EMG BASED PROSTHETIC HAND

Project/Thesis ID. 2023: 111

Session: BS. BME Spring 2020

Project Supervisor: Engr. Murk Rehman

Submitted By

Sarfraz Shahani

Ahsan Ali

Misbah Ali

Rubab Ashraf

Institute of Biomedical

Engineering and Technology

Liaquat University of Medical and Health Sciences Jamshoro

Certification

This is to certify that Sarfraz Shahani (20BME031), Ahsan Ali (19-20BME01), Misbah Ali (20BME022) and Rubab Ashraf (19-20BME033) have successfully completed the final project **EMG BASED PROSTHETIC HAND,** at the **Liaquat university of medical and health sciences jamshoro**, to fulfill the partial requirement of the degree **BS Biomedical engineering.**

External Examiner

[Name of Examiner]

[Designation]

Project Supervisor

[Name of Supervisor]

[Designation]

Dr. Sarmad Shams

Department of Biomedical Engineering and Technology, LUMHS

EMG Based Prosthetic Hand

Sustainable Development Goals

(Please tick the relevant SDG(s) linked with FYDP)

SDG No	**Description of SDG**	**SDG No**	**Description of SDG**
SDG 1	No Poverty	SDG 9	Industry, Innovation, and Infrastructure
SDG 2	Zero Hunger	SDG 10	Reduced Inequalities
SDG 3	Good Health and Well Being	SDG 11	Sustainable Cities and Communities
SDG 4	Quality Education	SDG 12	Responsible Consumption and Production
SDG 5	Gender Equality	SDG 13	Climate Change
SDG 6	Clean Water and Sanitation	SDG 14	Life Below Water
SDG 7	Affordable and Clean Energy	SDG 15	Life on Land
SDG 8	Decent Work and Economic Growth	SDG 16	Peace, Justice and Strong Institutions
		SDG 17	Partnerships for the Goals

Range of Complex Problem Solving			
	Attribute	**Complex Problem**	
1	Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering and other issues.	
2	Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.	✓
3	Depth of knowledge required	Requires research-based knowledge much of which is at, or informed by, the forefront of the professional discipline and which allows a fundamentals-based, first principles analytical approach.	✓
4	Familiarity of issues	Involve infrequently encountered issues	
5	Extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering.	
6	Extent of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs.	
7	Consequences	Have significant consequences in a range of contexts.	
8	Interdependence	Are high level problems including many component parts or sub-problems	✓
Range of Complex Problem Activities			
	Attribute	**Complex Activities**	
1	Range of resources	Involve the use of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies).	✓
2	Level of interaction	Require resolution of significant problems arising from interactions between wide ranging and conflicting technical, engineering or other issues.	✓
3	Innovation	Involve creative use of engineering principles and research-based knowledge in novel ways.	✓
4	Consequences to society and the environment	Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation.	✓
5	Familiarity	Can extend beyond previous experiences by applying principles-based approaches.	✓

Abstract

People who are adjusting to life without hands encounter a range of challenges. Losing hands can occur for a number of causes, such as trauma, illness, congenital defects, or damage. This loss has a significant psychological and social impact that renders the victim feeling helpless and disabled in addition to its physical effects. Each and every issue in modern life has a technological remedy. The loss of a hand can be treated with the assistance of an advanced technology known as a ‘Prosthetic Hand’. It is a prosthetic hand could prove to be the ideal substitution for a lost human hand. An EMG based Prosthetic Hand has been proposed, by combining the microcontroller and the myoelectric sensors which can detect the electrical impulses produced by the human body that trigger muscle movement. The designed EMG based prosthetic hand is in accountable for restoring to the amputee all of the typical hand functions, such as holding, grasping, and gripping items. The EMG impulses from the body are captured by a 3D-printed hand embedded with a microcontroller and myoelectric sensors, which then assesses each signal in accordance with the microcontroller's programming. Each one of the five fingers will carry out its distinct task in accordance with the recorded EMG signals, instructing the amputee to do particular activities. In addition to making this hand more effective at carrying out many daily duties, the five fingers provide it an enhanced aesthetic appearance like the real human hand.

Keywords— Hand prostheses, EMG signals, Rehabilitation technology, Artificial limb, Myoelectric sensors, Bioelectrodes.

Undertaking

I certify that the project **EMG BASED PROSTHETIC HAND** is our own work. The work has not, in whole or in part, been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged/ referred.

Sarfraz Shahani

20BME031

Misbah Ali

20BME022

Ahsan Ali

19-20BME01

Rubab Ashraf

19-20BME033

Acknowledgement

We truly acknowledge the cooperation and help make by Engr. Murk Rehman**, Lecturer** of Institute **of Biomedical Engineering and Technology.** He has been a constant source of guidance throughout the course of this project. We would also like to thank Dr. Sarmad Shams from HOD of Institute **of Biomedical Engineering and Technology** for his help and guidance throughout this project.

We are also thankful to our friends and families whose silent support led us to complete our project.

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Chapter 1

Introduction

Disability may be a nightmare for those who have to cope with obstacles all throughout their lives that prevent them from contributing fully to society. Disabilities might make it difficult to be independent and included in society due to physical restrictions and cultural stigma. It's essential to remember, though, that people with disabilities can get over these challenges and have happy lives with the correct assistance and modifications. The majority of disabilities in today's world can be overcome with various assistive technologies and improvements in healthcare. These advancements enable individuals with disabilities to lead fulfilling lives and actively participate in society. Moreover, promoting inclusivity and raising awareness about the capabilities of people with disabilities can help break down societal barriers and eliminate the discrimination they face.

Based on 2019 data, the number of people with upper limb amputations in the US and Japan is around 540,000 and 82,000, respectively. According to some research, between 50 and 60 percent of amputees with upper limbs reportedly utilize prosthetic hands on a regular basis. Upper limb prostheses fall into three main categories: externally powered, body-powered, and cosmetic. Electromyogram (EMG) signals, the exchange of ions across the muscle membranes produces minor electrical currents, which are produced by muscular contractions representing a person's internal state and motion intentions, are used by myoelectric prosthetic hands, a type of externally driven prosthesis. Therefore, by identifying motion intent from EMG data, myoelectric prosthetic hands enable amputees to manipulate their prostheses like biological hand [1].

The development of a prosthetic hand is one of these improvements for those without hands, allowing them to regain the ability to perform everyday tasks and engage in activities they enjoy. It is a significant advancement in technology that has greatly improved the quality of life for individuals with hand disabilities. Recent advancements in 3D printing technology have completely changed the prosthetics field by lowering the cost and increasing the accessibility of custom-made prosthetic hands. For those with limb differences, it enables the fabrication of complex designs and customized fits that lead to a more comfortable and useful prosthetic hand. Furthermore, 3D printing lowers the overall maintenance expenses of prosthetic hands by making it simpler to repair or modify individual pieces[2].

A prosthetic hand is an electrical or mechanical device used to replace a hand that is missing or not working. A prosthetic hand is one type of assistive technology. An assistive device is any tool, apparatus, or technological advancement intended to facilitate the performance of tasks by people with impairments or restrictions that they may find challenging owing to their conditions. For people who have lost a natural hand or have restricted hand use, prosthetic hands are designed to help. The project involves an EMG-based prosthetic hand that uses muscle signals from electromyography (EMG) to control its motions. Individuals may acquire precise and natural hand movements and do complex activities with ease by correctly detecting and translating these signals. This ground-breaking technology promotes acceptance and equal chances for everyone by not only restoring functioning but also enabling people with hand limitations to actively engage in a variety of aspects of life.

A five-finger, three-dimensional hand is connected to a microcontroller and myoelectric sensors, which collect the body's electrical signals used to move muscles. The microcontroller then interprets the signals, translating them into the commands needed to move the hand in a particular way.

1.2 Statement of the problem

Being handless is a very challenging condition that affects a person's life both physically and psychologically. Prosthetics can help treat this condition, but most people living in developing nations find the process of affixing a prosthetic hand and the prosthetic hand itself to be very expensive.

1.3 Goals/Aims & Objectives

- To create a functional prototype that uses myoelectric sensors to efficiently gather electrical signals produced by the muscles when they contract or relax.
- A cost-effective prosthetic hand that the general population may easily purchase.
- The suggested approach can improve the person's aesthetic appearance, even if they have lost their natural hand.
- The individual will feel better psychologically and more confident after utilizing this prosthetic hand.
- The suggested system would have the capacity to move each finger separately, enabling more efficient and improved item touching and grasping.
- To make this prosthetic hand easier to operate, non-invasive EMG signal detection would be included.

1.4 Motivation

This project is motivated by the challenge to develop a prosthetic hand that is very cost-effective (to be affordable by almost every amputee), with effective and efficient feedback sensing mechanisms and capable of reproducing most of a human hand's movement and gripping patterns. The prosthetic hand should be strong enough to hold different object shapes and weight, and its size should be comparable to a human hand.

1.5 Assumption and Dependencies

Assumptions

- **Consistent Signal Quality**
  The electromyographic (EMG) signals from the user's muscles will be consistently of sufficient quality for accurate and reliable control of the prosthetic hand.
- **User Adaptability**
  Users will be able to adapt to and effectively modulate their muscle signals to control different functions and grips of the prosthetic hand.

Dependencies

- **Hardware Reliability**
  The functionality of the EMG-based prosthetic hand is dependent on the reliability and durability of the hardware components, including sensors, amplifiers, and processors.
- **User Training and Rehabilitation**
  Successful integration of the EMG-based prosthetic hand is dependent on comprehensive user training and rehabilitation programs.

1.6 Methods

Prosthetic is an artificial device that replaces a missing body part that may be lost due to trauma, disease and congenital conditions. It is intended to restore the function of the missing body part. The prosthetic that will be developed in this project is prosthetic hand. This prosthetic hand will help the person to do their daily activities just as how they used to when they still have their hand, and will overcome the disability and will provide near to natural hand movement.

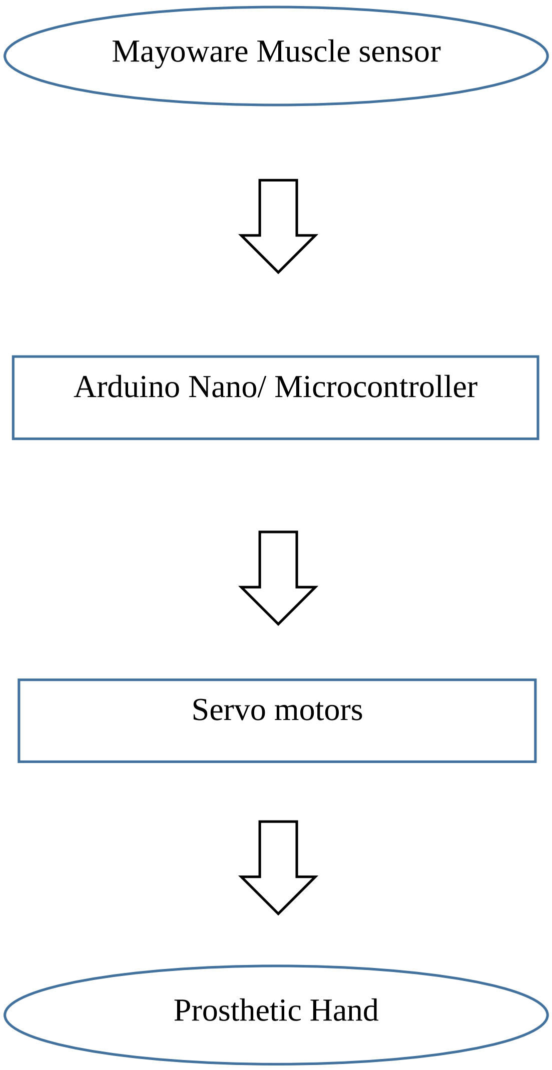
1.7 Report Overview

In this report a EMG based prosthetic hand proposed for amputees who lost their hand in accident or trauma. The Muscle signal is received by mayoware muscle sensor and interpreted, send to microcontroller and motors start movement with respect to muscle or finger movement. The main goal of our project is to provide social and psychological reassurance to the amputee that lost their hands due to industrial or car accidents which makes it hard for them to regain the function of their hands back after the accident.

Chapter 2

2.1 Methodology

Prosthetic hands are particularly those with advanced technology like myoelectric control, used to restore hand movements by detecting and interpreting signals from the patient's muscles. The prosthetic hand will work when there is a signal detected by the EMG sensor. The signal detected in this project is the muscle movement at the forearm area. After the EMG sensor detects which muscle that flex according to the placement of the electrode, the data is send to Arduino microcontroller. Arduino microcontroller then interprets the signal into movement.



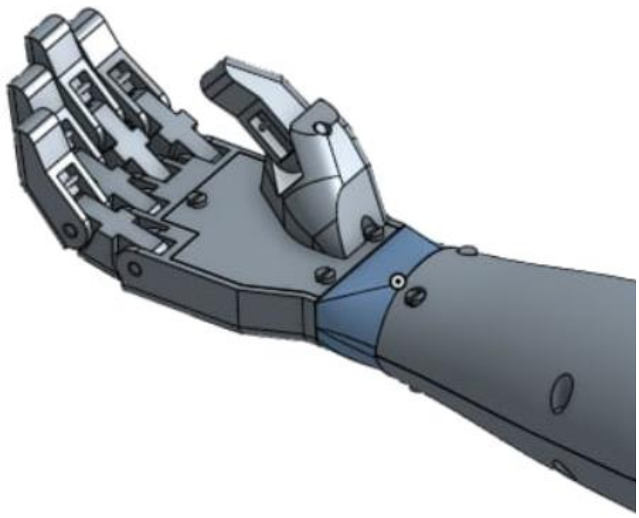


Figure 1(Prosthetic Hand)

2.1.1 Mayoware Muscle Sensor

Designing a EMG based prosthetic hand requires electromyography (EMG) signals which is detected by Mayoware muscle sensor. The MyoWare EMG sensor, shown in Fig. 1, measures electrical signals which are detected on the skin just before and during muscle contraction. These signals are usually on the order of μVolts to low mVolts. and need to be amplified so that they can be digitized, recorded, analyzed and utilized. The MyoWare EMG sensor is an all-in-one device which amplifies, rectifies and filters the raw EMG signal, and provides the RMS EMG envelope as an output with an amplitude between 0 and the supply voltage (2.9-5.7V). Some of the advantages of the sensor are that it is inexpensive, the raw signal is also available, and the electrode connectors, which are placed 3 cm apart, are embedded on the sensor board to minimize noise.

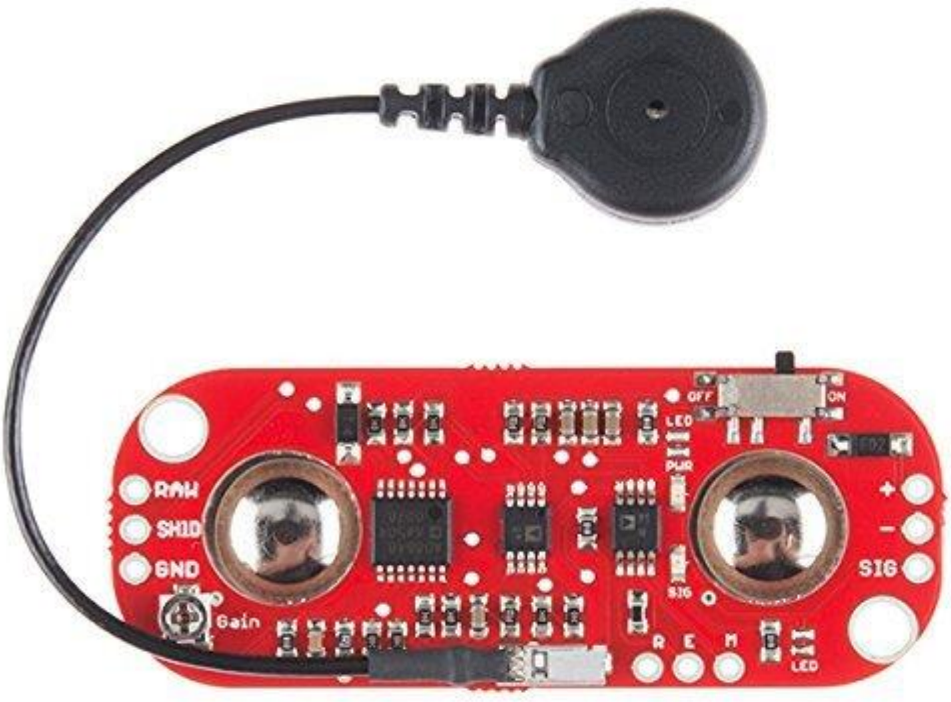


Figure 2(MayWare Muscle sensor)

Single-supply: MyoWare won't need ± voltage power supplies, Unlike the previous sensor, it can now be plugged directly into 3.3V - 5V development boards.

Embedded Electrode Connectors: Electrodes now snap directly to MyoWare, getting rid of those pesky cables and making the MyoWare wearable.

RAW EMG Output: A popular request from grad students, the MyoWare now has a secondary output of the RAW EMG waveform.

ON/OFF Switch: Speaking of burning out the board, Advancer Technologies also added an on-board power switch so you can test your power connections more easily. It's also handy for saving power.

LED Indicators: Advancer Technologies added two on-board LEDs one to let you know when the MyoWare's power is on and the other will brighten when your muscle flexes.

Here we are using three mayoware muscle sensors to get EMG signals and machine learning algorithms to get individual finger movement in prosthetic hand. Each sensor will produce a EMG signal and machine learning algorithms will classify the signal with respect to the finger movement.

2.1.1 Microcontroller

The Arduino Nano is an open-source breadboard-friendly microcontroller board based on the Microchip ATmega328P microcontroller, it has 22 input/output pins in total. 14 of these pins are digital pins. Arduino Nano has 8 analogue pins. It has 6 PWM pins among the digital pins.

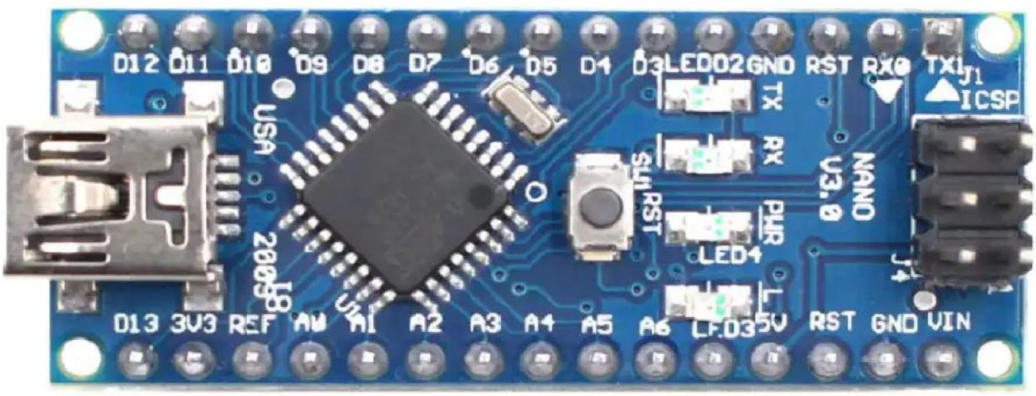


Figure 3(Microcontroller)

The EMG signal will transfer to the Arduino microcontroller, Arduino will interpret the signal and will provide the Output to the servomotors.

2.1.3 Servomotors

A servo motor is a rotational or translational motor to which power is supplied by a servo amplifier and serves to apply torque or force to a mechanical system, such as an actuator. Servo motors allow for precise control in terms of angular position.

Figure 4(Servomotors)

The Towerpro MG90S Mini Digital Servo is a 180° rotation servo. It is a Digital Servo Motor that receives and processes PWM signal faster and better. It equips sophisticated internal circuitry that provides good torque, holding power, and faster updates in response to external forces.

The Servomotors will have placed in the prosthetic hand and with the help of thread we will perform the movement of prosthetic hand

Chapter 3

3.1 Literature Review

Finch, Jacqueline and David et al proposed in 2012 that Marcus Sergius used an iron hand instead of real and natural hand. This was earliest time and no technology was introduced therefore they used artificial hand which was made up of wood or iron. It provided social and psychological reassurance to the amputee but this was not compatible with human body this caused rashes itching to body. Since then, the field of creating developing artificial hands has continued to grow [3].

Kiguchi, Kazuo Hayashi, Yoshiaki et al proposed in 2012 an electromyogram EMG based impedance control method for an upper limb power assist exoskeleton robot for physical weak persons who could not perform daily activities normally. This was not for those who lost their hand in different accidents [4].

Sandeep K. Choudhary, Debajit Chakraborty et al in 2012 developed a three fingered EMG based robotic hand which can grasp only oval, cuboid, circular and cylindrical objects with self-adaptability but no other shape objects [5].

Yinlai Jiang, Shintaro Sakoda, Suguru Hoshigawa et al proposed in 2015 simplified EMG prosthetic hand was online robotic based it was working quite good but this was unable to work in remote areas [6].

Jing, Xiaobei Yong, Xu et al in 2014 developed an EMG prosthetic hand with rotary motion which account for 85% hand motions in daily life. This project improved the mechanism of the hand with spring to connect the fingers to the palm and artificial nails equipped on top of the fingers. Results show a significant improvement of grasp ability, especially for the tiny objects. This could not grasp heavy particles [7].

Seo, Minsang Yoon, Dukchan et al in 2015 proposed a prosthetic hand for trans-radial amputees. When amputees shoulder is fixed, the EMG signals are steady, which enables the prosthetic hand to function well. However, the EMG signals alter and fluctuate whenever the shoulder position changes the prosthetic will not perfectly [8].

Almuhanna, Mohammad Yahya et al in 2016 proposed a cost-effective five-finger prosthetic hand. This was working on good condition but there was need to improve its sensing abilities [9].

The proposed EMG based prosthetic hand which could satisfy the needs of the amputees. The best design found to be useful to amputees are those that can mimic the actual movements of the human hand, have good sensory feedback, and create enough force to handle objects with smooth movements and have very good EMG signal detection and processing. A prosthetic hand that includes all these requirements in one prosthetic device would make it cost prohibitive for most amputees.

Chapter 4

4.1 Proposed Solution/Results & Discussion

A 3D printed, reasonably priced, and functional EMG-based prosthetic hand that can replicate the movements of the natural hand and offer support to the hand amputee is suggested as a way to assist the disabled who have lost their hand and cannot afford the costly prostheses. The general public will find this system to be user-friendly and reasonably priced.

4.2 Prosthetic Hand results

The results, $\theta 1$ ranges from 0 to 90 degrees, $\theta 2$ ranges from 0 to 80 degrees, and $\theta 3$ ranges from 0 to 60 degrees. It is important to note that a tie wrap is employed for the finger's closure and opening, causing $\theta 3$ to undergo changes at the conclusion of these movements. Throughout the processes of closing and opening, the angles of the joints will vary within the specified minimum and maximum values to meet the grasp requirements. As the joints rotate, the maximum value for x is achievable when all joints are at 0 degrees, while the maximum value for y will be slightly less than the length attained when the first joint angle was 90 degrees and the other joints were at 0 degrees.

Chapter 5

5.1 Summary and Future work

An artificial device known as a prosthetic hand is used in place of missing natural hands. when a person loses one or more of their hands as a result of injury, an illness, or a congenital defect. The patient finds it challenging and quite challenging to go about daily tasks like handling objects, writing, playing, etc. Prosthetic hands are utilized to restore function and make the patient's difficult life easier so they may go about their daily lives and live normal lives. The patient's forearm will be covered with an EMG electrode for the planned prosthetic hand, which will detect which muscles are flexed and send a signal to an Arduino microcontroller, which will then interpret the signal to determine which parts move. EMG (Electromyography) is a technique used to detect and record the electrical activity produced by skeletal muscles. EMG signals can be utilized to control prosthetic devices, enabling individuals with limb loss to regain some functionality.

In future the focus on advancing technology to enhance the functionality, comfort, reliable and accessibility of prosthetic hand for the amputees, cost effective and near to natural hand movement and light weight.

Chapter 6

6.1 Conclusion & Recommendation:

This prosthetic hand is controlled by the surface EMG signal which comes from the rest of the amputee's arm. The surface EMG signal should pass through many steps to be readable by the Arduino. The first step is detecting the EMG signal from the muscle by using three electrodes. Electrode one is connected to the top of the muscle, electrode two is connected to the end of muscle, and the third electrode is a reference electrode which is connected to the bone.

The reference electrode could be common between many muscles. That means if there is a circuit to test five muscles, it will need eleven electrodes. One will be common between all muscles and two electrodes for each muscle. After detecting a signal from the muscle, the next step will be to subtract the signal of electrode two from the signal of electrode one to remove the common noise. Then the signal should amplify several times to be large enough to pass through the next step.

After successfully designing and testing this project there is some recommendations for future work on this project. First of all, the feedback sensing ability should be improved. The recommendation for this project is creating an artificial skin which covers all hand and has a good sensing ability and good friction to catch the object.

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