Thesis Portfolio

Design and Construction of a Ferrofluid Kinetic Art Clock

(Technical Report)

Viability of 3D Printed Prosthetic Devices

(STS Research Paper)

An Undergraduate Thesis

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Table of Contents

Sociotechnical Synthesis

The turn of the 21st century brought about a sudden change in manufacturing technology that has permanently shifted the methodology of device creation and design: the 3D printer. Championed by hobbyist makers and industry professionals alike, the 3D printer has become the forefront of rapid manufacturing processes around the world. The technology allowed for new freedoms of design, allowing for the creation of complex geometries that were previously impossible or impractical to produce with traditional methods and materials. Due to this flexibility, there are a wide range of uses for 3D printing. In both my technical capstone project and STS research, 3D printing technologies are explored in two vastly different uses and settings. The STS research paper explores the possibilities of 3D printing applications to the field of prosthetics, in particular, if a 3D printed prosthetic device could become a viable alternative to traditional prostheses. Utilizing the technology in a different capacity, the capstone project sought to make practical and tangible use out of 3D printed componentry to create a captivating kinetic art piece for use in the University of Virginia school of engineering.

The final design for the capstone project was a ferrofluid digital clock, using actuated magnets to manipulate a ferromagnetic solution to create a clock face. This design is a novel take on ferrofluid artwork, because previous similar projects make use of electromagnets rather than permanent metal magnets as were used in our project. By avoiding the use of electromagnets, significantly less power is consumed making for a more practical and energy efficient product. This design came after a long process of iterative design, varying greatly from each prototype. The initial idea was to instead use magnetic ball bearings with a similar permanent magnet actuating system in order to create a clock face that would form and reform in a perplexing way sue to the magnets being out of sight. This proved too impractical, however, as the falling ball bearings caused too much noise and tolerances needed to be impractically precise in order for the small bearings to flow freely through the system without jamming. Several iterations were tested, including dropping bearings directly down the front face, using a rolling barrel to distribute the bearings only where they were needed, and even “faceplanting” a set of actuated magnets into a reservoir to create the digits on the clock face. Ultimately, it became clear that major design changes were needed to create a finished project, so a ferrofluid system became the most appealing choice as the magnet actuating mechanism could remain largely the same. Many different options for creating a homemade ferrofluid tank and suspension fluid were tried, including using laser-cut acrylic tank with a saline suspension fluid, as well as a glass tank with a salt water suspension fluid, but each iteration failed in different ways. Ultimately, it was decided to use proprietary ferrofluid containers which also brought the overall size of the project down. This was the final iteration, and with the inclusion of some LED lights for effect, the piece was successfully completed. The use of 3D printing in order to rapidly iterate through prototypes was absolutely critical in this project. With a short timeframe and many design variables to work through, the end result would have been impossible without the speed and flexibility that was achieved through the use of 3D printers.

The STS research paper extrapolates the exploration of 3D printing technology to an existing practical field. The primary motivation for creating 3D printed prostheses is to reduce cost and lower the barrier for entry for amputees and other people living with limb loss, as common prostheses are financially prohibitive for many people. The research involved all aspects of prostheses: upper extremity, lower extremity, socket design, and more. It was found that many companies are looking into or already using 3D printers to create lower extremity sockets, the part of the device that serves as the interface between the residual limb and the device. There are also organizations that produce 3D printed upper extremity devices for next to no cost, however the efficacy of these devices is currently under speculation. While the use of 3D printing in the field of prosthetics is still in its infancy, the technology has caused a paradigm shift that will continue to develop and further push the field of prosthetics for years to come.

Having worked on both of these projects at the same time has further convinced me of the groundbreaking potential of 3D printing in many different technological and cultural spheres. The sheer versatility of the technology, explored in both medical practice and in art, makes the case for the technology to be a permanent staple for many kinds of creators for the foreseeable future. Now, as 3D printers are being used to create parts on the fly in the International Space Station, and are used to relive medical device shortages during pandemics, new and exciting applications of this technology only continue to be revealed.