

University of Missouri

College of Engineering

3D Printing Club

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Printed Materials

The palm is printed using NinjaFlex TPU filament and an OpenBionics Ada v1.1 design. The back cover is a custom design printed with PLA filament. Files can be found on the club [GitHub repository](#). A M8 screw extends from the back cover for socket attachment.

Electronics Hardware

The interior of the hand houses three main circuit boards and a battery. First, the micro-USB port on the exterior of the hand is connected to a LiPo charging board to manage charging and protect the 3.7 V, 2000 mAh Lithium Polymer battery. Charging will take an estimated 4 hours from a completely empty battery. The battery will power the circuitry in standby for an estimated 20 hours, but for much shorter depending on hand use. Hand contraction draws 1.5 A of current for ~1 second, thus enabling an estimated ~3,000 contractions on a charge. This has not been verified yet.

Battery voltage is stepped up to 5V using a boost converter and routed to our main control board. This PCB hosts an ATmega32u4 using burned with an Arduino bootloader (See code section of repository). This microcontroller takes input from the myoelectric (red) EMG sensor and toggles servos (fingers) between in and out positions. The myoelectric is traditionally attached along the bicep, with the black electrode grounded on the elbow bone, or on another muscle, but any muscle can work. Further documentation about the myosensor and attachment can be found [here](#) and at the end of this document.

Peripherals also include a power switch, status LED, and hold button. The hold button, located near the pointer finger knuckle, simply holds the hand in the current state regardless of myoelectric input.

The power switch, located at the base of the thumb, for unknown reasons, takes two cycles to turn on. The first on switch will turn the status LED *bright* blue. Simply turn the switch back off and then back on. The status LED should now begin to blink a less intense blue.

Software

When the status LED blinks blue, the hand is in *training mode*. This is only entered right as the hand turns on. The hand will remain in this mode until it has processed three contractions (or spikes of EMG signal). These contractions will not toggle the finger position. How intense contractions are made during this time determines the activation threshold value, so one should not flex as hard as they can or too lightly. After three contractions, the hand enters standard *operation mode*. This is characterized by a red/green blink every 10 seconds. Now, the hand will toggle between open and closed states in response to a spike in the myoelectric. There is no

difference between action to open/close the hand, nor is there a method to close the hand part way.

Future Directions

For the next iteration, we intend to incorporate position feedback into the motors controlling the fingers—this way, the motors will “know” when to stop grabbing and the user will have the opportunity for feedback as well.

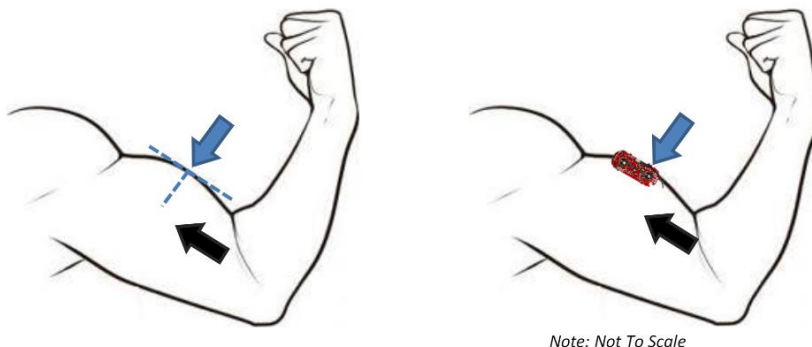
We have also designed a myoelectric sensor so this design will not have to rely on a third-party sensor. In addition, a myoelectric sleeve may be more comfortable and functional for the user.

Wrist attachment of the prosthetic will need to be a topic of further discussion.

The total cost of the hand is slightly under \$500 USD and is largely due to the \$350 USD cost of the servos. Ideas to lower this cost have been presented but may limit controllability and feedback options.

We welcome any feedback and are already working on a lower-profile, faster, more intelligent version.

EMG Placement



Example Sensor Location for Bicep

- 1) Thoroughly clean the intended area with soap to remove dirt and oil
- 2) Snap electrodes to the sensor's snap connectors
(Note: While you can snap the sensor to the electrodes after they've been placed on the muscle, we do not recommend doing so due to the possibility of excessive force being applied and bruising the skin.)
- 3) Place the sensor on the desired muscle
 - a. After determining which muscle group you want to target (e.g. bicep, forearm, calf), clean the skin thoroughly
 - b. Place the sensor so one of the connected electrodes is in the middle of the muscle body. The other electrode should line up in the direction of the muscle length
 - c. Peel off the backs of the electrodes to expose the adhesive and apply them to the skin
 - d. Place the reference electrode on a bony or nonadjacent muscular part of your body near the targeted muscle
- 4) Connect to a development board (e.g. Arduino, RaspberryPi), microcontroller, or ADC
 - a. See configurations previously shown