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Group 1

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Development and validation of a low-cost functional myoelectric hand prosthesis

Background

- Almost 2 million people in the United States live with limb loss of some form. Limb loss can be the result of a congenital birth defect or can be acquired as a result of a disease or trauma event.
- It is very common for a prosthetic user use their fitted prothesis for a year or less which is labelled as device rejection. Device rejection occurs due to dissatisfaction of ease of control and reliability, as well as performance, comfort and overall function.

Approach

- The team wants to design and validate a low-cost, open source, and highly functional hand prosthesis that can be fabricated using commonly available materials and 3D printing.

Deliverables

Hardware

Mechanical

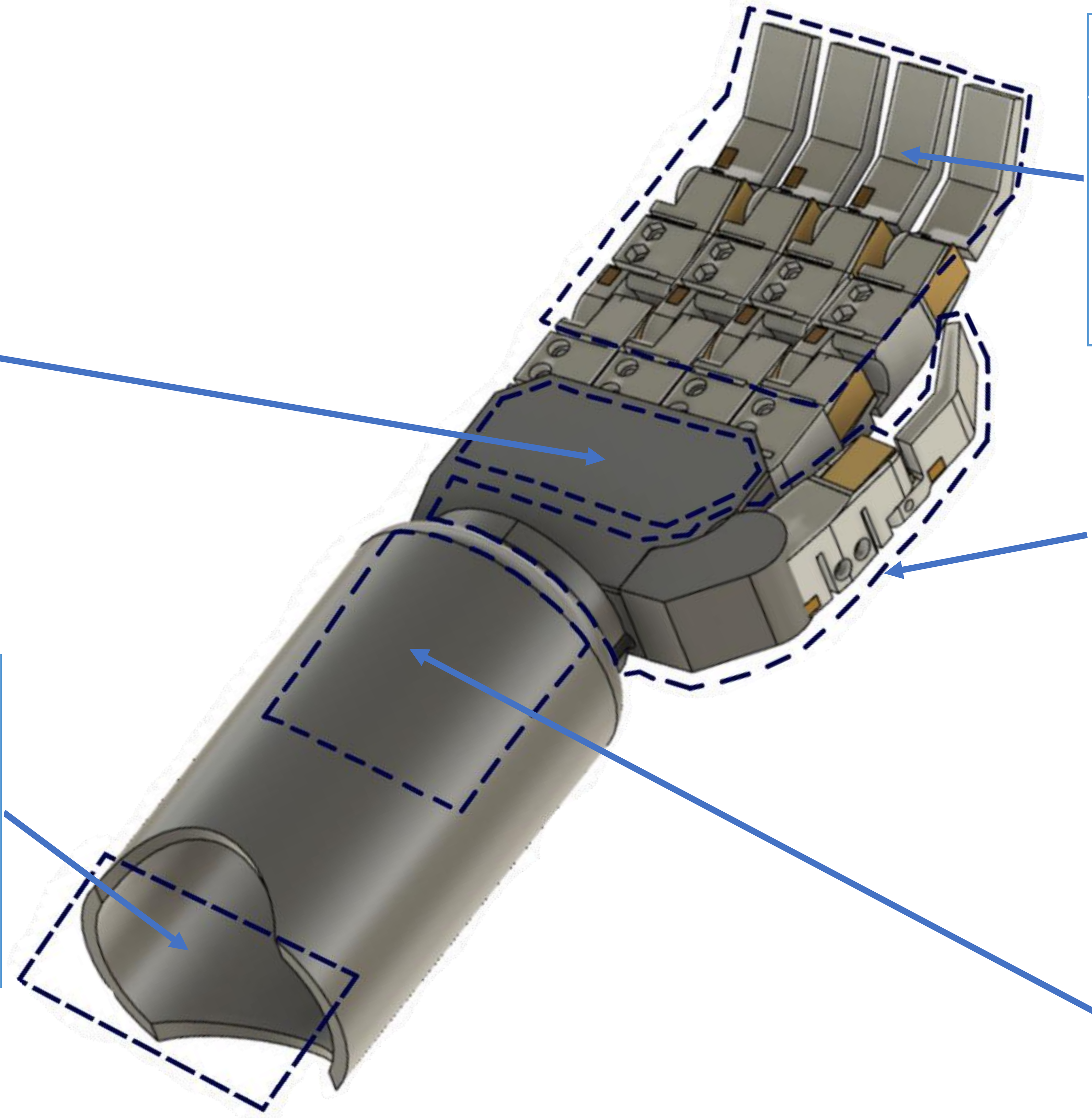
- 3D printed components
- 5 fingers with 2 degrees of freedom each
- Wrist joint with a single degree of freedom
- Palm

Electronics

- Force Sensors for force myography and torque feedback
- Position sensors for position feedback
- Effectors (DC motors and servos)
- Controllers (ICs and microcontroller)

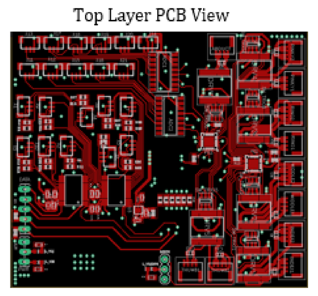
Software

- System to interface with hardware
- User-friendly interface
- Adaptable system
- Open-source

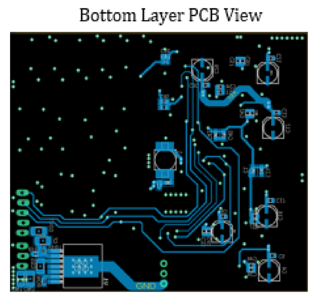


Hand PCB Components

Top Layer PCB View

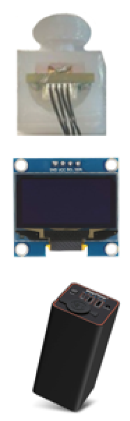


Bottom Layer PCB View



- 6.8 V converter to drive wrist servo.
- Analog to Digital converters for strain gauge amplification and absolute position sensors.
- Motors drivers.
- Port expander to route multiple inputs from the motor drivers to one concise output for the microcontroller.

Off-Board Forearm Components



- Force Myography Sensors (FMG) to measure the force generated by muscles on the forearm. This force will be used to determine hand position along with other sensor feedback in the fingers.
- OLED screen and buttons for a user interface on the forearm. A calibration routine and system power control are the primary functions.
- 12 V Battery to supply input power for the system.

Finger Components

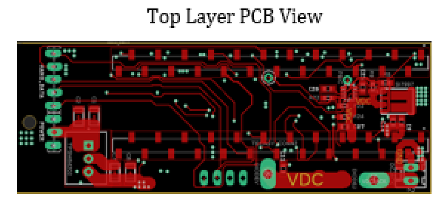
- Two 12V DC motors per finger situated between knuckles to drive the fingers.
- Absolute position sensor (APS) on the motor shafts for precise position control.
- Strain gauge to detect force applied on fingers and to adjust motor speed and applied torque (to prevent a weak grip, or an overly forceful grip).

Thumb and Wrist Components

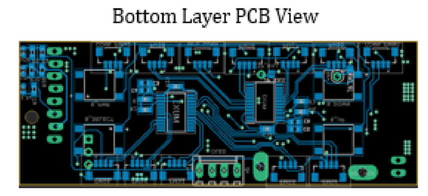
- Accelerometer to monitor wrist angle determining whether the wrist needs to pronate or supinate.
- 6.8 V DC motor to rotate the wrist.
- 12 V DC motor to adduct/abduct the thumb.

Forearm PCB Components

Top Layer PCB View



Bottom Layer PCB View

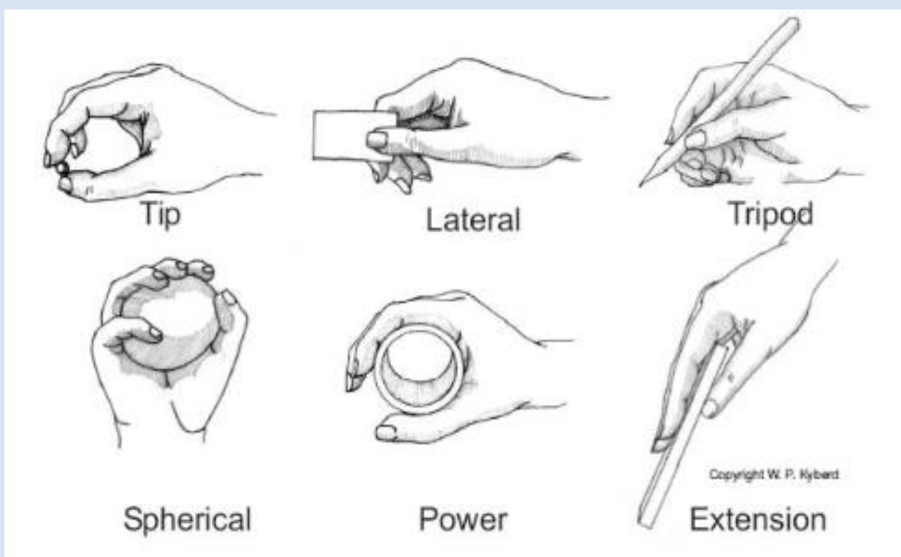


- 3.3 V converter for logic level voltage.
- On/Off IC to safely power the system up and down.
- OLED screen and buttons for a simple user interface.
- Multiplexer to route multiple I2C inputs from force sensors into one output accessible on the microcontroller.
- Microcontroller to perform the computation necessary for accurate position control and overall system function.

Validation

- The Southampton Hand Assessment Procedure (**SHAP**) test developers determined six different grip patterns that are necessary to complete a series of everyday activities, coined as the 14 Activities of Daily Living (**ADLs**).
- Validation of the team's design will be considered successful if the hand can complete the SHAP ADLs and grip patterns in a similar timeframe to a native human hand. Each ADL is expected to take between 1 and 8 seconds, depending on the task.
- Specific tasks were chosen because they covered the grip patterns and the highest weight (**1kg**), as well as the control requirements.

SHAP Grips



SHAP Activities of Daily Living

- Pick up Coins
- Button Board
- Simulated Food Cutting
- Page Turning
- Lifting a Light Object
- Glass Jug Pouring
- Carton Pouring
- Lifting a Heavy Object
- Lifting a Tray
- Rotate a Key
- Open/Close Zip
- Rotate a Screw
- Door Handle
- Jar Lid

Conclusion

- The completed hand prosthesis will meet the functional requirements of the test. The successful completion of the SHAP test will signify a highly functional hand prosthesis that will be open-source, to be developed by individuals at a low cost compared to market competitors.

Future Work

- To achieve the final goal of completing the SHAP test, the team will continue to develop the hand prothesis code to ensure complete system integration.

References:
Limb Loss Statistics. (2017, August 1). Amputee Coalition. https://www.amputee-coalition.org/resources/limb-loss-statistics/
Merrett, G. (2002). SHAP: Southampton Hand Assessment Procedure. SHAP: Southampton Hand Assessment Procedure. http://www.shap.ecs.soton.ac.uk/about.php
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