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Robotic Prosthetic Hand

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VIRGINIA TECH

Background

Our customer Renee has a **partial hand amputation**, and we were tasked to make a **robotic prosthetic hand** for her that is capable of the following:

- **Basic functionalities** of a human hand
- Performing **everyday tasks** like pointing or holding objects
- Being **comfortable** for long periods of time

Requirements

Product Objectives

- Hold large objects with two hands
- Hold smaller objects with one hand
- Be safe, comfortable, and easy to use

Other Requests

- Perform hand gestures, like pointing and the birdie
- Put hair up with hair ties
- Light a handheld lighter

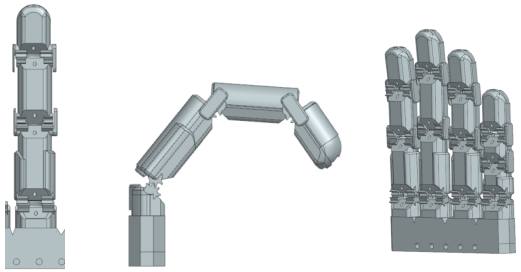
Challenges

- It took many iterations to achieve a good balance between cable routing, motor strength, friction, and pulley system layout for a smooth operation
- Our customer, Renee, needed another surgery on her hand in March, so our design was no longer custom fit, and she wasn't able to test the final product due to being in recovery

Design Breakdown

Fingers

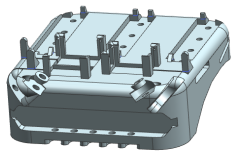
- Fingers design to emulate human
- Cable Driven
- Designed to form around objects when activated
- Lightweight → 3D printed
- Adjustable Design



Hand Piece

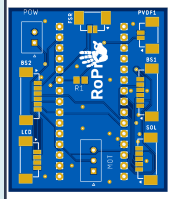
The hand piece is a **cast** that is situated on the **back of the hand**. The lever system allows it to be **underactuated** while enabling a **self-adjusting grip** when holding items. The solenoids drive the **braking system** for the cables, allowing **multiple synergies** to be achieved in an automated fashion.

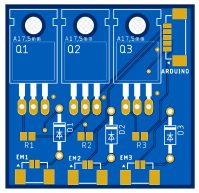
- Lever system
- Pulleys
- Solenoids
- Cable routing components



Wrist Piece

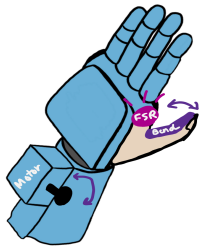
This piece of the design houses the **electronics** for the hand. A PCB, we call our **"Sensor Board"**, was designed to act as the interface between an **Arduino Nano** and the sensors. There is a board that powers the solenoids, **"Solenoid Board",** and an **OLED display** to communicate with the user.





The sensors on the robot include:

- **Force sensitive resistor**: user taps to change modes
- **Bend sensor**: tracks movement of user's thumb so motor can mirror that motion
- **Motor feedback**: tracks angle of motor



Results

Engineering Characteristic	Unit	Marginal Value	Ideal Value	Final Value
Finger Degrees of Freedom	# DoF	3	4	3
Grip Strength	lbs	10	20	X
Attachment Strength	lbs	10	20	20
Weight	lbs	3	1	X
Number of Synergies	# synergies	1	4	X
Time for Actuation	s	3	1	X
Interface Temperature	°F	100	98	X
Hours without Discomfort	h/day	6	8	X
Cost of Hand	$	5,000	1,500	1,600
Steps until Actuation	# steps	3	1	2
Battery Life	h	4	8	X

Conclusions

- It is difficult to make a successful cable-driven product that is strong enough due to motor limitations
- The cable routing should have been much more prioritized since it ended up being the biggest source of issues
- Some heavier signal processing might be useful to combat the sensitivity and noise of many of the sensors

Future Work

The files and research put into the project this year will be passed off to Renee, and her dad—who is also an engineer—will continue to improve the design and make it overall more comfortable and helpful for Renee once she is more ready to use a prosthetic.

Acknowledgements

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