturralde.

After the Impossible

The impossible figures and Yturralde's relationship with mathematicians opened ground for new ideas. Subsequent to his participation in the GAFP seminar, Yturralde took a deeper interest in n-dimensional figures and not just impossible figures. In a 2014 interview, Yturralde recalled his transition after the seminar experience:

> I was, and still am, very interested in the idea of multidimensionality. The fact that, for example, there could be a 12th dimension. I am fascinated to be able to advance within the world of art supported by science. The recognition and knowledge of other dimensions interested me. That was the reason why I went to MIT, to establish contact with geometers who helped me understand a little better those geometries that had more dimensions [35].

In 1975, Yturralde was a visiting scholar at the Center for Advanced Visual Studies (CAVS) at MIT. This experience allowed him to collaborate with scientists as well as with other artists such as György Képes and Otto Piene. During this time, he became familiar with hyper-polyhedra, lasers and natural power sources. The hyper-polyhedra research evolved in a series of flying structures (Figure 8) called Estructuras Volantes, featured in the 1978 Venice Biennale, the Sky Art exhibit of 1982, and Ars Electronica in 1983. Yturralde has been an emeritus professor of painting at the Universitat Politecnica de Valencia at the Facultad de Bellas Artes since 1979. His contributions have transcended both fine art and new media circles, and are illustrated in an outstanding exhibit record [36]. Yturralde's relevance in Spain has led to comprehensive exhibits, such as his first retrospective at the Instituto Valenciano de Arte Moderno (IVAM) in 1999 [37].

Summary

Yturralde was able to utilize the computer as an opportunity to visualize impossible figures through the design of his Impossible Figure Generator. It was in this way that he joined a wave of artists who began to understand the potential of the computer as a tool to join art and science. Through his work, he demonstrates his inspiration in mathematics, but also represents the subtle language of art through a concrete aesthetic. This study is a comprehensive glimpse into a pivotal point in Yturralde's career. Through the re-creation and implementation of Yturralde's lost program, we have sought to not only enable an outlet for modern experimentation of impossible figures, but also to provide a historical analysis of Yturralde's time period to re-signify the original methods that allowed him to expand his visual knowledge of enigmatic shapes.

References and Notes

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28. Ibid.

29. This is not a complete description and we are actually using directed graphs. For the interested reader a formal description of graphs as mathematical entities can be seen in any book about graph theory. A good example is: *Introductory Graph Theory* by Gary Chartrand. Dover Publications, 1984.
30. Yturralde [27]. We reproduced the same geometric process described on Yturralde's texts and sketches.
31. One neighbor points to the Variable and the neighbor that the Variable points to.
32. This is a very common restriction in Computational Geometry, where they like to say that the variables are in "general position."
33. The cases C and D look suspiciously symmetric. However, they are not the same case, since we are dealing with *directed* graphs.
34. Yturralde [27].
35. Yturralde [9].
36. A chronology is posted on Yturralde's website: <www.yturralde.org/n-cronologia-es.html>. This website served as point of contact to access documentation originally published in the CCUM newsletters. The space in this article is too short to document Yturralde's accomplishments.
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