Thesis Portfolio

Design and Construction of a Ferrofluid Kinetic Art Clock

(Technical Report)

Impacts of the Development of Environmental Suits on the Future of Human Spaceflight

(STS Research Paper)

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Trevor Stutzman
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Department of Mechanical and Aerospace Engineering

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Sociotechnical Synthesis

Introduction

The STS and Capstone projects are connected by the machine elements and materials science used in their construction. Both spacesuit design and magnetic clock construction involve the operation of miniature motor systems, 3-D printing, and advanced manufacturing techniques that provide the basis for the next stage of mechanical engineering design. New materials are also used in both constructions, with the clock project providing a hands-on experience when dealing with metal, refined plastics, and ferrofluid, a component developed to operate in zero-gravity through magnetic interaction. Ferrofluid is used in spaceflight, where magnetic forces are able to move fluid through channels and into combustion chambers, and used in the clock device as a display mechanism that is actuated by magnets and motor mounts. Spacesuit STS research and mechanical clock design have a strong overlap, with the STS research being largely theoretical, and the mechanical clock acting as a physically constructed system.

Design and Construction of a Ferrofluid Kinetic Art Clock

Our capstone project is represented in a mechanical clock that uses motors to actuate magnets, which influence the organization of the ferrofluid particles. The motors are programmed through Spin, a computer programming language that effectively operates servo motors. A Propeller chip enables the commands to be run to the motors, as well as keeping time and allowing user input through an LCD screen attached to the side of the device. A power supply draws power from a wall circuit, and powers the motors as well as removing excess heat buildup inside the device. The actuation of the motors moves magnets closer or farther from the ferrofluid containers, the magnetic attraction causing the ferrofluid to assume the shape of the magnet in order to produce numbers ranging from zero to nine. Four motor-magnet arrangements provide the necessary structure to display time to a user, as well as six light emitting diode strips lighting up each digit, and the colon between the hours and minutes. The arrangement of the magnets will gather ferrofluid in a pattern to display time to the user.

Impacts of the Development of Environmental Suits on the Future of Human Spaceflight

The STS research concerns the development of spacesuits, specifically how spacesuit development could limit the exploration and commercialization of space. Spacesuit design is extremely costly, demonstrated by the cost of the Apollo spacesuit program. It also faces the barriers of safety in design, social support, and the technological integration required for a next generation system. Government space agencies have a fraction of the budget they did during the Cold War, and therefore lack the resources required to fund another large planned space mission without massive delays in current programs or pursuing alternative funding sources. Private spaceflight has been rapidly increasing in popularity, with companies such as Boeing or SpaceX now sending vehicles into low earth orbit, but without a large human component of spaceflight. Safety is a second major factor, where the age of the current suit body is considered, as well as the necessary safety features that must be included to protect future civilians and workers in space. Space tourism carries inherent risk due to the danger of the environment, and spacesuits must be designed with minimally trained civilians in mind. A third factor is social support, where investors, society, and the government may not want to direct funding to spacesuit design and testing when facing more dire problems on Earth. Many groups are opposed to spending money on human spaceflight, even with the financial benefit that could be gained from space exploration. Finally, the technological integration necessary for spacesuit design is complicated by the various government agencies, universities, and companies that are developing human spaceflight across borders and through language barriers. These groups fear loss of intellectual property or improper data, increasing costs and decreasing system integration for the future of human spaceflight. Spacesuit design must undergo rigorous testing before it placed in the environment of space, as a single failure could eliminate participation in human spaceflight efforts.

Concluding Reflection

Doing both projects simultaneously highlighted the myriad of design challenges that designing a new spacesuit must face as the ferrofluid clock was designed. Even working on a minimally intensive project, the capstone team still faced significant design issues and team integration concerns. Trying to create a novel system meant fewer resources that were available for reference, which is a concern that a cutting-edge spacesuit would face in the design phase. Resources used for the mechanical clock, such as miniaturized motor data sheets and new materials, provided research paths when looking at the next stage of spacesuit design. However, by far the most significant learning experience that consumed the entire technological integration section of the STS research paper was how to communicate ideas between groups. Just as companies and countries face physical borders and language barriers that impact scientific data sharing, the capstone teams faced internal disputes over best methods for improvements of the project. Working through and explaining design ideas was the most valuable learned skill that directly applied to both projects.