Integrating Detection and Activation in a Myoelectric Hand Prosthesis

Erin Cressman & Ryan Yoder

School of Science, Engineering, and Health, Messiah College, Mechanicsburg, PA

Problem Statement

Our client, nine-year-old Lily Inzey, was born without a left forearm or hand. Lily's options for prosthetic assistive devices are limited by the high cost and lack of insurance coverage of pediatric prostheses.

Figure 1: Our client, Lily Inzey

Goals

- To create a custom fitted myoelectric prosthetic device for Lily that is able to control the hand based on muscle contractions in her residual limb.
- To share the love of Christ with our client and her family by gifting her with the hand and praying for her.

Figure 2: The "Hero Arm" from OpenBionics, an example of a high-tech and high-cost pediatric myoelectric prosthetic arm (openbionics.com).

Specifications

Criteria	Goal
Weight	< 500g
Grasps	Power/Cylindrical (Fig 3)
Grip force	60 N
Grasp Speed	Close in 1.2 s
Compliant Grip	Force-Sensing Resistors (Fig 4)
Feedback	Safety Switch
Cost	< $1000
Life of Daily Use	1-2 hours continuous use
Lifetime	2 years

Figure 3: Depiction of power/cylindrical grip pattern

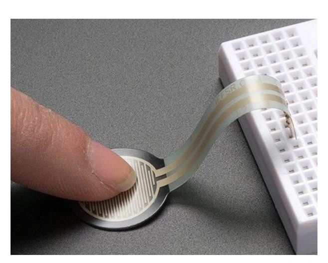

Figure 4: Force sensitive resistor that will provide feedback to the hand (adafruit.com).

Electrical Design:

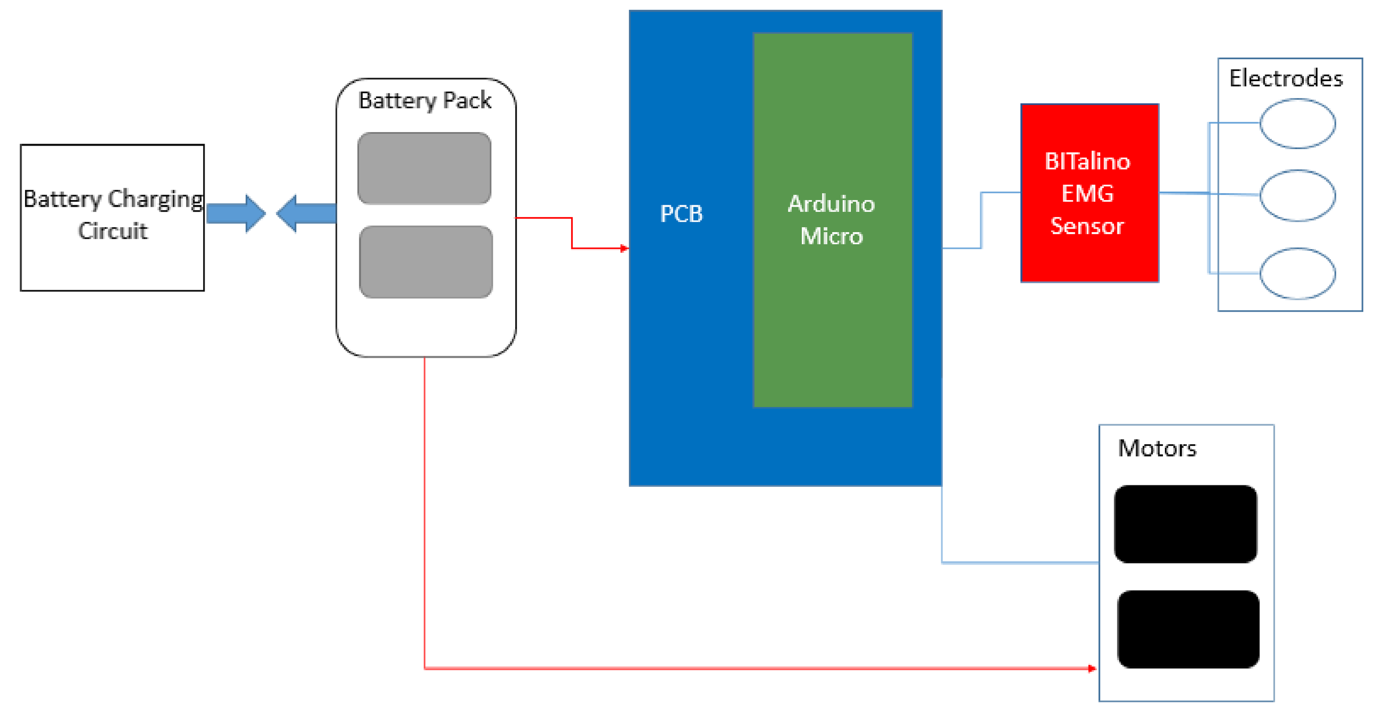

Figure 5: Block Diagram of Electrical Components

BITalino Electromyogram (EMG) sensor - reads muscle impulses from arm. Connected to the arm by adhesive electrodes.

Printed Circuit Board (PCB) – Customized to connect electrical components including the microprocessor, the Arduino Micro.

Batteries - Two 3.7 V Lithium Polymer. Rechargeable with circuit.

Motors – Two motors power hand: one for thumb, index, and middle fingers and the other for the ring and pinky fingers.

Software Design:

Our code takes the input signal from the EMG and calculates the Root Mean Square (RMS, Figure 6).

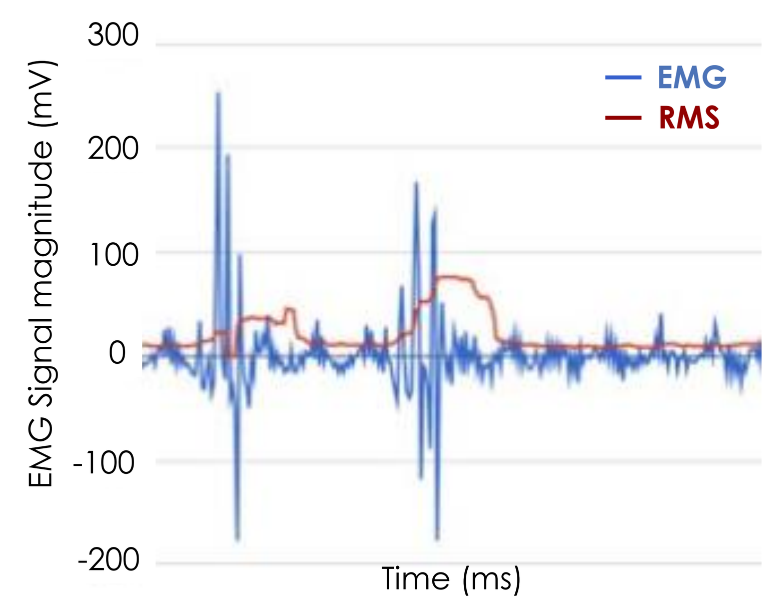

Figure 6: The muscle signal (EMG) processed by the code into a RMS signal.

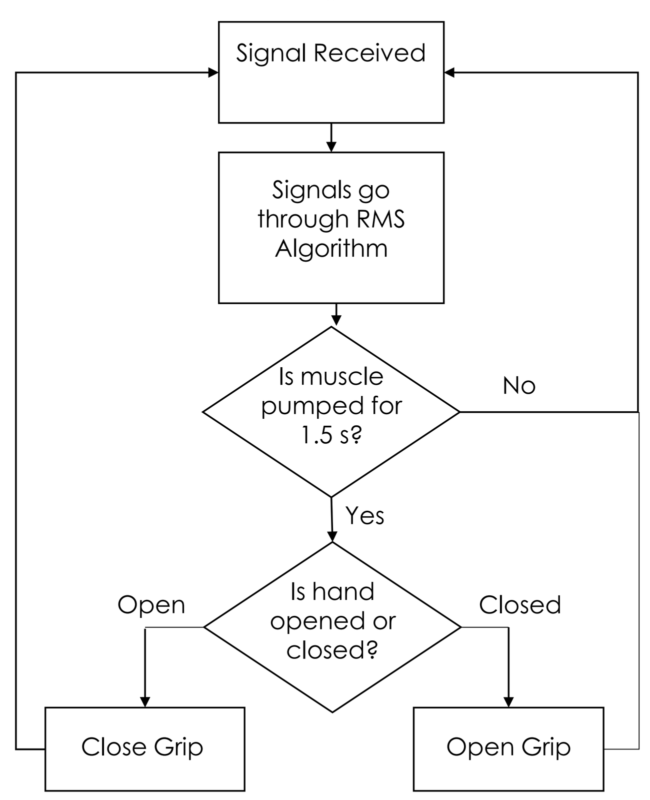

Figure 7: Flow chart of code

The code compares the RMS value to a set threshold value and if the muscle is flexed for 1.5 seconds (RMS > threshold) it switches from open to closed or visa versa (Figure 7).

Mechanical Design:

- The hand is 3D printed from soft PLA and the forearm from traditional PLA.
- For the hand to close or open, linear servo motors in the forearm of the device retract or extend, pulling on a system of tendons (Figure 8).
- A hatch allows easy access to the components (Figure 9).
- The hand connects to the forearm via heat set threaded inserts (Figure10).

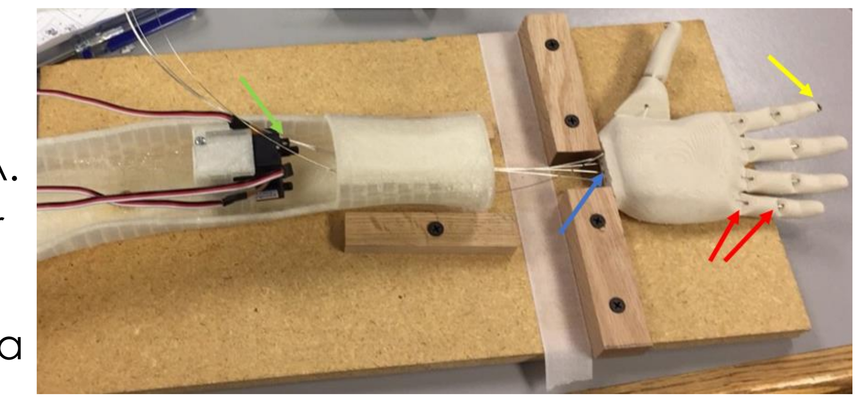

Figure 8: Guitar string "tendons" are fixed at the tip of the finger (yellow arrow), run through channels in each finger (red arrows), exit channels at the wrist (blue arrow), and connect to the linear servos in the forearm (green arrow).

Figure 9: Shows access hatch in forearm and mounts for actuators.

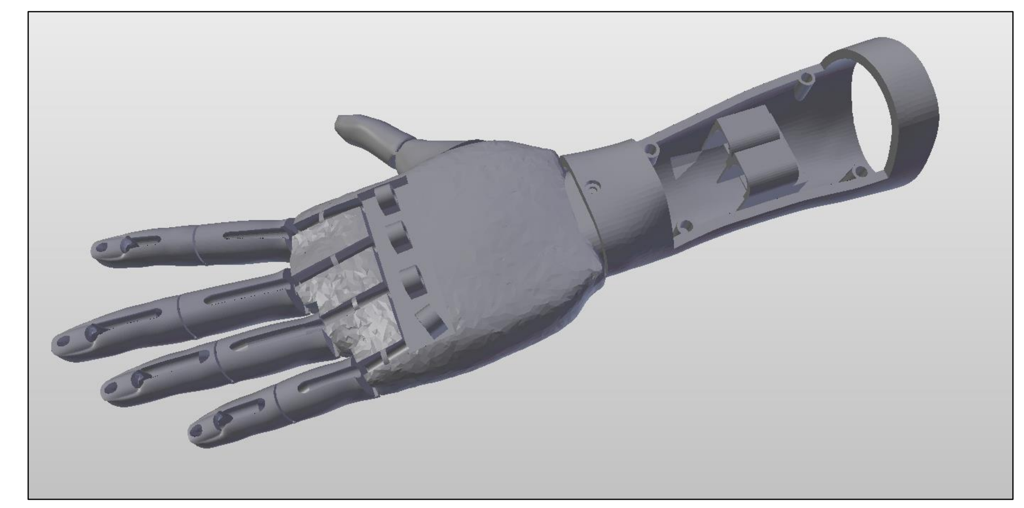

Figure 10: Shows connected hand to forearm and added slots for back tension.

Prototype and Future Work:

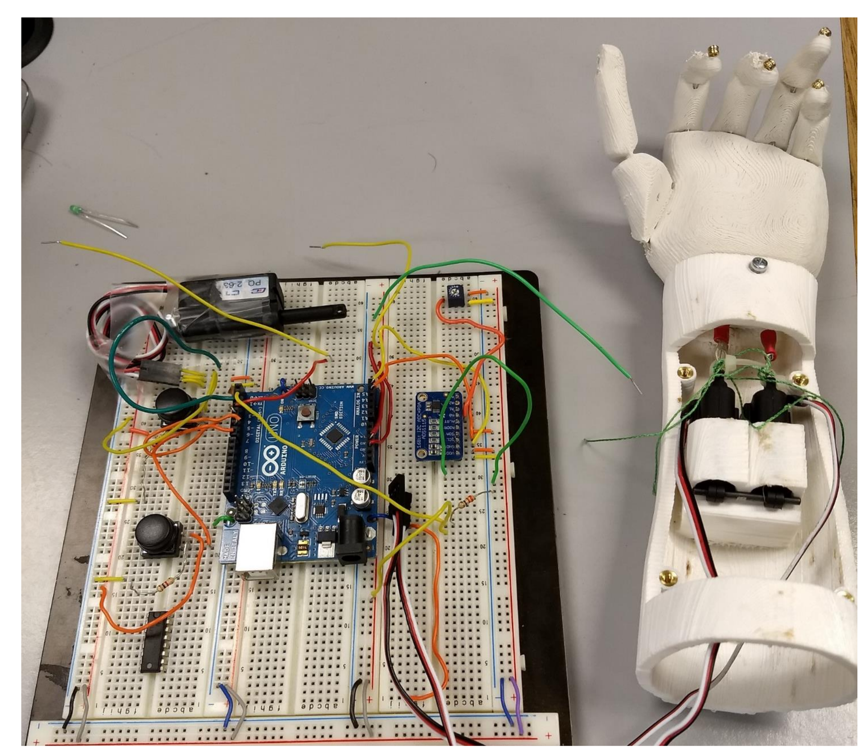

Figure 11: Current Prototype

- Implement Force Sensing Resistors to give feedback to the hand and client.
- Print, populate, and implement printed PCB design.
- Increase strength and longevity of the hand.
- Improve electrode system.
- Redesign forearm.
- Continue work on the part of the device that connects to Lily's arm (the socket), including getting her feedback on fit and function.

Conclusion

We currently have a prototype device that reads muscle signals to open and close the hand. In the future, we are working to improve the function and customize fit to our client, Lily.

Team Members

- Erin Cressman
- Sam Gulinelli
- Alaric Kobzowicz
- Keith Wei Luen Lim
- TJ Quintilian
- Sam Whittle
- Seth Williams
- Emma Workman
- Ryan Yoder

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Messiah College