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Unfolding Humanity: Cross-Disciplinary Sculpture Design

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Unfolding Humanity: Cross-Disciplinary Sculpture Design

Abstract

Unfolding Humanity is a 12 foot tall, 30 foot wide, 2 ton interactive metal sculpture that calls attention to the tension between technology and humanity. This sculpture was conceived, designed, and built by a large group (80+) of faculty, students, and community volunteers at the University of San Diego (USD). The piece is a dodecahedron whose pentagonal walls unfold under human power, an engineered design that alludes to Albrecht Dürer's 500-year-old unsolved math problem on unfolding polyhedra. When closed, the mirrored interior of the sculpture makes visitors feel as though they are at the center of the universe. The idea for the sculpture began with two USD mathematics professors, they recount their journey elsewhere (Devadoss & Hoffoss, 2019). This narrative focuses on the story of bringing their vision to a reality.

Keywords

STEAM, Maker, Kinematic Sculpture, Interdisciplinary

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Cover Page Footnote

This project was a deeply collaborative effort, with over eighty volunteers and a faculty leadership team of Susie Babka, Satyan Devadoss and Diane Hoffoss. We are particularly grateful to the community members, without their effort this project would never have become a reality. In particular, the contributions of Max Elliott, Lee Hemingway, and Sean Pennington went above and beyond. Thanks also to everyone at the USD Machine Shop and San Diego CoLab for providing both valuable insight and a physical space for this collaboration. Lastly this work was made possible by generous funding from USD and the San Diego Collaborative Arts Project.

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Unfolding Humanity is a 12-foot-tall, 30-foot-wide, 2-ton interactive metal sculpture that calls attention to the tension between technology and humanity. This sculpture was conceived, designed, and built by a large group (80+) of faculty, students, and community volunteers at the University of San Diego (USD). The piece is a dodecahedron whose pentagonal walls unfold under human power, an engineered design that alludes to Albrecht Dürer's 500-year-old unsolved math problem on unfolding polyhedra. When closed, the mirrored interior of the sculpture makes visitors feel as though they are at the center of the universe. The idea for the sculpture began with two USD mathematics professors, they recount their journey elsewhere (Devadoss & Hoffoss, 2019). This narrative focuses on the story of bringing their vision to a reality.

The process of creating Unfolding Humanity brought together faculty and students at the University of San Diego from engineering, theatre, theology, and mathematics - a true STEAM collaboration. For the engineers on the project, including faculty from mathematics and theatre on the design team fundamentally changed the design process. Rather than designing to a set of specifications provided by an external client, the build was a collaborative process where voices from theatre and math were present at every step of the way. While this led to substantial conflict - for example parts of the artistic vision were discovered to be impossible from an engineering perspective - in the end the success of the sculpture was due to this collaborative approach.

The design process began with an engineering student working closely with the math faculty to develop an artistic rendering of the desired sculpture in Blender, a 3D graphics tool (Figure 1). From this conceptual rendering, a larger team was assembled to create a design that could be physically constructed. Due to the unique geometry of the dodecahedron, the team quickly realized that the desired kinematics - which linked together two pentagonal faces at complex angles - were impossible from an engineering perspective given the constraints on time and budget. This led to several different conceptual revisions and simplifications - eventually landing on the concept shown in Figure 2. What is not shown is that between these two figures were dozens of preliminary hand calculations and simple computer models developed to evaluate the designs for feasibility. Having agreed upon a conceptual model, a detailed design was created using the computer aided design (CAD) package Solidworks (see Figure 3). As the sculpture called for large pentagonal panels to be lifted overhead, safety was a major concern. As such, the CAD model was used to develop detailed finite element analysis (FEA) and kinematic simulations to validate the design.

The last phase of the project was to build the sculpture. In retrospect, the team realized that the project should have been spread out over a considerably longer period of time. Compressing the build phase for a 4,000-pound moving steel sculpture with 17,000 LEDs into 10 weeks was, to say the least, unwise. The structural build was completed by a core team of five engineering students, supported through undergraduate summer research grants. Their work was complemented by contributions from 80+ community volunteers - without whose help the project never would have been completed. The build took place at both the Shiley-Marcos School of Engineering at the University of San Diego as well as Co-Lab, a collaborative workspace for creating both communities and art in San Diego. Students and community members intermingled throughout the process, providing many opportunities for students to learn from community

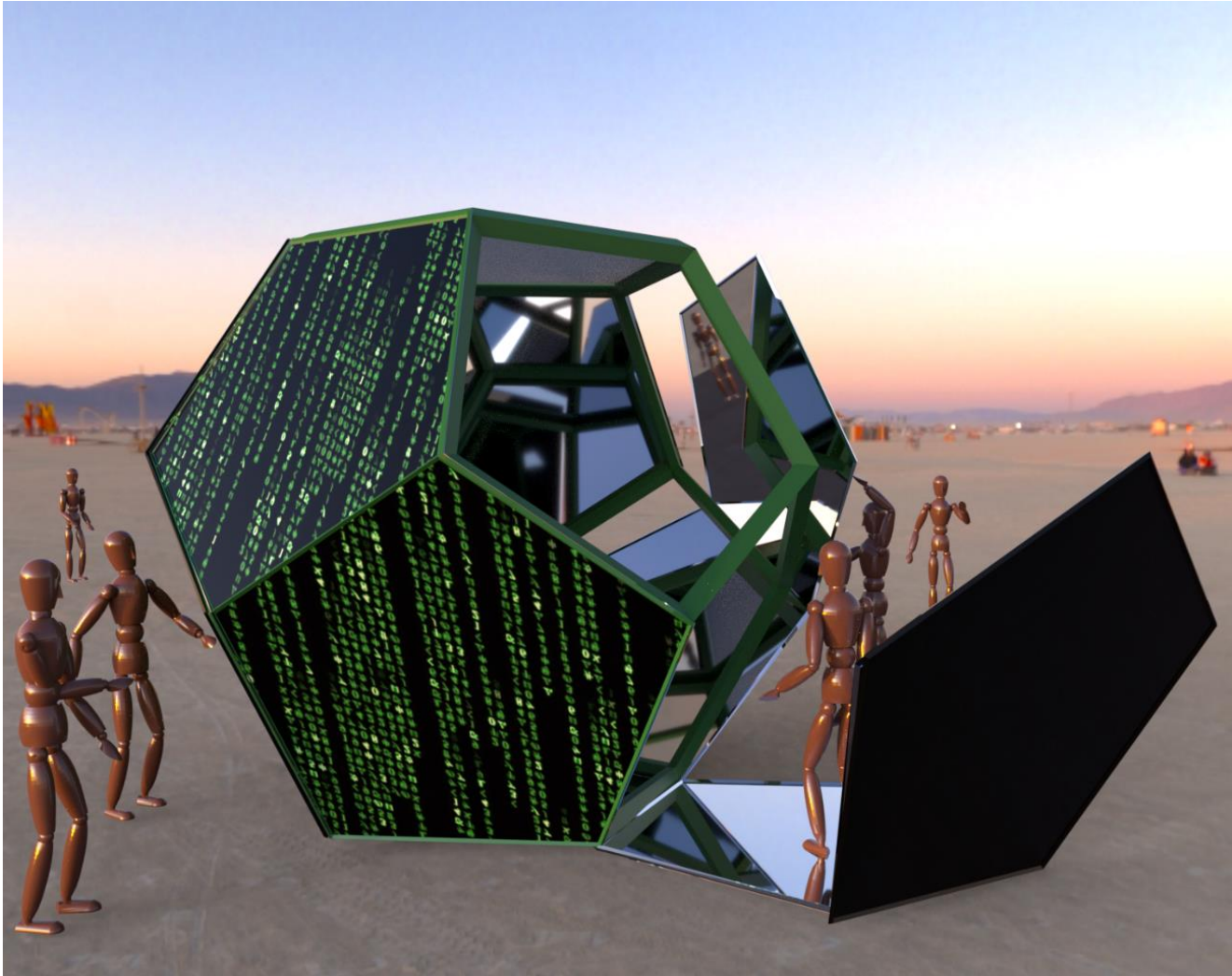


Figure 1. The original conceptual design for the Unfolding Humanity sculpture.

members and vice-versa. One of the best aspects of the project was the informal learning that happened during these interactions.

After the sculpture was completed, it was unveiled at Burning Man 2018, a premier large sculpture festival. A subset of the team, including faculty, students, and community members, traveled to the remote Black Rock Desert of northwest Nevada to assemble the sculpture. It was then transported back to San Diego and reconstructed at the San Diego Maker Faire (see Figure 4). Those that visited the sculpture had a wide range of reactions: some were transfixed by the artistic elements, some deeply pondered the mathematical implications, and still others marveled at the engineering design.

Throughout this project the authors of this narrative (primarily engineers) became aware of just how crucial the artistic aspect was to this experience. While this successful completion of this sculpture required STEM skills, it was the artistic element that was transformative. It was the artistic vision that built a community - bringing together students, welders, LED gurus, artists, set designers, and engineers. It was the sheer spectacle of the sculpture that constantly made passersby stop and ask “What... are you building?” For many of those involved this was their first STEAM project, but it will certainly not be the last.



Figure 2. The final conceptual design. Substantial changes were required from the original design.

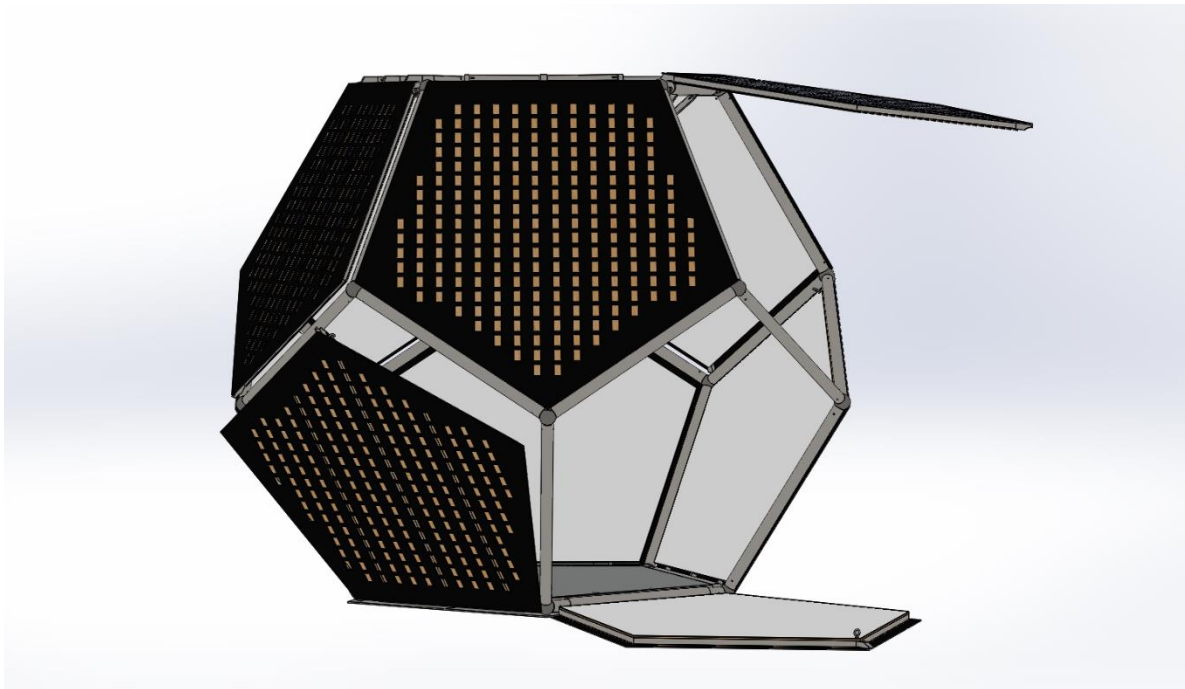


Figure 3. The engineering CAD model that was developed to evaluate the design for safety.

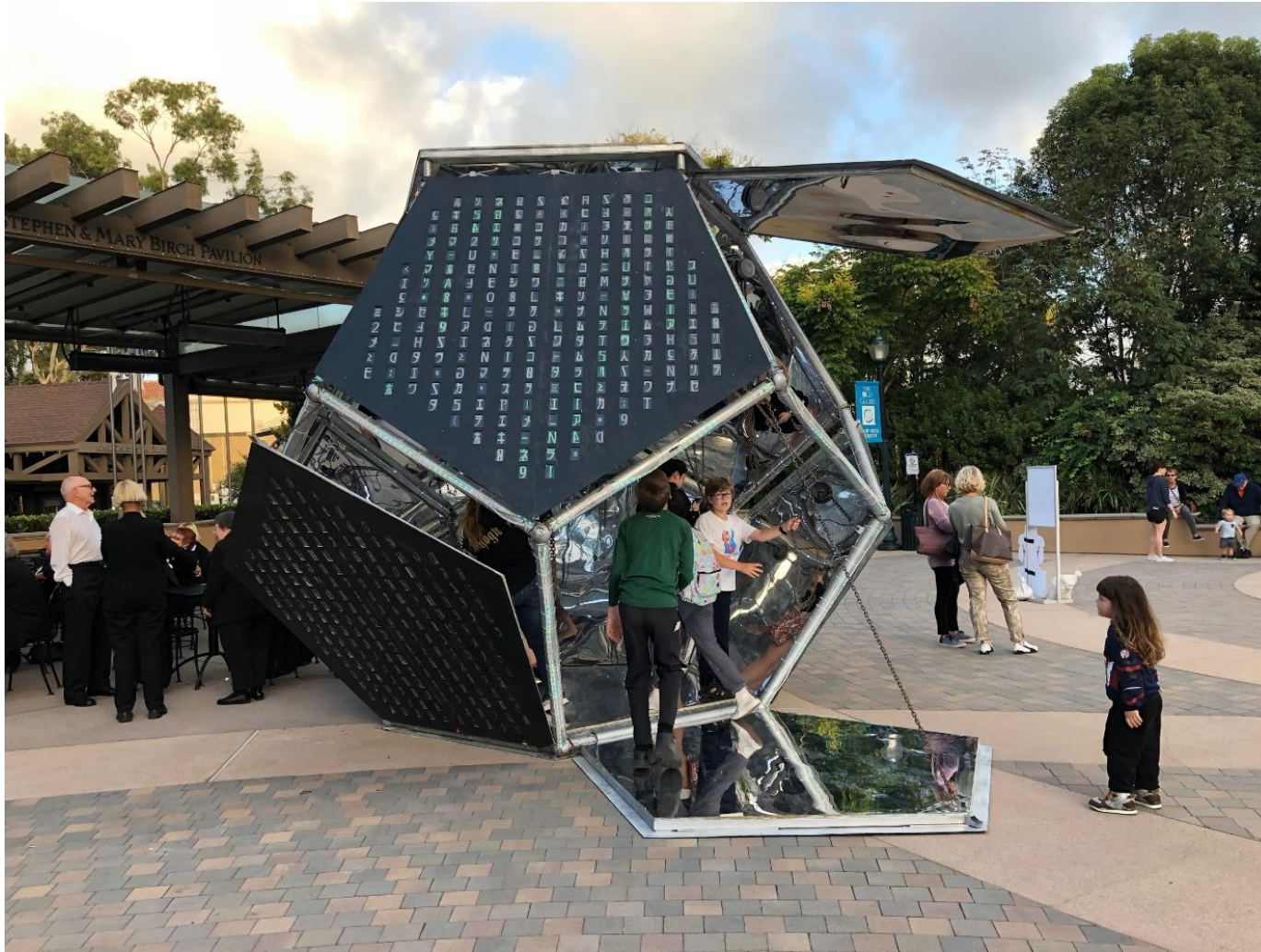


Figure 4. Unfolding Humanity in its final form, installed at the San Diego Maker Faire.

References

Devadoss, S., & Hoffoss, D. (To Appear 2019) Unfolding Humanity: Mathematics at Burning Man. *Notices of the American Mathematical Society*.