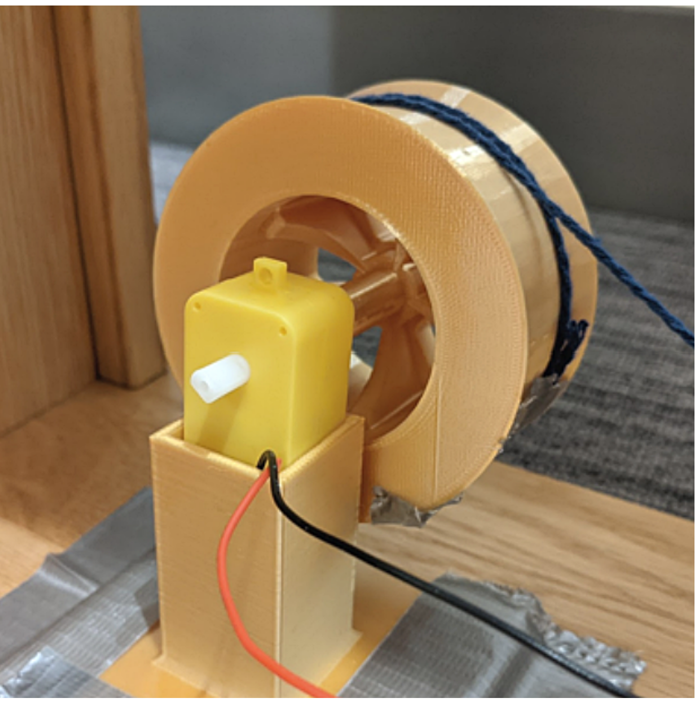
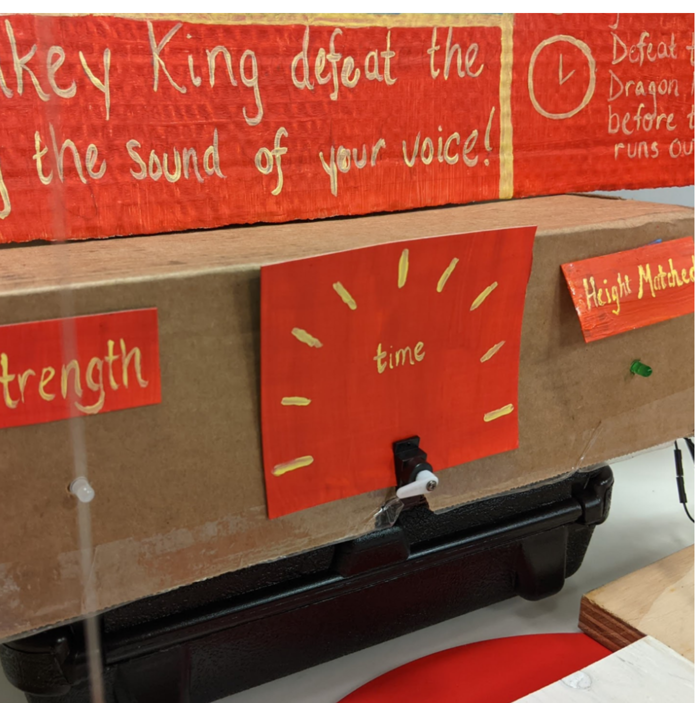




AN ELECTROMECHANICAL GAME INSPIRED BY CHINESE MYTHOLOGY

BATTLE OF KINGS

Summary

In the Spring of 2021, I was tasked with creating an electromechanical game within a team of four. The game was meant to be played by Northeastern students during finals season, obey COVID-19 restrictions, and depict an aspect of another country's culture.

Our game depicted the famous Chinese myth of the battle between the Monkey King and the Dragon King of the East Sea and consisted of C++ code on Arduino hardware, 3D printed elements, motors, pulleys, and a wooden frame. Players would shout into a sound detector to raise the height of the player character (the Monkey King), who was mounted on a pulley system that fell at a constant rate. The opposing Dragon King figurine would move up and down randomly on its pulley system. When the heights of the two characters were aligned via ultrasonic sensors, players could press on a foot pedal to decrease the health of the Dragon King, which was depicted by a color-changing RGB LED. Players aimed to defeat the Dragon King within the time limit, which was tracked by a servo-driven timer.

Our sound detector and foot pedal input systems allowed us to remain in compliance with COVID-19 guidelines. Our goal was to create a fun, stress-relieving game by encouraging students to scream into the sound detector, especially as the game would debut during finals week. Ultimately, players rated the game a 4.83/5 for fun and a 3.94/5 for stress relief on average.

Personal Highlight

I was responsible for constructing the pulley system. The pulley system consists of four parts: a motor, a 3D printed (PLA) spool, and two metal pulleys.

The motor sits inside a 3D

printed mount attached to the bottom of the frame. One end of the motor shaft is press fit into the 3D printed spool. We used 3D printing extensively in the physical construction of our project because of our need for custom pieces: a mount that would hold our exact motor, and a spool that can be press fit into our exact motor.

The thread wraps under one metal pulley attached to the bottom of the frame. This metal pulley makes it easier for the motor to lift the character and allows us to ensure the excess thread wraps neatly around the spool by adjusting its distance to the spool. The minimum distance between the center of the spool and the center of the bottom metal pulley is 12 times the width of the spool (0.75 inches), which is 9 inches. We thus spaced the two apart around 10-11 inches. The thread then wraps over the other metal pulley – attached to the top the frame – and is tied to the top of a figurine.

As for the avatars, each figurine was modeled in ZBrush, as shown in figure 3. The flat, circular base as well as the loop on top of each avatar was modeled in Solidworks, and the two parts were combined in Autodesk Meshmixer. ZBrush facilitated the creation of the organic shapes needed to model a monkey and a dragon, while Solidworks made it easier to generate more geometric parts. We used Meshmixer to put together multiple 3D models, as well as to calculate the center of mass of our final model. The base of the avatars had to be as parallel to the ground as possible for the ultrasonic sensors below to obtain accurate readings, and therefore the loop on top of each figurine was placed right above each model's center of mass. For this same reason, the base was modeled with four holes. The thread from the pulley system was placed in one hole, while some transparent fishing line was taped vertically taut through another. This prevented the avatars from swinging out of the range of the ultrasonic sensors. Like before, the avatars were 3D printed in the same silk gold PLA to fulfill our needs for custom geometry. 3D printing also allowed us to keep our parts light with enough weight to exert a small tension on the thread.

Custom Robot Controller

In the winter of 2019, as part of my high school's competitive robotics team, we sought to create a custom control box for our robot.

In the past, we used an XBox controller to activate the substantial number of mechanisms on our robot during competition, but the learning curve was steep: mapping the XBox controls to the robot was not intuitive. That meant our human robot driver took longer to learn the controls, wasting precious time during competition season.

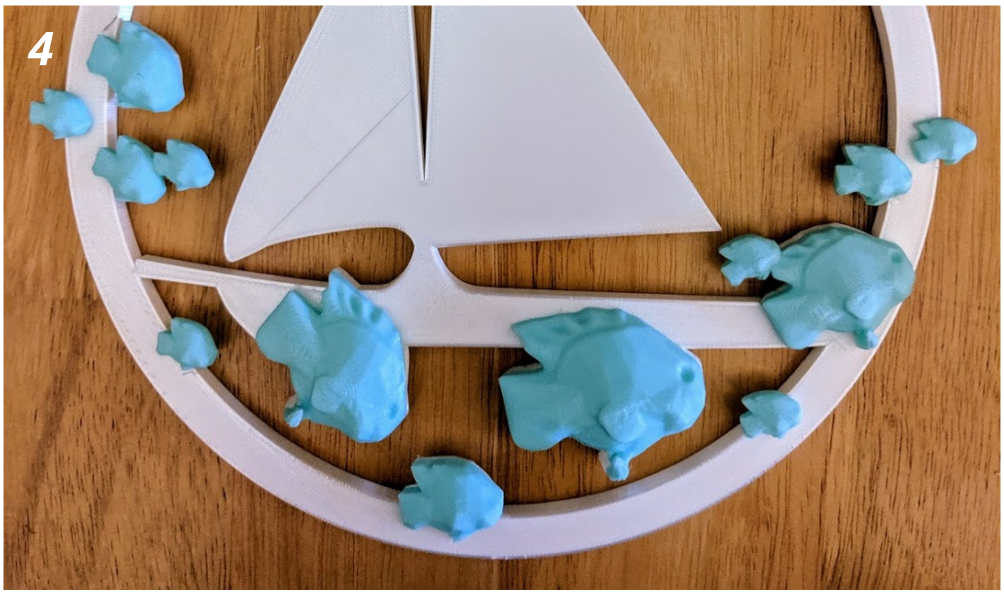
That year, to reduce the learning curve, we chose to create a custom control box made of laser cut sheets and 3D printed box corners. I designed the physical aspects of the control box and soldered its components to the Arduino Leonardo that powered its functions.

The laser cut sheets were created in Adobe Illustrator, with labels and diagrams engraved to optimize its intuitiveness. Mounting spots were laser cut for the buttons, switches, LCD screen, and linear actuator required to drive the mechanisms on our robot. The engraved top interface was made out of clear acrylic mounted on top of a black acrylic sheet to enhance visibility.

The box corners were 3D printed out of carbon fiber filament on a Markforged Onyx One, with nuts embedded midway through printing to allow the acrylic sheets to be screwed onto each corner. The entire control box is angled down, like a trapezoidal prism, so the controls can be easily seen.

Sculptures in Five Different Programs

Four sculptures made in ZBrush, Autodesk Inventor, Adobe Illustrator, Cinema4D, and Autodesk Meshmixer.



In the summer of 2019, I explored the intersections between five very different programs: ZBrush, Autodesk Inventor, Adobe Illustrator, Cinema4D, and Autodesk Meshmixer. I was already familiar with Autodesk Inventor from my work building robots -- it was a very technical program suited for mechanical applications.

I began my exploration into more organic 3D modeling with an incredibly ambitious project -- sculpting a human being. I started out with Cinema4D, a primarily animation-driven software. With its algorithms, I could model the behavior of fabric falling across the human form. However, Cinema4D still leaned more technical than organic, especially in its sculpting features. It was difficult to manage the divisions in the model's mesh to increase or decrease detail when needed. The end result was a stoic figure mounted on a base (modeled in Autodesk Inventor), printed in wood PLA and stained two different colors (Figure 1).

I quickly realized Cinema4D was not the program I needed -- I was looking for a software that would produce organic models much quicker. My second project was an experiment in ZBrush, modeling a decorative bookend inspired by my mother's favorite animal. Immediately, ZBrush's DynaMesh tool differentiated itself from Cinema4D, allowing a sculpture to be built quickly and intuitively. The base of the bookend was modeled in Autodesk Inventor, which still was best for more precise applications (like setting the thickness of the bookend's base). The two parts were simply overlaid in Prusa Slicer, and printed in marble PLA (Figure 2).

Fully comfortable with ZBrush, I modeled a more detailed sculpture -- the logo of my robotics team, a hawk with a gear balanced atop it. The entire sculpture was made in ZBrush, although the small size and the high detail of my print proved somewhat difficult for my FDM printer to handle at first. The end result was printed in silver PLA (Figure 3).

My final project was a piece of wall art for a friend who had owned blood parrot cichlids for many years. The fish themselves were modeled in ZBrush, while the sailboat base was drawn in Adobe Illustrator and extruded in Autodesk Inventor. To create the low poly look of the fish, the mesh detail of each one was reduced in Autodesk Meshmixer. The two parts were then combined in Meshmixer, which allowed the fish to be resized and repositioned easily. Finally, the base was printed in silk white PLA, switching over to teal PLA for the top fish layers (Figure 4).

Figure 1. A sculpture of a human mounted on a base with a sword. Modeled in Cinema4D and Autodesk Inventor. Printed in wood PLA and painted with two different colors of wood stain.

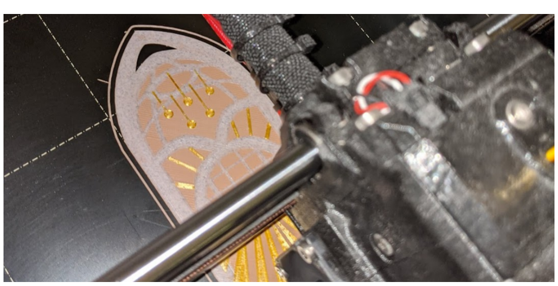
Figure 2. A bookend with a decorative tiger. Modeled in ZBrush and Autodesk Inventor. Printed in marble PLA.

Figure 3. A small sculpture of a hawk with a gear on top, meant as a keychain. Modeled in ZBrush and printed in silver PLA.

Figure 4. Wall art of fish swimming past a sailboat. Modeled using ZBrush, Adobe Illustrator, Autodesk Inventor, and Autodesk Meshmixer. Printed in two different colors of PLA.

Infill/Color Bookmarks

AN EXPLORATION INTO COLOR CHANGE AND INFILL PATTERN



In the summer of 2020, I wanted to explore 3D printing's potential to create 2D art -- specifically, how layer-based color changes and infill patterns could create 2-dimensional art pieces that are uniquely products of 3D printing.

With a printer with only a single extruder, my ability to change colors on a single print was limited to swapping out the filament between layers, which made it optimal for 2D art pieces.

To test it out, I created a series of bookmarks. Each layer was drawn in Adobe Illustrator, and extruded to different layer heights in Autodesk Inventor. The first few prints were simply layer-based color changes: silk gold PLA sunflowers on a black PLA blackground, black PLA power lines in front of a wavy silver PLA ground and moon against a light pink PLA sky, and silk gold PLA and marble PLA structures against a wood PLA blackground inspired by the Penn Station of the 1900s.

The later prints had each top layer set as an infill type: Archimedian Chords and 0% for the sunflowers, and Octagram Spiral and concentric circles for the power lines, creating bookmarks very representative of my appreciation for 3D printing and additive manufacturing.