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Muscle Activated 3D Printed Prosthetic Arm

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Muscle Activated 3D Printed Prosthetic Arm

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Problem Statement

Our client, fourteen-year-old Lily Inzey, was born without a left forearm and hand. Lily's options for prosthetic assistive devices are limited by high costs, lack of insurance coverage of pediatric prostheses, and the rapid growth of children's limbs.

Figure 1: Our client, Lily Inzey, testing the 2022 prototype

Goals and Specifications

1. Create a custom-fitted, myoelectric, transradial prosthesis in which the hand is controlled by muscle contractions in the residual limb.
2. Achieve the required complexity of the design while hitting the low-cost target and maintaining reproducibility.

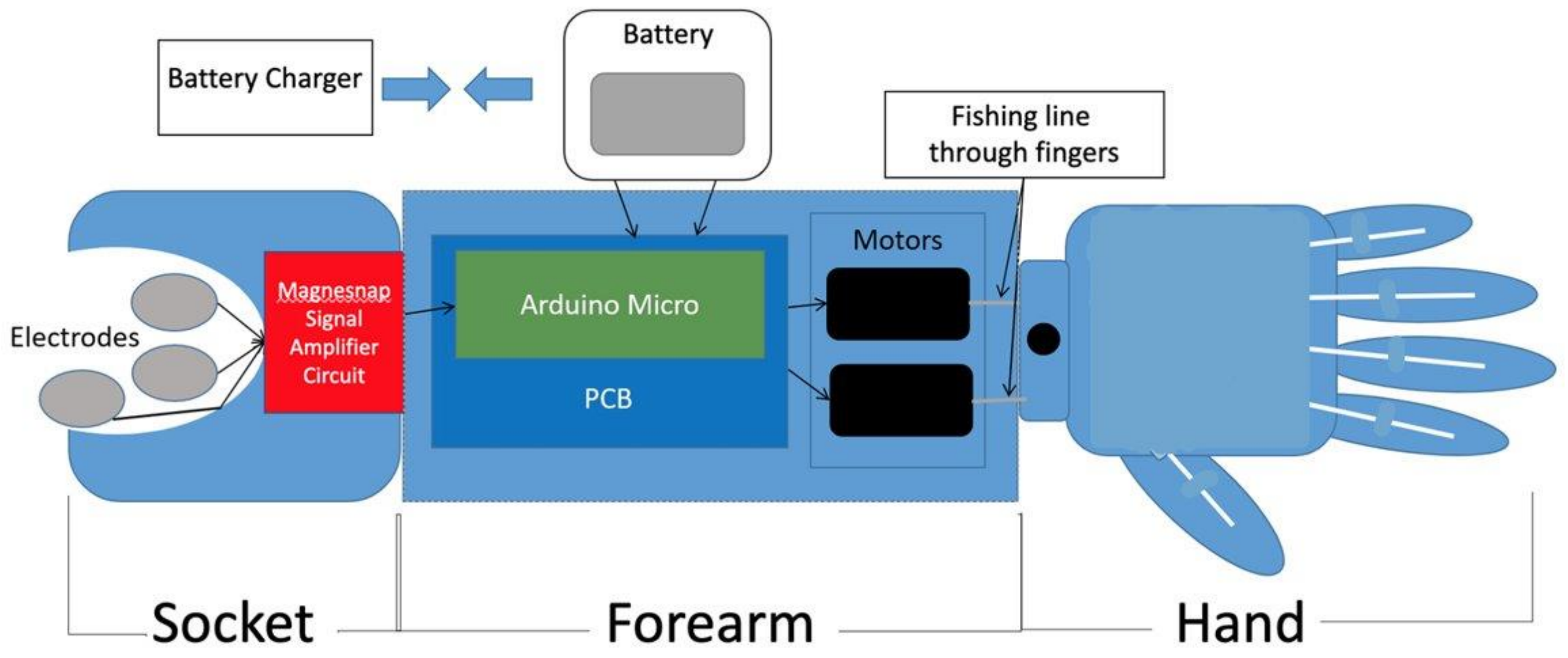

Figure 2: High-level block diagram illustrating prosthesis components

Criteria	Goal
Weight	< 500 g
Grasps	Power/Cylindrical (Fig 3)
Grip force	5 N
Grasp Speed	Close in 1.2 s
Feedback	Safety Switch
Cost	< $1,000
Life of Daily Use	1-2 hours continuous use
Lifetime	1 year

Figure 3: Power/cylindrical prehensile-pattern

Electrical Design

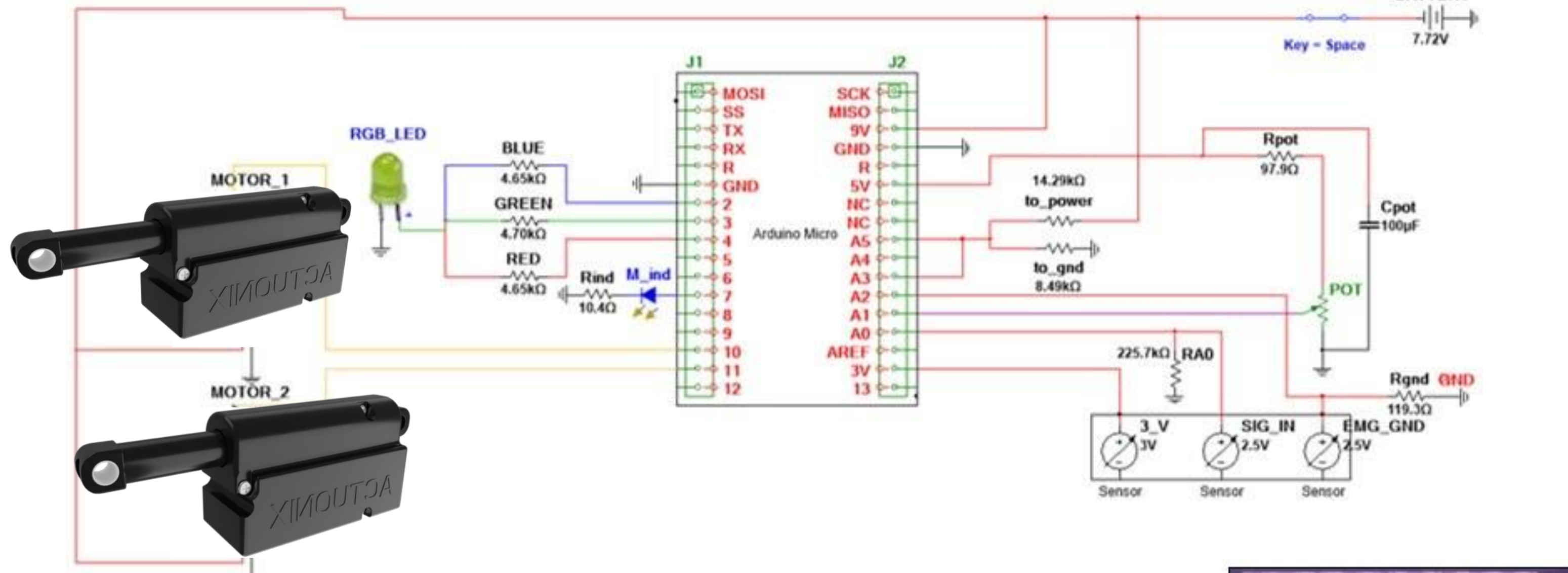

Figure 4: Diagram of internal circuitry for the prosthesis.

<u>MagneSnap Electrode System</u> - Reads and amplifies muscle impulses from the arm. Connected to the socket liner via magnets.
<u>Batteries</u> – One 7.4 V Lithium Polymer (rechargeable).
<u>Motors</u> – One motor powers the thumb and index finger, and another powers the middle, ring, and pinky fingers.
<u>Printed Circuit Board (PCB)</u> – Customized to connect electrical components including the amplifier and motors to the microprocessor to receive power and commands.

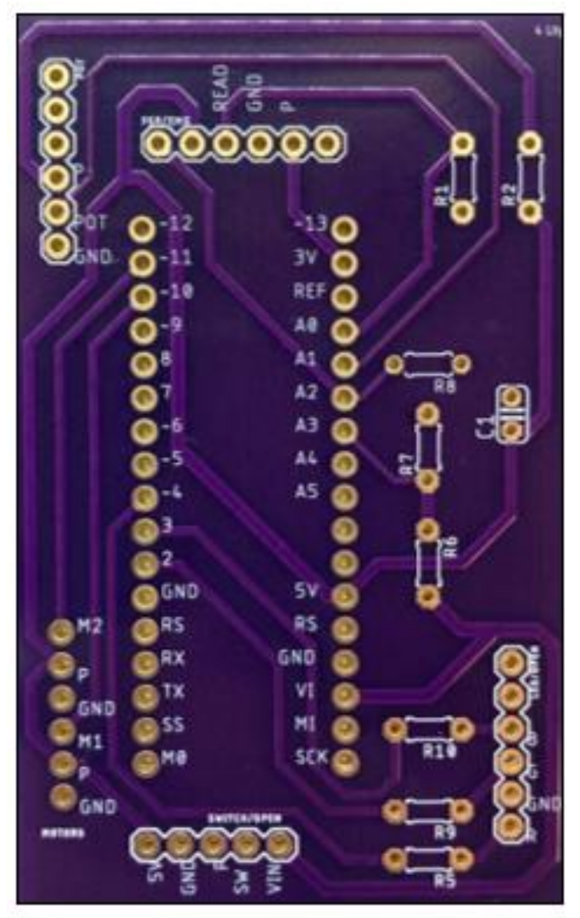

Figure 5: Layout of the PCB

Muscle Activated Prosthesis Assessment Procedure

a) Deodorant application task
b) Test with Lily's hand

Figure 6: Testing of Activities of Daily Life

The MAP team adapted the Southampton Hand Assessment Procedure (SHAP) to be applicable to our pediatric, single prehensile-pattern observing prosthesis. The procedure consists of 5 tasks, including applying deodorant, a task that our client found especially difficult. Using an "adaptive prosthetic attachment," the team created, members were able to test the prosthesis attached to their able-bodied arm. A timer was activated by the subject before and after each task trial in order to track modifications made to the prosthesis and their improvements or downfalls.

Mechanical Design of Current Prototype

The team chose to upgrade from the Open-Bionics hand model to the Unlimbited arm's hand model from eNABLE. The Unlimbited Hand's pin joint design increases the fatigue resistance of the interphalangeal joints and maintains its natural appearance with the OpenBionics palm superimposed on top.

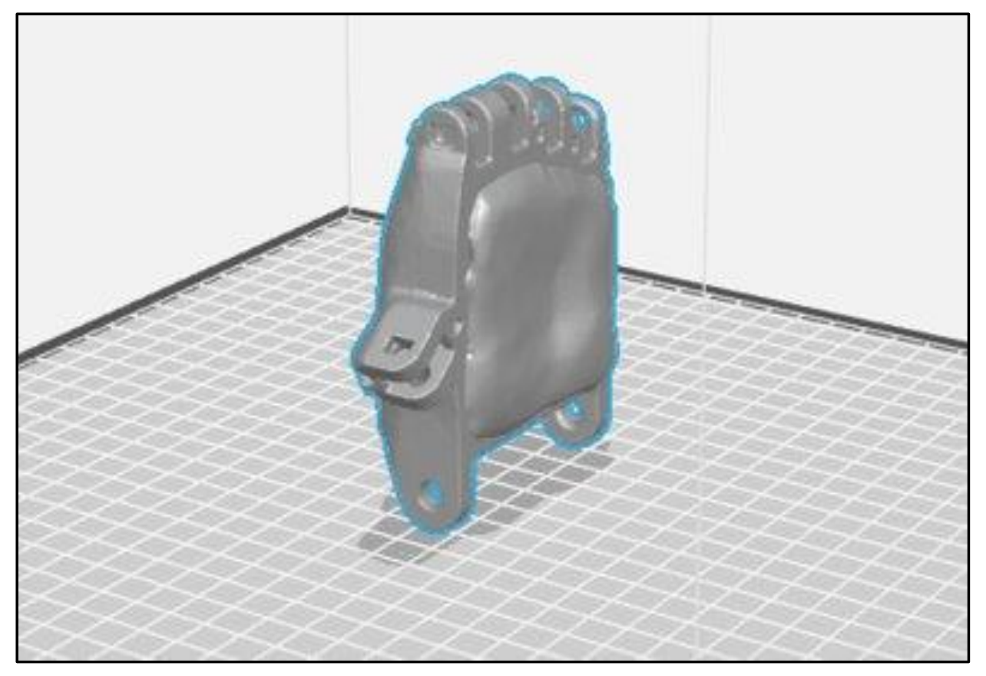

Figure 8: Unlimited hand

The 3D models are printed on an Makerbot Replicator Z18 3D printer. Pins connect the phalanges to the palm and the palm to the wrist. The three lateral-most fingers are wrapped around a screw at the ulnar-sided linear actuator, and the thumb and index finger is wrapped around at the radial-sided linear actuator; the tendons are 80-lb braided fishing line. The electrodes are threaded through the socket wall to attach to the liner magnetically, and the Velcro loops through the socket to pull the socket liner into a snug fit.

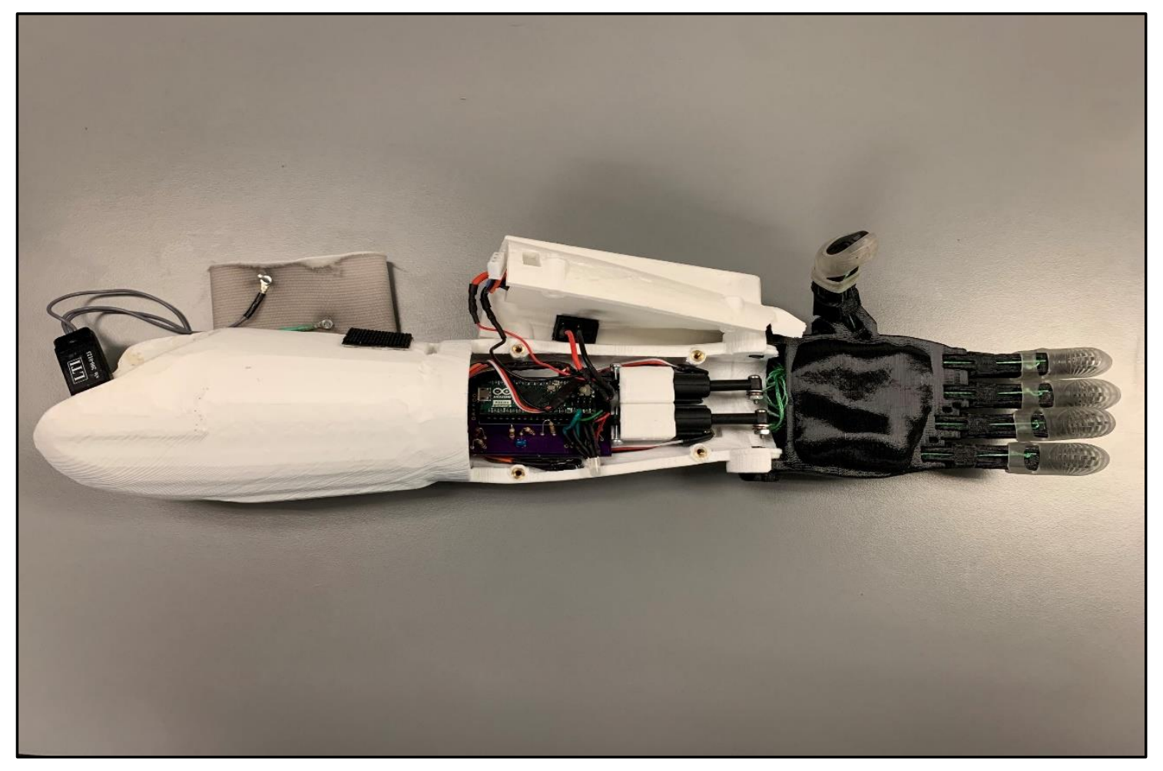

Figure 9: Current prototype

Prototype and Long-term Outlook

Following the client visit on February 19th, 2022, with our working prototype, Ms. Enkeboll and the team decided to end our partnership on this project. Lily has become very familiar with her congenital amputation and has learned how to achieve nearly all tasks without a prosthesis.

After receiving and addressing Lily's feedback, the team will transition to working with CURE International to develop a similar 3D-printed dynamic transradial prosthesis for patients at CURE International's Kijabe, Kenya hospital. The team is also looking to work with a local surgical amputee.

Conclusion

The MAP team currently has a functional 3D printed myoelectric transradial prosthesis capable of performing power/cylindrical grip on everyday objects. The prototype has been approved by our partner, Ability Prosthetics, but will be improved with motion protection and life cycle testing data in the upcoming work cycle.

Team Members

- Antonio Santelli
- Lindsay Haseltine
- Meghan Sampson
- Caleb Wright
- Jaymie Monday
- Paige Campbell

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