DEVELOPMENT OF A LOW-COST, OPEN SOURCE, MYOELECTRIC ARM

Meagan Gagnon[1], Eric Bubar[1]
1 Department of Physics, Marymount University, 2807 North Glebe Road, Arlington, VA 22207
Funding Provided by Marymount University Discovery Program, Arlington, VA

The advent of low cost microcontrollers has led to significant advances in hobbyist levels of prosthetic development. Notably, prosthetics utilizing a myoelectric control system allow for greater functionality, mobility, and dexterity than traditional body powered or cosmetic prosthetics. A myoelectric prosthetic picks up electromyogram (EMG) signals that are sent by the brain to control a muscle; this signal must then be translated by a microcontroller and converted to a digital output for servos from the analog input that is the signal from the residual limb. Current commercially available myoelectric prosthetics are heavy, due to metal hardware, as well as, expensive. To solve these problems we used 3D printing to drastically reduce both the weight and cost, allowing a myoelectric prosthetic to be more financially accessible and usable by a wider audience, particularly children, due to the significant cost and weight reductions offered by utilizing 3D printing. In this work, we present our prototype design which utilizes combinations of multiple open source designs, such as the Ada Hand by Open Bionics, and the MyPo by Poparaguay, along with customized Arduino coding to interpret muscle signals from a low-cost Arduino-compatible myoelectric detector.

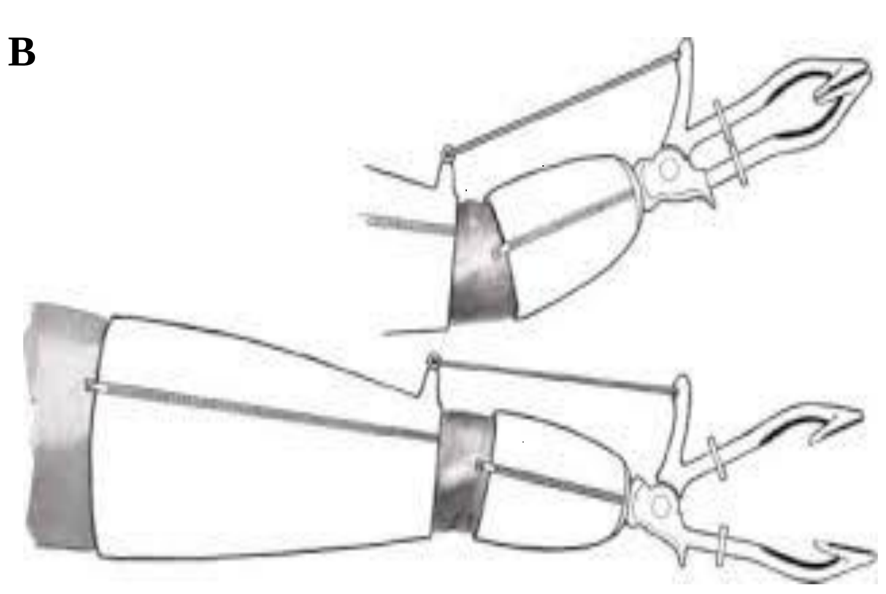
Background

This project is the result of a collaboration with the Enable the Future group PoParaguay. This design the MyoPo, had multiple errors, was not highly functioning with only 3 poses. We also utilized the Ada Hand from OpenBionics. This project is to increase functionality, mobility, and dexterity compared to other prosthetics. Using myoelectrics we pick up electromyogram (EMG) signals sent by the brain to control a muscle; this signal is then translated by an Arduino microcontroller and converted to a digital output for servos from the analog input that is the signal from the residual limb.

Fig. 1: This is the Po Paraguay MyPo arm that was the inspiration for this project (https://www.thingiverse.com/thing:1675356).

A

B



C

D

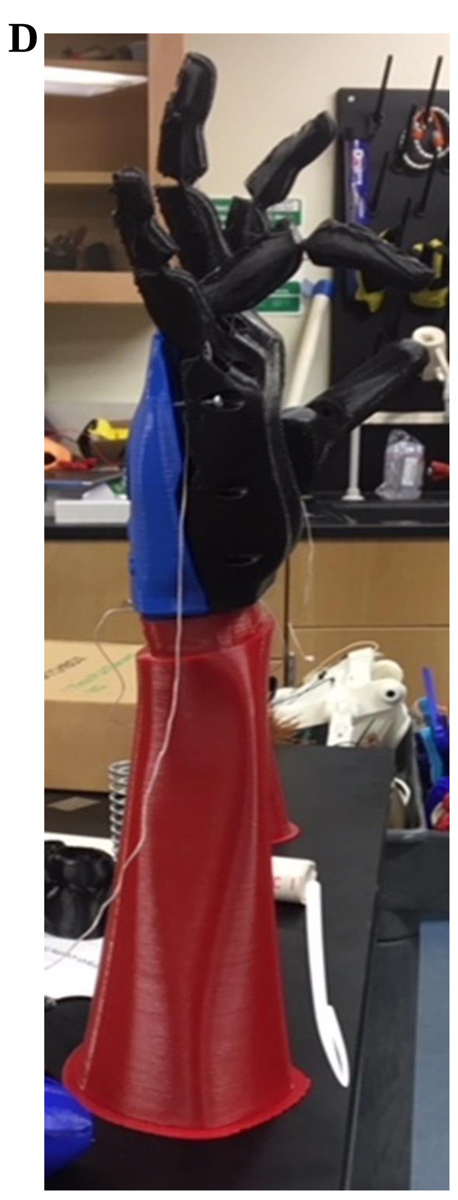


Fig 3. A- A classic cosmetic prosthetic, no functionality but provides an aesthetically realistic look and feel. **B**- A body powered prosthetic that only opens and closes which are difficult to manipulate, can cause other physical injury. **C**- A comparable on the market prosthetic with 14 poses and grip strength for a significant price. **D**- The prototype from this project.

Goals

Functionality	Weight	Inexpensive
Allow for 5 poses and the ability to reprogram these due to the individual linear actuators used for each finger.	3D printing the arm cuts down on the weight of the prosthetic as there is no metal frame or components, excluding electronics.	Utilizes simple parts any individual can get and the casing is 3D printed plastic which greatly reduces the cost.

Analysis

This project was about improving mobility and quality of life for those by increasing functionality, while reducing weight and cost. This project succeeded in meeting the three goals set forth at the start of this project. Cost was reduced through the use of 3D printing and simple hobbyist electronics. Three-dimensional printing also reduced weight by cutting out any metal used, excluding the linear actuators and basic electronics. Functionality was achieved through the editing the code from the MyoPo arm. This project has two viable options to receive the muscle signal from a user, either with the myo gesture band, or with electromyography(EMG) electrodes. The myo gesture band prototype allows for greater functionality, but at an increased cost. While the EMG electrode option provides 2 poses with a reduced cost. This project has the ability to provide inexpensive and functional prosthetics to growing kids, and to people whose insurance will not cover a traditional prosthetic.

Fig. 4: This is the final prototype design that has been developed. This is paired with a commercially available Myoelectric Armband from Thalmic Lab (https://www.myo.com/). This system allows for 5 different poses. The hand, which houses 5 linear actuators to control individual finger motion, is the open source Ada hand design from Open Bionics (https://openbionicslabs.com/downloads/). The arm is designed using solid body modeling in Fusion 360 and mesh-refinement in Meshmixer based on a 3D scan of PI Gagnon's arm. The project took 6 weeks to complete and has been adjusted to be easier for the general public to be able to afford and replicate. In total this prototype would be about $350 dollar, $130 due to the 5 linear actuators, $200 for the Myo gesture band, the rest is for batteries, wiring, and the plastic for the casing of the prosthetic.

Signal Path

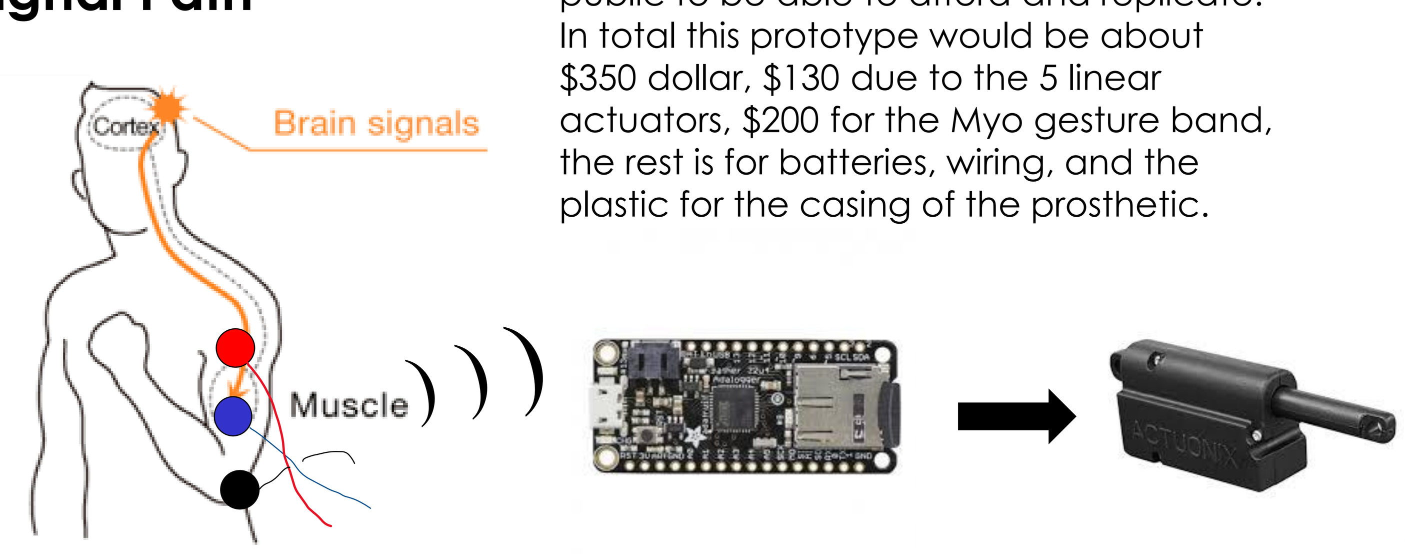


Fig. 5: The new approach Three electromyography electrodes are placed on the arm, 2 on either side of the targeted muscle, and 1 in an area as close to a bone as possible. These electrodes pick up the muscle signal and relays it to the Arduino board which translates it into a digital signal. This digital signal is sent to the linear actuators and depending on the signal determines which linear actuators to trigger and achieve the right pose.

Prosthetic Price Comparison

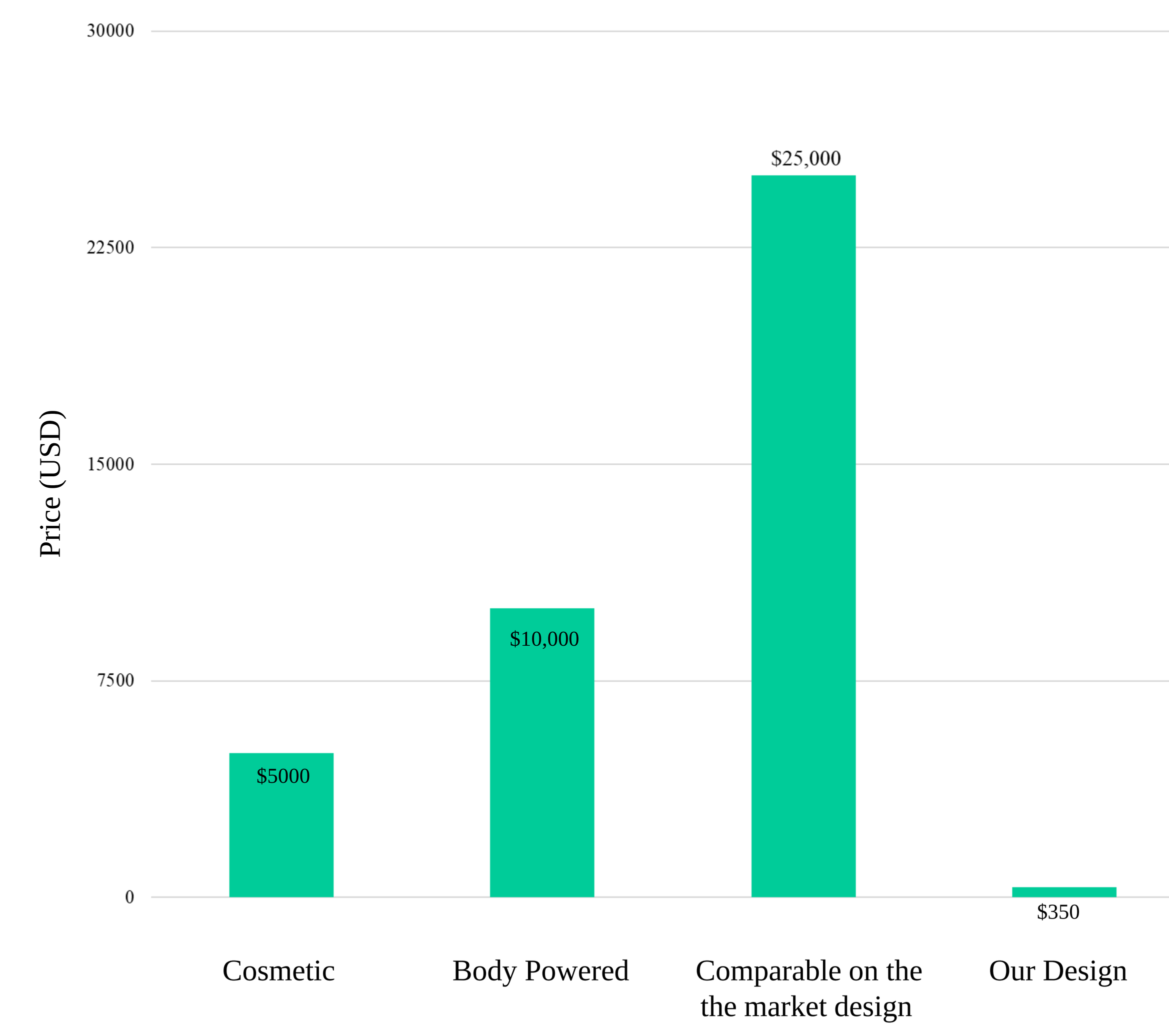


Fig. 2: This chart shows the drastic difference between commercially available prosthetics and the one designed for this project. Refer to figure 3 for images of these devices. (http://health.costhelper.com/prosthetic-arms.html)

Why Myoelectric?

	Cosmetic	Body Powered	Myoelectric
Number of poses	0	2	5
Dynamic	No	No	Yes
Independent Movement	No	No	Yes

Conclusions

- We were able to create a functional, inexpensive prosthetic that the general public could access.
- This prototype was developed in 6 weeks and had 5 unique poses that could be reprogrammed for individual users.
- Over the course of the year since the project completion, we have gotten rid of the use of the myo gesture band. We now use electromyography electrodes which are cheaper, as well as, need a smaller and lighter microprocessor.
- This prototype offers a comparable option in terms of functionality, at a greatly reduced cost that provides a more accessible option for kids, and those whose insurance may not cover the cost.