Design of a Muscle-Activated Prosthesis

Nicholas Ports, TJ Quintilian, Sam Whittle, and Ryan Yoder
School of Science, Engineering, and Health, Messiah College, Mechanicsburg, PA

Problem Statement

Our client, eleven-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.

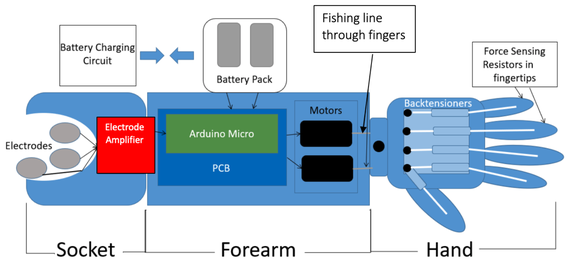

Figure 2: Block diagram illustrating the components needed for prosthesis

Specifications

Criteria	Goal
Weight	< 500g
Grasps	Power/Cylindrical (Fig 3)
Grip force	10 lbs
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	1 year

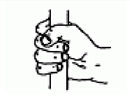

Figure 3: Depiction of power/cylindrical grip pattern

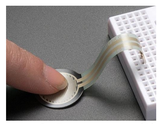

Figure 4: Force sensitive resistor that will provide feedback to the hand (adafruit.com).

Electrical Design:

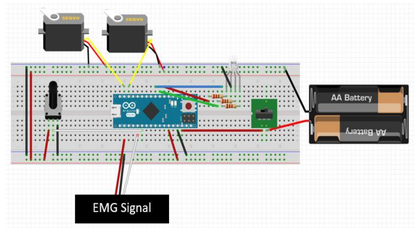

Figure 5: Diagram of the main circuitry for the hand.

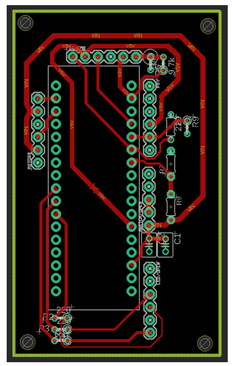

Figure 6: Layout of the PCB

- MagneSnap Electrode System- reads and amplifies muscle impulses from arm. Connected to socket liner via magnets.
- Printed Circuit Board (PCB) – Customized to connect electrical components including the microprocessor, the Arduino Micro.
- Batteries – One 7.4V Lithium Polymer.
- Motors – Two motors power the hand: one for thumb, index, and middle fingers and the other for the ring and pinky fingers.

Back Tension System:

- A back tension design is needed to return the hand to a neutral open state (Figure 7).
- Design consists of elastic string on the back of each finger tied to individual sliding blocks on the back of the palm.
- Each sliding block is adjustable via screws threaded into each block to allow the back tension to be adjustable (Figure 8).

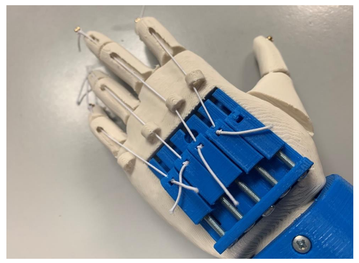

Figure 7: Fully assembled back tension system

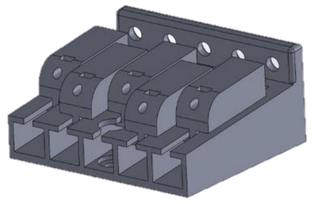

Figure 8: SolidWorks assembly of back tension system.

Mechanical Design of Current Prototype:

- Custom fitted socket for our client (Figure 9).
- Embedded into the forearm are a power switch, charging port, RGB LED to display battery level, and a potentiometer that controls sensitivity of muscle input (Figure 10).
- The forearm is 3D printed using traditional PLA and the hand is printed using Soft PLA to allow the joints to bend when tension is applied.

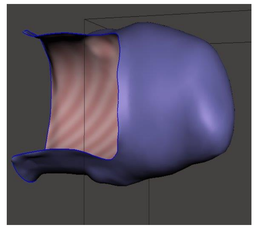

Figure 9: 3D scan of client's residual limb for socket design

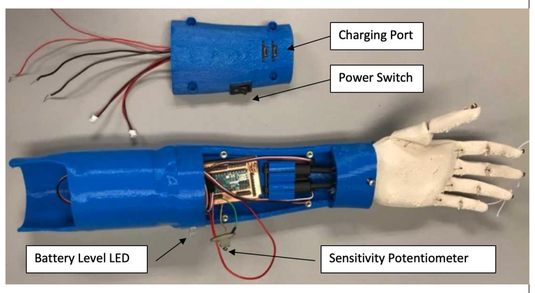

Figure 10: Current Prototype

Mechanical Design for Future Prototype:

- Redesign of the hand is needed to improve longevity and strength of the current tendon based hand design.
- New design consists of a rigid linkage system (Figure 11) that decreases points of mechanical failure, reduces energy lost to friction, and takes away the need for a back tension system.

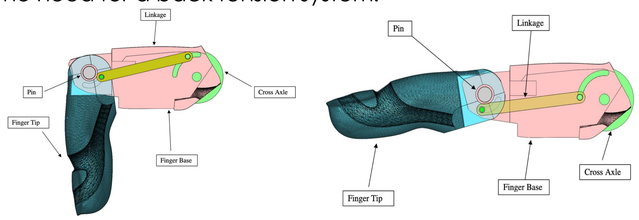

Figure 11: SolidWorks assembly of the internal linkage system used in the future prototype when the finger is closed and opened

Conclusion

We currently have a functioning device that reads muscle signals to open and close the hand. We have made plans to give Lily a prosthesis to test for several months during the summer of 2019.

Team Members

- Erin Cressman
- Nicholas Ports
- Sam Gulinello
- Ryan Yoder
- Sam Whittle
- Tess Stutzman
- TJ Quintillian
- Keller Martin
- Brittany Durben

Acknowledgements

- Dr. Eric Shoemaker
- Ability Prosthetics and Orthotics
- Dr. Emily Farrar
- Dr. Donald Pratt
- Dereck Plante
- OpenBionics
- Ms. Camille Enkeboll
- Lily Inzey

the Collaboratory for strategic partnerships and applied research

Department of Engineering
Messiah College