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Using EMG Signals to Control an Arduino Prosthetic Arm

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Introduction

- A prosthetic serves as an artificial limb to improve the lifestyle of a person with limb loss
- Electromyography (EMG) via myoelectric technology allows for a prosthetic to move and function based on electricity from muscle activation that occurs naturally[3]
- Arduino is a small microcontroller board that can receive input from sensors, analyze the information, and provide a desired output on a physical board[1]
- Computer-aided design (CAD) modeling and 3D printing has allowed for prosthetics to be cheaper overall[2]

Purpose

- Build and test a prosthetic arm controlled by an EMG sensor and an Arduino microcontroller

Materials and Methods

- Created a design for a prototype of a prosthetic arm with appendages using Autodesk Fusion 360
- 3D printed the prototype using polylactic acid (PLA) filament
- Wrote up a code in Arduino to power a stepper motor, and another code to power a servo motor
- Assembled the elbow joint using a stepper motor and assembled the appendages using a servo motor
- An EMG sensor was implemented into the design to control the arm and appendages in one motion
- The sensor with three electrodes was placed on the arm of the participant, with one electrode placed on the bicep, one slightly below, and one near the elbow (to ground the connections)
- The participant curled a 5 to 10-pound weight, and then relaxed
- The electrical signals from the participant's muscles passed through the Arduino microprocessor, which then should have powered the prototype arm to move in a similar motion

Results

- Successfully designed and 3D printed one prototype for a prosthetic arm with appendages
- Arduino code able to power the stepper motor and servo motor simultaneously
- EMG sensor successfully sent signals to the Arduino to power the servo motor to move the fingers
- EMG sensor failed to send signals to the Arduino to power the stepper motor

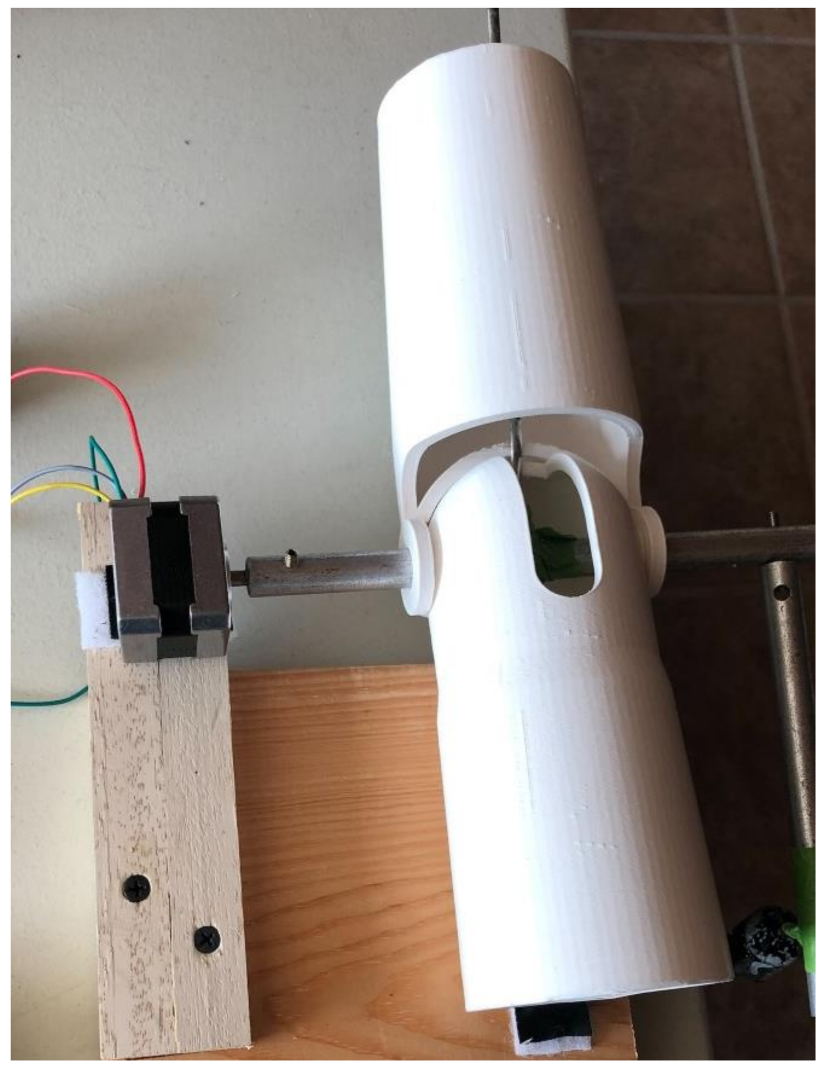

Figure 1. Setup of elbow joint with the stepper motor attaching the upper arm and lower part of the arm together.

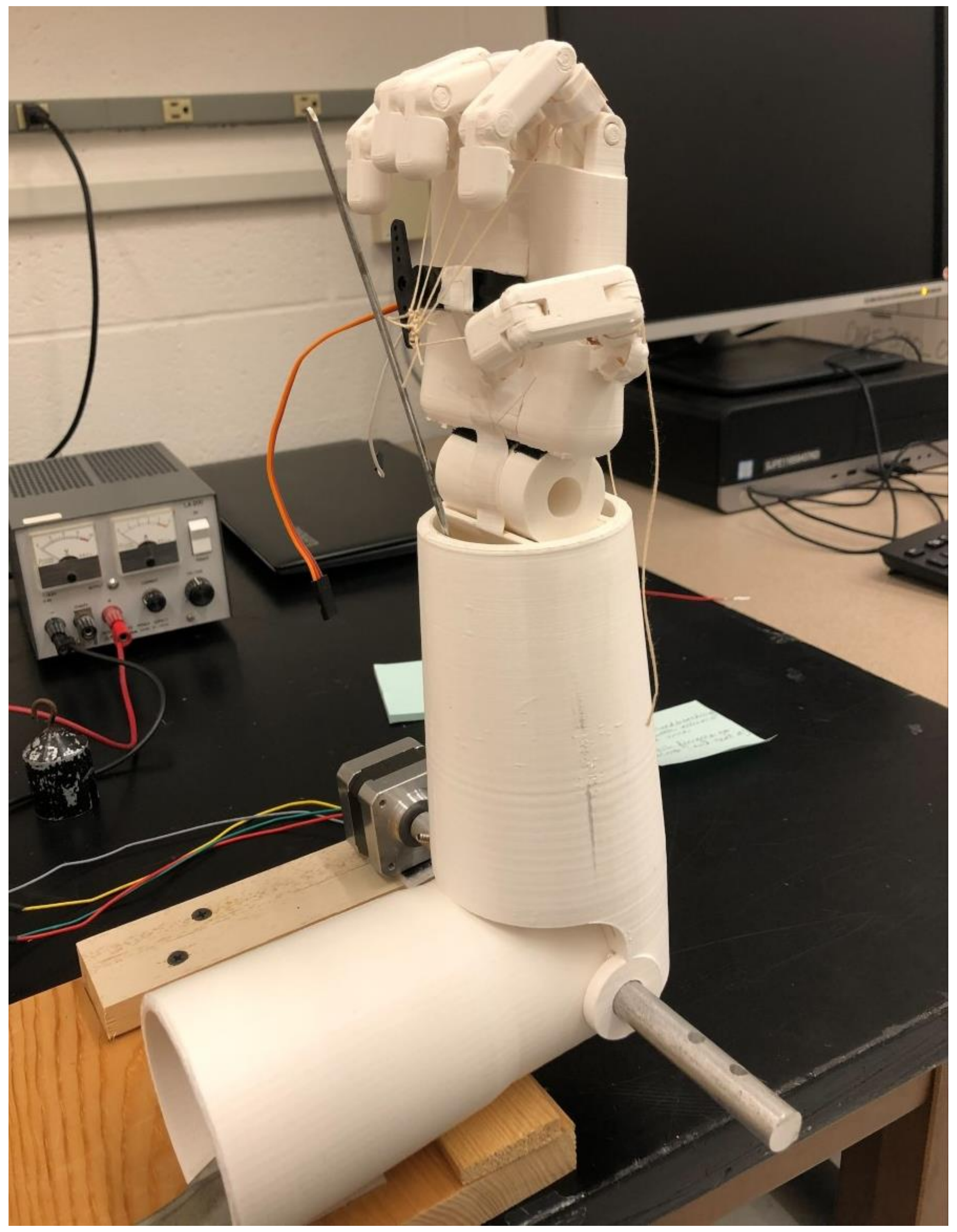

Figure 2. Setup of the entire 3D printed arm with the stepper motor acting as the hinge joint of the elbow and the servo motor is attached to the fingers.

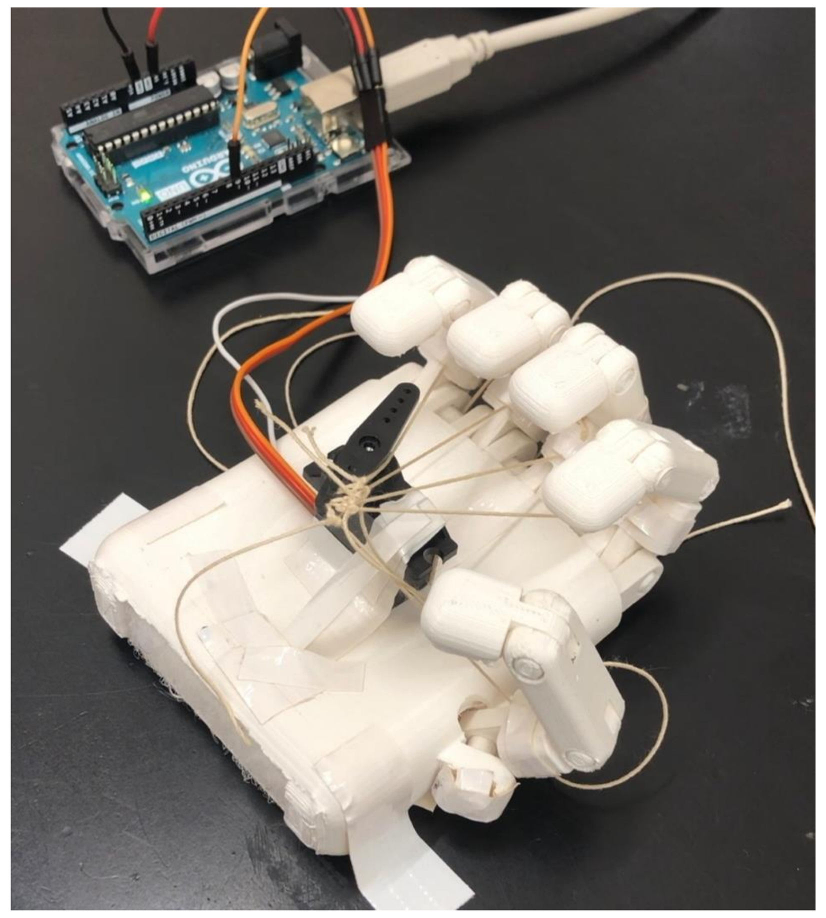

Figure 3. Setup of the 3D printed hand with the servo motor attached with each of the fingers.

Literature Cited

1. *Arduinoboarduno*. Arduino. (n.d.). Retrieved June 7, 2021, from https://www.arduino.cc/en/Main/arduinoBoardUno>
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3. Prakash, A., Sharma, S., & Sharma, N. (2019). A compact-sized surface EMG sensor for myoelectric hand prosthesis. *Biomedical engineering letters*, *9*(4), 467–479. https://doi.org/10.1007/s13534-019-00130-y

Discussion

- Arduino is versatile, and its technology is capable of being implemented for a variety of uses
- The sensors may have interfered with the power supply powering the stepper motor, possibly leading to its failure to send its signal to the Arduino
- Arduino program only used one motion when incorporating both motors: "close fist → flex arm → relax arm → relax fist"
- The arm prototype needed a counterweight to make the curling motion due to torque constraints of the stepper motor

Future Work

- Design a lighter-weight prototype in Autodesk Fusion 360
- Implement two sensors into the design to separately control the servo and stepper motors
- Run an experiment on multiple participants to test the EMG sensor compatibility and EMG activity

Conclusion

- Arduino has potential to be an effective, and cheaper, alternative to current myoelectric prosthetics currently on the market

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