Thesis Project Portfolio

The Abaclock

(Technical Report)

Challenges for the Adoption of Metal Additive Manufacturing Based on the Evolution of Polymer Based 3D Printing

(STS Research Paper)

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Executive Summary

Historically, most manufacturing has been classified as subtractive manufacturing, where a piece of material is whittled down by any variety of processes until a final part remains. However, over the past fifty years or so, a new class of manufacturing techniques has emerged, collectively referred to as 3D printing. In these processes, a net shape part is built up in a layer-by-layer process. A wide range of materials can be used in 3D printing depending on the specific process utilized, but the two main classes of materials are polymers and metals. With this, a small distinction has arisen where 3D printing is generally used to indicate the use of polymers, while additive manufacturing has emerged to refer to the use of metals, relating to the ability of metal parts to be used in final products, rather than just rapid prototyping. This portfolio is primarily themed around 3D printing and additive manufacturing, concerning both their practical uses, and understanding the history and potential future of these technologies.

For our technical project, my teammates and I developed a prototype of an abacus-based mechatronic clock, nicknamed the "Abaclock". Abacuses are ancient devices that allow the user to perform a range of mathematical operations from basic counting to complex multiplication using the motion of beads that slide along a column or row to represent numbers. The vision of the Abaclock was to create a four-digit clock where each number in the time was represented by the position of the beads in four individual columns. These beads would be magnetic and moved by a mechatronic pick and place mechanism to move the beads from behind an opaque panel without direct contact. This would give the Abaclock the appearance of being almost magical by concealing the method of motion. This project utilized our knowledge of robotics, mechanical design, and manufacturing methods with a heavy focus on laser cutting and 3D printing to rapidly iterate on our design. Ultimately, we were only able to create a working prototype of one column, rather than four. However, this column did function properly and could be used to count robotically from 0 to 9. To complete the project, this design would only need to be tweaked slightly and then duplicated three more times to result in a full working Abaclock.

For the STS portion of my work, I chose to take a closer look at 3D printing due to our heavy use of the technology for our technical project. Polymer 3D printing is a well-established technology at this point, but its spread has been remarkably marred by the use of patents in the field. I wanted to examine the history of how intellectual property was distributed as well as other factors and compare them with that of metal additive manufacturing which has far greater potential than polymer-based processes but is currently much more inaccessible to the average person. By understanding the differences in the state of patents, the costs of each technology, differences in safety, and potential demand, I sought to anticipate what challenges metal additive manufacturing may face in its adoption, and what limits there might be to its spread. Overall, my findings were fruitful, and I came to understand that although technology is still developing the cost of such a machine could be greatly reduced, so much so that it would be accessible for individual consumers. However, the issue that became most glaring was the cost of consumables associated with the process, namely shielding gases like argon that must be used to prevent property degradation in additively manufactured parts. In order for these machines to reach the widest audience, the cost of these consumables must be greatly reduced or eliminated, but without additional research and development on the subject this currently seems unlikely.

Considering the past year, I am both disappointed and satisfied. I personally wish that my group was more successful in creating a final product, rather than a quarter-finished prototype, but I believe that we successfully identified our major stumbling blocks which would allow someone else to complete the work without great difficulty. On the other hand, I am very happy with the STS focused portion of my work. I think that it is of great interest to any 3D printing enthusiast, and my findings were of great help to spark new ideas of how to improve metal additive manufacturing on a technical level, ideas I plan to pursue as I attempt to spark the same sort of open-source development of the technology that polymer 3D printing experienced with the advent of the RepRap Project.