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Robotic Hand

Synopsis

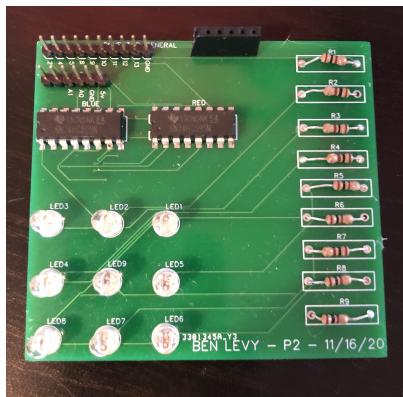
My goal for this project was to build a robotic hand that can be implemented in real-world situations.

First Prototype Video: <https://youtu.be/pxXw7kwlrp0>
Final Prototype Video: <https://youtu.be/0LL9Cf hTjM>

Introduction

My name is Ben Levy. I'm a junior at Fremont High School. During the summer I took a summer camp at Cal-Poly (E.P.I.C) which focused on Arduino. This introduction to Arduino gave me the opportunity to begin experimenting with it myself.

After creating some simple projects, I decided to make Tic Tac Toe using LEDs, buttons, etc.... After creating it with breadboards I designed a PCB and had it printed. It took a few iterations but eventually, I had created a working PCB. Here is a picture of the final PCB with the component



soldered on:

Once I finished this project I really wanted to experiment with some new electronic components and focus on motion. I included my friend, Yash Athma, and we started with a servo motor connected to an Arduino and created a working finger, controlled by a computer. This gave us the idea to create a glove that senses your finger's movements and replicates them on a robotic hand.

Objectives

- Accurately measure finger movement
- Replicate a human hand's movement in a robot

So far I have...

Prototype 1

I began by creating the output hand. This took a few iterations to decide which materials to use and I eventually found a type of foam that I could shape easily and accompanied that with a spring with matching properties. I constructed a hand with these fingers and routed strings from the top of each finger, through the palm. These strings were then connected to servos. I connected the servos to an Arduino and created a base for the hand.

Next, I began to work on an input hand. I used an old glove and created a sensor, using potentiometers and rubber bands, which could sense the finger's movement. I created one of these for each finger and connected all of the outputs of the potentiometers back to the Arduino's analog input. This gave me the position of every finger with some level of precision.

I wrote a simple microcode in Arduino which translated the potentiometer's inputs to commands for the servos.

This created a working robotic hand but with many problems. These problems came in the form of complications with wiring, fingers not returning back to original positions due to faulty springs, problems with string routing, inaccurate potentiometer readings, and much more.

Some of these problems I fixed with a redesigned routing system, but the biggest problems were with the potentiometers. I tried to fix them using varying strategies, such as redesigning the sensor assembly, using different materials, but the potentiometers still lacked sufficient precision. This prompted the change to linear potentiometers for prototype 2.

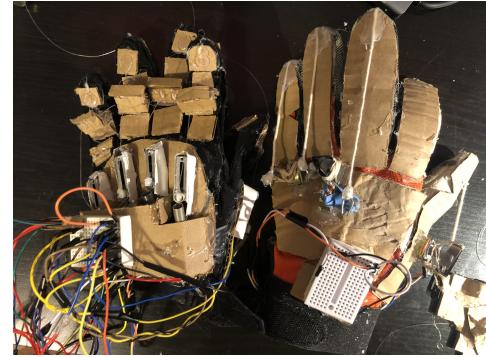
Prototype 2

For our new input glove, I used linear sliding potentiometers, with a spring instead of a rubber band. After a few tests, I realized this would be a massive improvement. Continuing this strategy I changed the way the cardboard was positioned, to give the hand more flexibility, and made connectors to make the wiring more simple.



This new design yielded much more precise and accurate results and lacked many of the problems the first did. It allowed me to match the input finger's position perfectly to the robotic finger. A problem that arose in the development of P2 was the fit of the fingers. When bending your finger the glove which held the line rotated around the finger leading to inaccurate readings. To fix this I added cardboard crutches around the finger to build stability when bending the finger. This is our latest input glove but I have ideas for improvement for the third prototype.

Lesson learned for the next prototype: I needed to work on the new output robotic hand. I'm testing new fingers with more robust springs, a simpler routing system, and a different stronger type of foam. I also plan to use stronger servos and integrate them into the robotic hand.

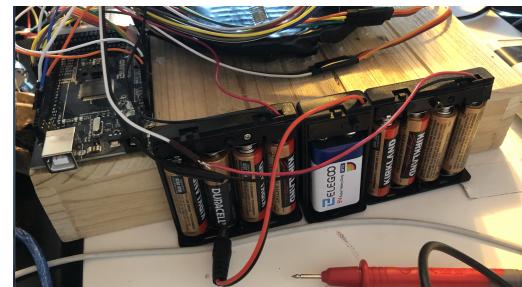


Final Prototype

The final prototype had various improvements. The basic idea was the same, with the use of the same output hand system as the previous prototype, just with much more robust parts.

The first improvement came in the form of implementing more powerful servos. With this implementation, a new problem with voltage began to occur. The arduino with a low output of 5v and 1A was not able to handle the 7 new powerful servos. I solved this problem by boosting the power with external batteries.

The next improvement was incorporating wrist movement. This movement was controlled with a servo. This improvement created a new problem with line tension. I used lines connected to a servo to move the fingers and the increased tension from the movement of the wrist created unwanted finger movement. To fix this I wrote a script that adjusted the fingers' servo's angle in respect to the wrist's rotation. This worked as active tensioning and provided more precise finger positions as the lines were always tensioned to the same amount.



Another feature I added was incorporating an "elbow". This elbow used a servo on the base to provide rotation capabilities. I also used a powerful servo near the bottom of a "forearm". This feature created a new problem. Although, this servo was powerful

the leverage of the weight of the arm was too much for it to move. I used a spring on each side to help reduce stress on the servo.

This final prototype was much more realistic and its varying features helped create a much greater robot!

Things I have learned

This project gave me so much helpful experience. I learned many aspects of mechanical, electrical, and software engineering. I learned the engineering process and how to creatively problem-solve. I enjoyed this project so much and I'm thrilled with the completed product.