Building a Prosthetic hand with Microcomputers and Sensors

SUU SUCCESS Academy

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Introduction

In my 2022 SUCCESS Science Fair Project, I am building a Prosthetic Hand using Microcomputers and Sensors. The goal of building this prosthetic hand is to make a prosthetic hand that can complete many functions that a normal hand would be able to perform, and functions that other, more expensive, prosthetic hands can perform.

This Prosthetic hand's goals are to complete functions that a normal hand could so that people who need a prosthetic hand will be able to complete many of the same functions that someone else with a hand would be able to do.

Another one of the goals of the prosthetic hand is to be able to be much cheaper compared to a normal prosthetic hand that can do the same functions. To do this, we will use normal plastic filament but make sure that it is strong by using one of the strongest 3D Printing designs by having it print in a hexagon pattern.

For this project, we will be combining engineering of the hand itself using CAD/3D Printing with programming (python code) so that we can create a hand that can complete many of the same functions and tasks that a normal hand/expensive prosthetic hand can complete. This includes the following tasks. Pick up an item. Hold a pencil. Shake someone's hand. Make a fist. Tap or Push Buttons. Point. Show numbers using the fingers. Show hand gestures.

The point and the goal of this hand are to make a prosthetic hand that in theory would be much cheaper compared to a normal prosthetic hand of the same ability. This would allow people that need a prosthetic to have one in a much more affordable manner, this project is simply to help a problem that needs more addressing, and that is the point of this project, to address and attempt to fix those problems.

Materials and Methods

Methods

For the project, the first step was to assemble my materials. Some of those materials are including the 3D Printed project files, so I also had to print those out using a 3D Printer. The next part was to assemble the hand together. Once the hand was put together using screws and fishing line, the next step was to put the Raspberry Pi Inside the hand so that it can still be plugged in correctly. The best way that was found to do this is to have the USB ports that Microbit, Mouse and Keyboard all plug into, inside the hand part, with the rest of the Raspberry Pi (the HDMI and Micro-USB Port and the Micro SD Port) facing outside the hand part and above the gauntlet. Afterwards, the goal was to assemble each of the 5 motor driver boards inside the gauntlet, on the side walls, so that all the wires from the motors can go through the top of the gauntlet. Afterwards, the goal was to assemble each of the 61 individual Male-to-Male, Male-to-Female and Female-to-Female wires from the driver boards into the dedicated GPIO pins on the Raspberry Pi and into the power. Afterwards, we connected the touch sensors to the middle of the hand from the thumb phalange to the other end of the hand using some of the Erector Set pieces as well as zip ties. Afterwards, connect the sensors to the power, ground, and dedicated GPIO Pins on the Raspberry Pi. After that has finished, we carefully wrapped the entire hand up with medical wrap so that the wires would not be able to move and get dislodged, and so that the touch sensors would work whenever anything comes against it. Afterwards, connect the motors to an Erector Set Base Platform so that you can have the strings (fishing line) wrap around the motors and then connect the base platform to the hand by using zip ties, bolts, and screws.

The next part of the project was to put in the code. We use python to create files that can move the motors, receive data from the serial data from the Micro:Bit, and to receive data from the touch sensors. After this is done, use the Micro:Bit data codes, such as B’1’ to make functions that use the motors to do the selected tasks, such as shake someone’s hand, push buttons, and more.

Materials

- Raspberry Pi 3B+
- Microbit
- 3D Plastic Filament
- 3D Printer
- Stepper Motors
- 9V Batteries
- Mini-Breadboard
- Monitor
- Keyboard
- Mouse
- USB Drive
- Elastic Rope or Rubber Bands
- External Computer
- Micro SD
- Touch Sensors
- Conducting Wires (male to male, male to female, and female to female)
- Electrical Tape
- Screws of Various Sizes
- Medical Wrap
- Erector Set

- Zip Ties
- Fishing Line
- Gloves
- Multi-Tool/Knife
- Lighter
- Drill and Saw

Results

Tasks:

Test	Result
Pick Up and Item	Successful
Hold a Pencil	Successful
Shake Someone's Hand	Successful
Make a Fist	Successful
Tap or Push Buttons	Successful
Point	Successful
Show Numbers Using the Hand	Successful
Show Hand Gestures	Successful

Code:

Display Serial Data from Microbit:
B'1' = True
B'2' = True
B'3' = True
B'4' = True
B'5' = True
B'6 = True
B'7' = True
B'8' = True
B'9' = True
B'10' = True
B'11' = True
B'12' = True
B'13' = True
B'14' = True

Motor Left and Right Results:
Motor 1 Left = Successful
Motor 2 Left = Successful
Motor 3 Left = Successful
Motor 4 Left = Successful
Motor 5 Left = Successful
Motor 1 Right = Successful
Motor 2 Right = Successful
Motor 3 Right = Successful
Motor 4 Right = Successful
Motor 5 Right = Successful

Fingers Movability:
Finger 1 (pinky) = Good

Finger 2 (ring) = Moderate

Finger 3 (middle) = Moderate

Finger 4 (pointer) = Good

Finger 5 (thumb) = Moderate

Discussion

This project had many ups and downs throughout it, including many times messing up on altering the files to print the hand, messing up on getting the code to work correctly and even completely almost catching the entire project on fire. Afterwards though, after a lot of time and work, the results had been gathered.

The First table in the results represents the functions that the hand was set to do. The left side of the table is the list of the functions, and the right side of the table is the result of that function. Overall, everything ended up being successful, however, it took a lot of time to perfect the code to be able to complete the functions. One of the ones that took the longest would be picking up a pencil. Because pencils are so small and you must have such a specific grip on them, it took a lot of time to pick up the pencil and be able to hold it, however, we aren't able to conclude that it can write with that pencil.

The next set of results would be the "Display Serial Data From Micro:Bit", this would be a basic part of the project and would be when we coded the Micro:Bit to send serial data to the Raspberry Pi Via USB. All the 14 different data entries that we can collect were successful (aka. True). For the part next to that, which would be, "Motor Left and Right Results", this would be where we tested to see if the motors could move both directions using code. Each motor was able to successfully work, however, motor 2 did seem to have some problems, but this is most likely due to manufacturing defects.

The final set of data that was recorded was if the fingers were able to move well with the motors. Most of the fingers worked quite well with this except sometimes they would get a little stuck. We concluded that the reason they would get a little stuck was due to the strings weren't able to pull correctly, and/or the screws were pressing up against each other a bit.

Conclusions

As for conclusions in the project, the goal of the project was to create a relatively cheap prosthetic hand that would be able to complete many of the same functions that a normal hand or an expensive prosthetic hand would cost. In relation to a normal prosthetic hand, the average prosthetic hand in the world costs around "without insurance you can expect to pay around $5,000 for a cosmetic prosthetic, $10,000 for a functional prosthetic with a hook, and between $20,000 to $100,000 for the latest myoelectric arm technology" (Medical Center for Orthotics & Prosthetics). Before we compare, let me explain what "Myoelectric technology" is. "' Myoelectric' is the term for electric properties of muscles" (Ottobockus). This means that Myoelectric Technology in prosthetics is replicating the muscle properties and how the muscles move in the actual body. Now compared to just a simple 3D printed prosthetic hand, it costs "as little as $50" (Riedel) to create one of these. My project in comparison to the functionality of the hand is between the prosthetic with a hook and the myoelectric arm technology. This means that my hand can complete functions that are a little more advanced than the hand with a hook, but a little less advanced than the hand that uses myoelectric technology. Now in comparison to pricewise, what would usually cost around $9,000-$40,000 (plus or minus some), would cost the consumer of my hand $105 to be created. The median of 9,000-40,000 is $24,500. $105 out of $24,500 is about 0.429% of the cost.

In conclusion, this project has seemed in that it has completed the goal of being a relatively cheap prosthetic hand that can complete many of the same functions as a normal or expensive prosthetic hand. The project has been able to do this by using cheap, but strong parts and using code to achieve only 0.429% of the cost relative to other hands and has been able to be quite functional relative to normal hands and expensive prosthetic hands, as seen by the results.

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