Department of MECHANICAL ENGINEERING
THE UNIVERSITY OF UTAH

Magnetic Haptic Device

Calvin Barnett, Ethan Evans, Brendan Ezzell, Andreas Hendricks, Spencer Iverson, Andrés Rosero, Spencer Schleich, Spencer Stubbs, Jakob Thygerson, and Brandon Whitehead
Advisors: Dr. Jake Abbott and Master Ashkan Pourkand

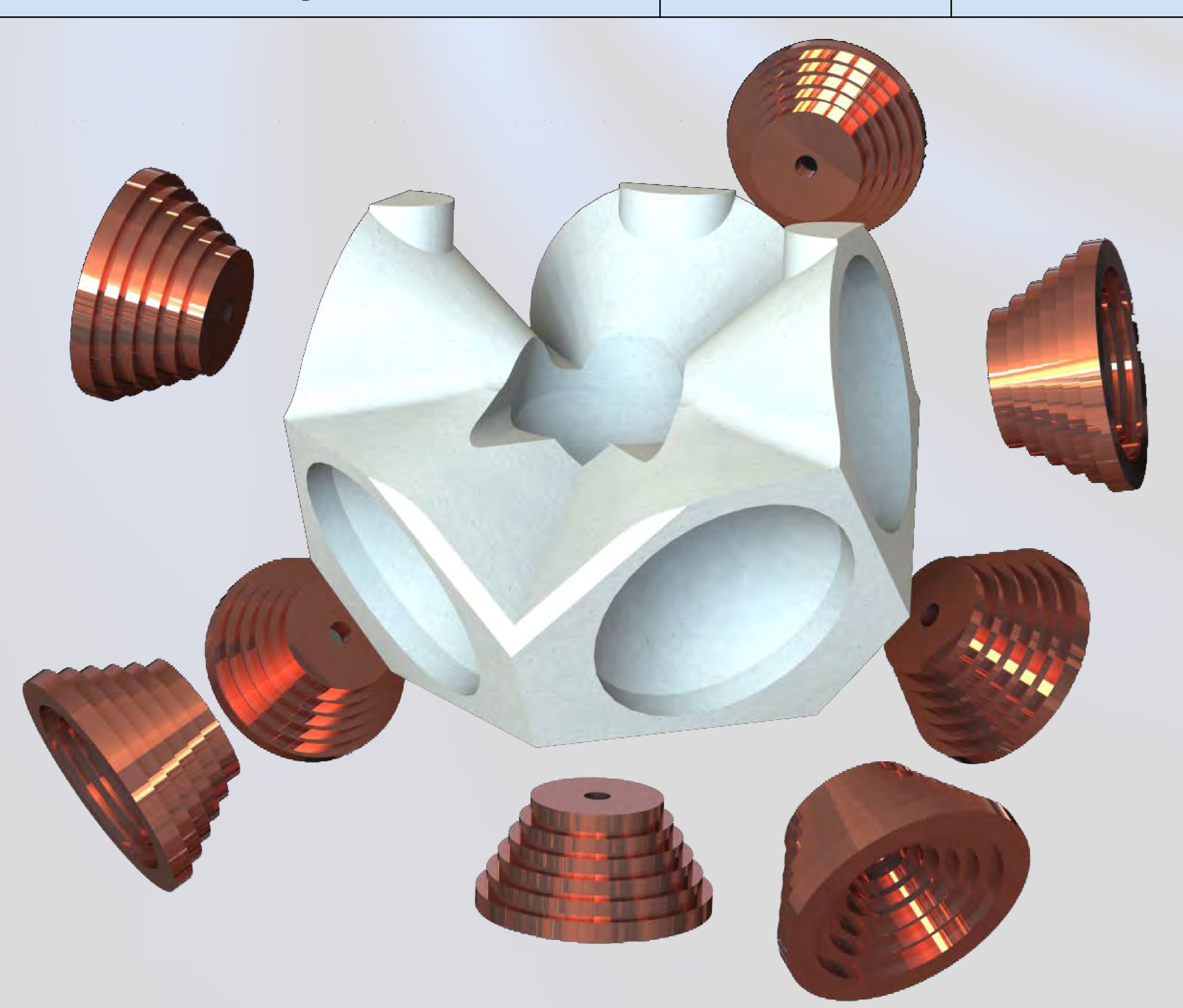
Introduction

A haptic device is a robotic device that acts as a force-feedback human-input device. Haptic devices are used to enable a human user to teleoperate a remote robot (e.g., a surgical robot), or to interact with virtual environments (e.g., surgical simulators). Haptic devices are typically constructed like small robots, comprising a mechanical linkage with electric motors. Even if well designed, it is never possible to completely eliminate the inertia and friction of the robot. For certain applications, such as simulators for eye surgery training, this inertia and friction can impede the realistic simulation of the surgical experience.

Our objective is to design an untethered haptic device that uses eight electromagnets to render forces on a magnetic stylus held by the user. Our team has split into three sub teams, the structure team, the cooling team, and the camera and lighting team.

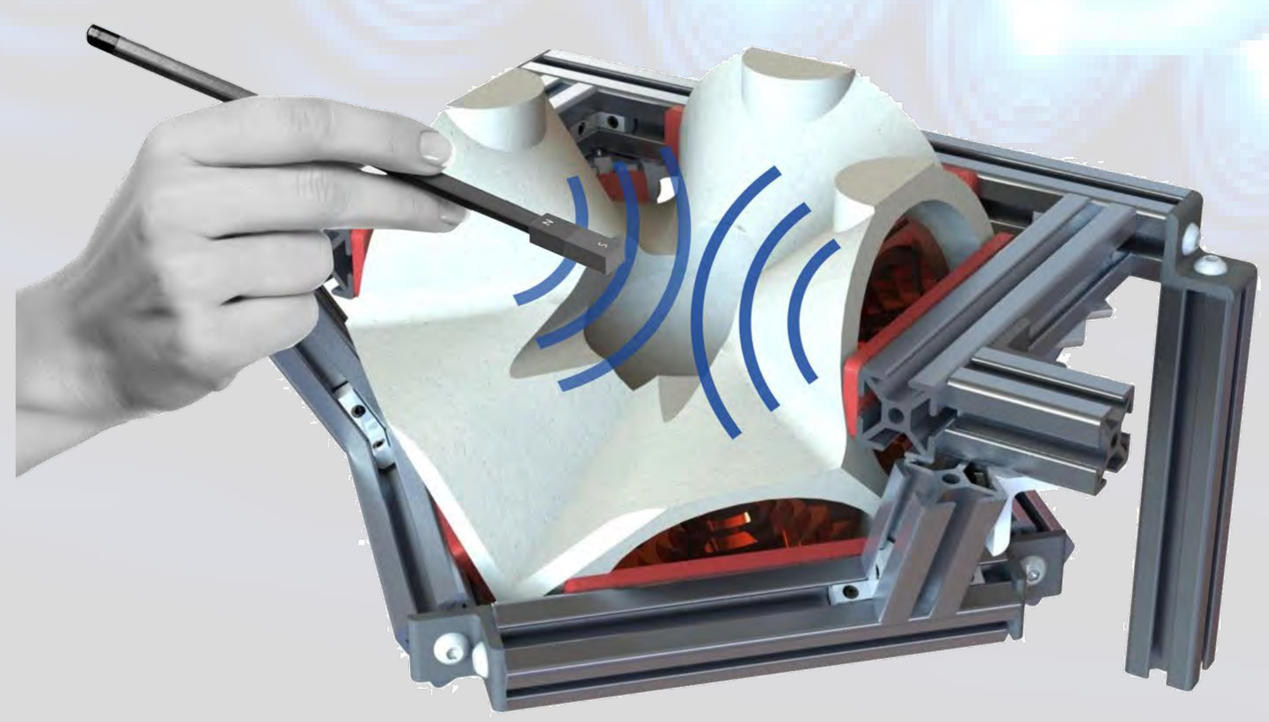
Design

Metric	Desired Value	Actual Value
How many square ft will the footprint of the haptic device structure take	10-13 ft^2	10-13 ft^2
Number of degrees of freedom of the frame	3 degrees of freedom	2 degrees of freedom
Design concept evaluation metric: Number of causes of failure	0 failure modes	0 failure modes
Overall Cost of the system materials and labor to build it	<=$1000	$2000
Lumen light output	750+ lm	10000 lm
Time before overheating	20+ minutes	500 minutes



Objectives

Cameras and Lighting: To design a camera and lighting system to track the position of the stylus.
Structure: To fabricate the eight electromagnets and to design the main structure that supports the magnetic haptic device, which will be made from extruded-aluminum frame designed to support the electromagnets and the cameras.
Cooling: To design a cooling system that lengthens the amount of time the electromagnets can run before overheating.



Conclusion

Due to unforeseen circumstances not all components were built or assembled to create a final product. Instead we have put forth more time and effort into the design and optimization of the system. Detailed construction documents and models were also created. This project will be fully assembled at a later date.

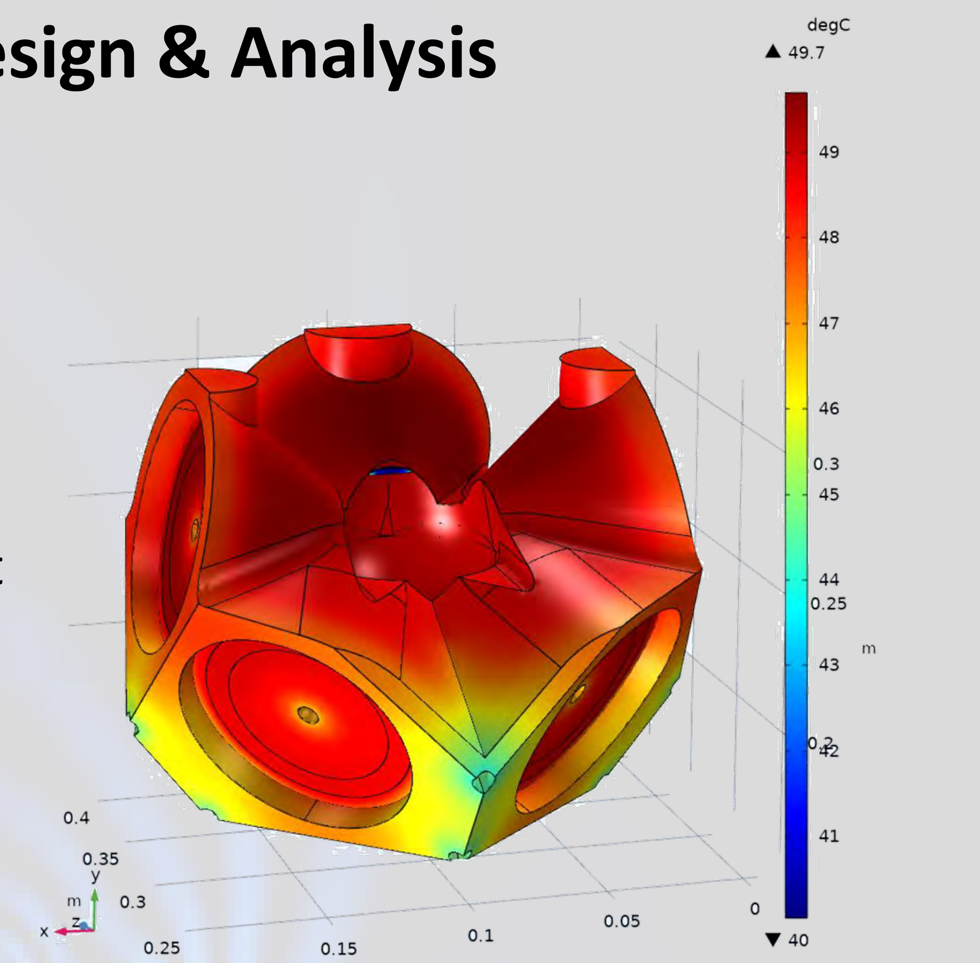
Analysis and Results

Electromagnetic Analysis

Test	Results
Surface Finish	No scratches
Bonding	Self-bonded with no visible flaws
Final shape	Fits within mold
Unravelling	Does not unravel without significant applied tension

Cooling Design & Analysis

Comsol Model: A simulation of the heat transfer from the electromagnets was performed. From this the most effective cooling sub-assembly was found to consist of: **Thermal Paste, Ceramic Material, Heat Pipe, Heat Sink.**



- **Thermal Paste:** A thermally conductive interface that allows efficient heat transfer from the coils
- **Electromagnetic Coil:** Used to create a magnetic field that emulates a force on the user's stylus while emitting heat
- **Ceramic Material:** A Material with a high thermal capacitance, used to draw heat away from the coils
- **Heat Pipe:** A component that efficiently transfers heat from the ceramic to the Heat Sink
- **Heat Sink:** Used at the end of the Heat Pipe to dissipate the heat through a larger surface area using natural convection