Development of an Upper Arm Prosthesis with Myoelectric control

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Abstract

Upper limb amputees make up about 30% of amputees in the world today. This condition significantly restricts a person's ability to perform day to day tasks especially considering the importance of hands being dextrous instruments that are used to execute them. A loss of a limb can be from accident, disease, or birth defect. The area of prosthetics is one that is always evolving and implementing robotics is one of the most notable changes in the history of prosthetics.

Current commercial myoelectric upper limb prostheses offer a great functionality and appearance such as the Michelangelo hand from Ottoblock, the cyber hand, the Be-bionic hand, and the most recent the DEKA arm. Unfortunately, these arms are expensive and difficult to acquire in developing countries. For this reason, 3D printing is an ideal method of making the materials as the cost of robotic arms should hopefully decrease as well as reducing weight of the overall prosthetic.

The objective of the project is to develop a surface electromyogram (EMG) based prosthetic hand. EMG electrodes will detect muscle movement in the user's arm. The system determines the type of grasp a human subject is using to allow daily tasks such as grabbing and releasing objects to be possible with the robotic hand. The prosthetic hand will be used to prove that the EMG signal pattern are being recognised correctly. Success for an EMG-controlled prosthetic would involve the prosthetic being able to accurately interpret the user's muscle signals, allowing for smooth and precise control.

Declaration

I declare that this thesis and the project it describes are exclusively my own work, except where specifically noted. I confirm that I have appropriately cited all information derived from the published and unpublished work of others.

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1 Introduction

The area of prosthesis has existed since the ancient Egyptians. Originally, these prosthetics were simply a replacement for body parts without much flexibility. For example, Amenhotep II had a toe replaced with a prosthesis made of leather and wood. It wasn't until the 15th Century, French surgeon Ambroise Paré made prostheses mechanical using springs and catches [1]. This sparked a monumental change in the history of human-machine interfaces, bringing us to where we are today with robotic prostheses. Currently, the most advanced robotic prosthetic arm is the Atom Touch that is being released in 2023 [2]. This arm uses electromyography (EMG) to detect the user's intended movement and give access to the user to control each part of the arm. Similar to the Atom Touch arm, this thesis will use EMG signals generated in the muscle tissue to control a robotic prosthesis. This is achieved by EMG sensors, which are placed on the skin over the muscles that would be used to control the missing limb. The signals are then processed and used to control the movements of the prosthesis. Using EMG in controlling a prosthetic requires adaptivity, accuracy and speed.

Modern robotic protheses are very expensive and for this reason, they are predominantly used in developed countries. EMG controlled robotic arms can be used outside of prosthetics, such as industrial automation, military situations or in less dangerous fields like in entertainment. In industrial automation or in the military, it can be used to perform tasks that would be dangerous humans such as handling hazardous materials or for handling delicate objects. Within a medical field, EMG control of robotics could allow precise control over small robotic arms in surgeries or in anything that is dangerous to the medical professional.

1.1 Project Problem

The goal of this research is to provide a low-cost alternative to existing robotic prostheses that can be controlled by electromyographic impulses from the user's arm. One of the project's goals is to find an approach for keeping the overall cost of the project lower than that of already existing robotic prosthesis. This has the potential to make prosthesis more accessible to a broader population. This is especially important in impoverished nations or conflict zones, where access to healthcare and services for rehabilitation may be limited and the number of amputees is significantly larger.

1.2 Project Approach

Due to the aim of this project being to act as a low-cost prosthetic, there are some restrictions on the materials that can be used. One of the first choices that have to be made is to use 3D printing technology using Polylactic Acid (PLA) and Acrylonitrile Butadiene Styrene plus(ABS+) for the structure of the arm itself.

Another choice that was made for this project was to choose a method of control for the prosthetic arm. To allow the user to feel more comfortable and movement to feel more natural, electromyographic control was chosen. In this thesis, the current state of EMG controlled prostheses will be explored, including their advantages and limitations. This paper will also discuss potential future developments and applications of this technology.

2 Technical Background

2.1 The Human Hand

In order to design a prosthetic hand, one must take inspiration from nature first to be able to mimic it. The human hand consists of 27 bones that can be separated into 3 main groups: 8 carpal bones in the wrist, 5 metacarpal bones in the palm and 14 phalanges for the fingers and thumb [3]. The typical human hand and forearm have over 30 individual muscles that work together in order to have a range of diverse movements [4].

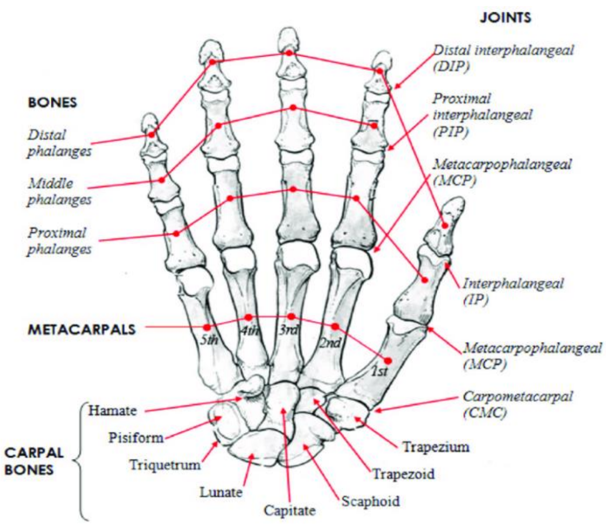


Figure 1: Skeletal structure of a human hand with joints included [5]

A human hand has twenty-seven degrees of freedom, with twenty-one degrees of freedom being in the fingers and thumb alone [6]. The finger alone has four degrees of freedom with three of them being rotation at each joint and the final one being at the knuckle to allow abduction or adduction of the finger. Abduction and adduction are terms that describe body movement in relation to the body's midline with abduction being the movement away and adduction being the movement toward one's midline[7].

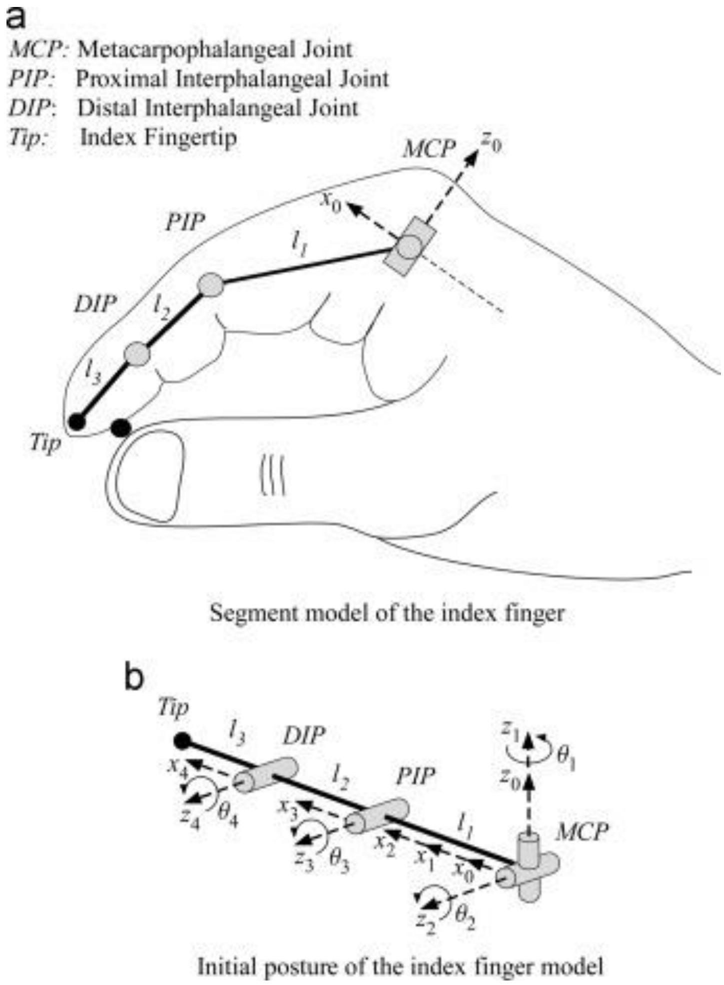


Figure 2: Joints of a human finger and degrees of freedom [8]

The distal interphalangeal (DIP) joint, proximal interphalangeal (PIP) joint and the metacarpophalangeal (MCP) joint are the three rotational joints that are shown in Fig. 2, that give humans the ability to control flexion and to extend the finger. The distal interphalangeal joint and the proximal interphalangeal joint have one axis of movement which account for two of the degrees of freedom in the finger. The remaining metacarpophalangeal joint is located at the knuckle with two axes, allowing up to four degrees of freedom in the finger. The thumb has a lower joint called the carpometacarpal (CMC) joint which gives it a fifth degree of freedom.

2.2 Comparison of Robotic Upper Limb Prostheses

There are several factors that can be compared when evaluating the design of different robotic arm prosthetics. Some of the key factors to consider include:

1) Degree of freedom: This refers to the number of joints and the range of movement that the prosthetic arm is capable of. Some prosthetic arms may have more joints and a wider range of movement than others, which can increase their versatility and ability to perform a wider range of tasks.
2) Control methods: Different prosthetic arms may use different methods to control the movement of the arm. For example, some may use electromyography (EMG) sensors to detect muscle signals from the user's residual limb, while others may use touch sensors or other methods.
3) Sensory feedback: Some prosthetic arms may provide sensory feedback to the user, such as touch or temperature sensations, to enhance the realism of the prosthetic.
4) Durability and reliability: As it will be subjected to regular wear and tear, it is important to consider the durability and reliability of a prosthetic arm.
5) Cost: The cost of a prosthetic arm can vary significantly, and this is an important factor to consider when evaluating different designs.
6) Appearance: The appearance of a prosthetic arm can be an important consideration for some users, as it may affect their self-esteem and confidence.

Ultimately, the best prosthetic arm design for a particular individual will depend on their specific needs and preferences, as well as the tasks they need the arm to perform.

2.2.1 The Bebionic 3

The Bebionic hand is a commercially available prosthetic hand currently developed by Ottobock, a company that specializes in the development of advanced prosthetics. The Bebionic hand is designed to be highly functional and is able to perform a wide range of movements, including grip patterns and individual finger control. The Bebionic hand is capable of 14 different grips, including: pinch, hook and mouse that can be seen below in Fig. 3 [9]. Rather than having control of each finger movement, the user can use choose which grip type they want depending on the muscle activity detected.

Figure 3: Bebionic 3 hand using pinch, hook and mouse grips[10]

One of the drawbacks to this design is that the user cannot have fine control over each individual finger, meaning that a user must choose which grip is best suited to a task rather than adjusting the grip themselves. This causes issues when handling irregular shaped objects that do not fit within the 14 grip types. This method of control is that it could be frustrating to the user to cycle through different grip types until they get the desired choice.

The Bebionic 3 design is that the thumb can be opposed or non-opposed [11]. The thumb is set manually by the user to either of the two previously mentioned options. This contributes to the time needed to change between grips and can add further frustration to the user.

2.2.2 i-Limb Digits

The i-Limb Digits hand is a bionic hand that is developed by Ossur, a company based in Iceland. The notable difference about the i-Limb digits is that it is compatible with amputees who have lost fingers but still have their intact. The i-Limb digits is a partial hand prosthesis that has a range of designs from the absence of one digit to five digits [12]. This makes it a more appealing choice for amputees, giving them the option to use the prosthesis in addiction to their own fingers or thumb.

Similar to the Bebionic hand, if the thumb is needed in the prosthetic, a user must manually rotate it. Due to the prosthetic being much smaller and more compact than other options in the market, the motors and power supply are much smaller.
This leads to a slower and weaker model.

Figure 4: Ossur's partial prosthesis – iLimb DIgits[13]

2.2.3 Naked Prosthetic Hand

Naked Prosthetic is another company that addresses that is if a person doesn't lose the full hand but instead loses either digits or partial digits. The products they offer focus on which joint is replaced such as the MCPDriver that is designed for those who have amputations and need to restore the middle and distal phalanges. Unlike the previous designs mentioned, this doesn't need as much focus on different grips types as it depends on body powered control. This design appears to focus more on the individual as they measure to fit the individual and give the user more variety of colours to choose [13].

Figure 5: MCPDriver from Naked Prosthetics Devices [13]

2.2.4 3D printed Hands

InMoov is an open-source 3D-printed robotics project that was developed by Gael Langevin, a French sculptor and inventor. As an open-source project, this can make the hand more accessible to people who may not be able to afford a commercially available prosthetic. The InMoov robot is not constantly being updated by Gael Langevin but is not complete in this moment in time. As seen in the Fig. 6 below, the legs are not yet complete, but majority of the robot is.

Figure 6: InMoov Robot holding skull[14]

The InMoov hand is a fully functional prosthetic hand that can be 3D printed and assembled by individuals with access to a 3D printer and basic tools. The InMoov hand can be 3D printed using readily available materials, which makes it significantly less expensive than many commercially available prosthetics. This also means that it can be customized to fit the individual user's needs and preferences. Although the primary use of this design is not for prosthetics, this makes a useful foundation for building robotic hand that can be adjusted to use for people who may need it.

Dissimilar to the previous designs, this design is much cheaper as its materials are not as modern or dependent on technology. The tendons that move the digits in the hand are controlled by a pulley system using fishing line and moving the servos.

One of the setbacks to this design is that that the forearm is completely taken up by the servos within it, therefore, limiting the possibilities for upper arm prosthesis to be at the elbow. Another limitation to this design is that the digits have three degrees of freedom as it doesn't have adduction and abduction in the fingers.

2.3 User Control

This section will explore the different methods a user can control a prosthetic including passive, body-powered, myoelectric and through direct brain interface.

2.3.1 Passive Control

Passive prosthetics are the simplest types of user control as they only have basic functionality for an amputee. As this was the oldest form of prosthesis, its use was for mostly basic structure and cosmetic reasons. This form of prosthesis is still used today as studies have shown that one out of three potential prosthetic hand users uses a passive prosthesis[15].

2.3.2 Body Powered Control

Body powered prosthesis were the first type of active prosthesis that were invented in the nineteenth century. They are usually attached to the body via a harness and the hand open or closes depending on body movements such as stretching out the arm.

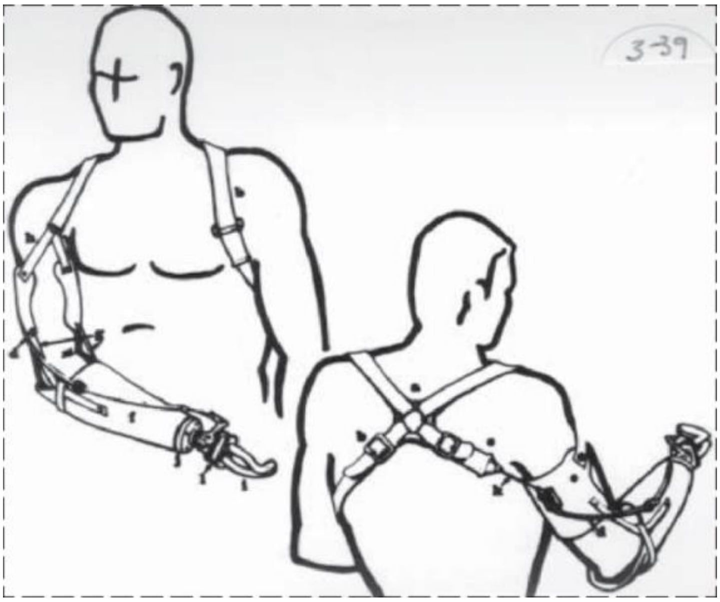
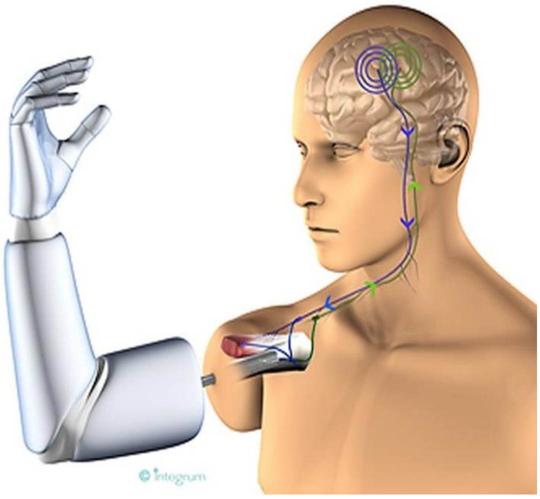


Figure 7: Body powered upper arm prosthetic [16]

2.3.3 Neural Control



Direct brain neural interface allows individuals to control prosthetics using signal directly from the brain. When an upper limb is surgically removed, the patient still sends electrical impulses along their nerves in order to control their missing limb. Using direct brain interface, these signal that are sent can be recorded and transmitted to move a prosthesis. This stage of prosthesis control is very much in its early stages but have shown another possible solution.

Figure 8: Diagram of mind-controlled prosthesis[17]

2.3.4 Myoelectric Control

Signals from the motor cortex travel through spinal cord to the intended muscle via motor neurons. These signals cause the muscle to either contract or relax, this contraction generates an electrical potential that can be detected on the surface of the skin. Electromyography is a technique used to measure the electrical activity of muscles [18] . To detect electromyographic signals, electrodes are attached to the skin over the muscles being studied. The sensors convert these signals into electrical signals, which are then used to activate the prosthetic's motors or other control systems. This signal is sent regardless of if the muscle is present or not, thus this signal can be used to control a prosthetic in a more natural way. However, they can also be more complex to set up and may require training and practice to use effectively.

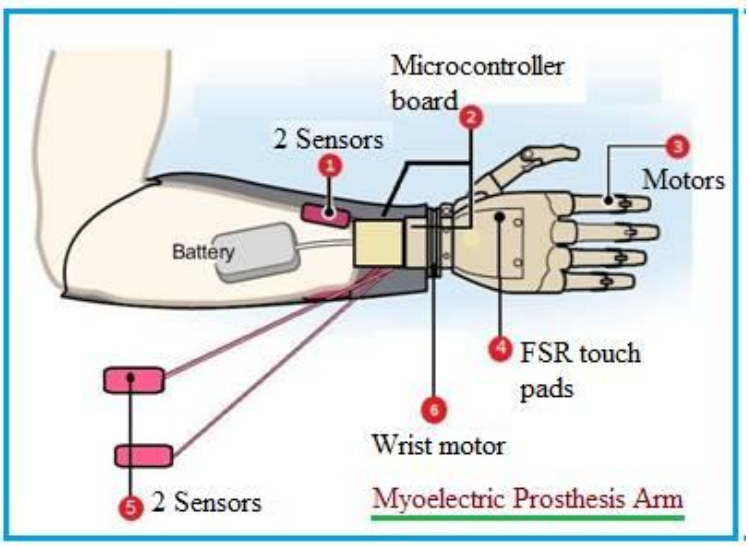


Figure 9: Myoelectric control of a prosthetic[19]

3 Design

3.1 Mechanical Design

The design that was chosen for this project was the InMoov open-source hand and forearm design by Gael Langevin. The ability to use a 3D printer to obtain the components allowed the cost of the prosthetic to be significantly lower and give more options to the material that are used in the prosthetic. The design uses a tendon-driven mechanism to control finger movements while using a geared mechanism to control wrist rotation.

Most of the mechanical and structural components of the arm were manufactured using an Ultimaker 2+ 3D printer with a combination of ABS+ and PLA plastics. Due of its higher strength and thermal stability, ABS+ plastic was used to print the gears within the wrist. PLA was used to print structural components of the hand and forearm.

PLA vs ABS+

PLA has a lower strength and tends to be more fragile than ABS. However, it is less challenging to print as ABS is prone to warping or shrinking which can cause many issues when working with structural component that must fit one another. The reason ABS+ was chosen over ABS was due to the toxic fumes that ABS emits when printing. ABS+ retains the same properties as ABS but without the toxic fumes as it is a blend of other 3D printing materials.

3.1.1 Tendons

The digits in the hand are tendon-driven mechanisms that use thread as tendons to control joints. Those tendons must be able to sustain high tension and resist deformation when force is applied. As a result, braided fishing line was chosen to act as the tendons.

- 4 stranded braids
- Thickness: 0.18mm
- Strength: 11.2kg

3.2 Electrical Design

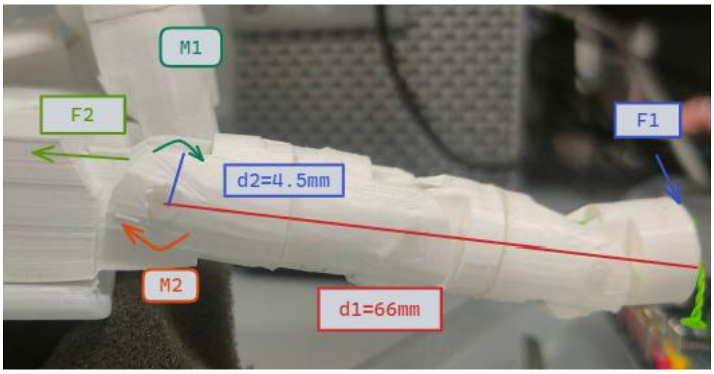
3.2.1 Servo Motors

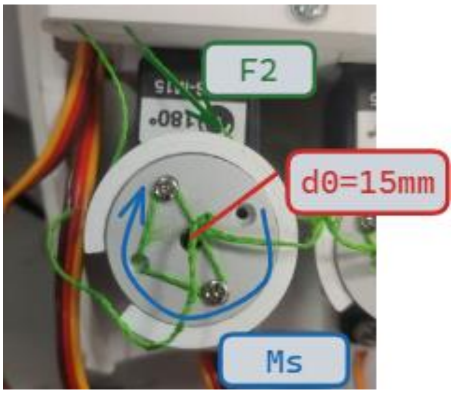
Five servo motors were needed to control the movement of each digit and a final sixth servo motor to rotate the wrist. The servo motors that were chosen for this project were the Tower Pro MG996R Metal Gear servo. The weight, rotation, low torque and operating voltage made this servo motor the best choice from those available at the time of assembly.

- Each motor is 55 grams, allowing the prosthetic to remain light for any possible user.
- Operating voltage is 4.8V to 7.2V allowing power supply to be compact.
- The rotation is 0 to 180 degrees.
- Maximum torque is 11kg/cm.

Force in fingers

To find the strength of each finger, the index finger as its extended will be discussed and a force will be applied to the tip of the finger.





$$Moment = Force \cdot Perpendicular\ Distance \tag{1}$$

$$M = Fd \tag{2}$$

The tendons create a moment in each joint in the finger with the greatest one being at the MCP joint as it is the furthest away from the applied force at the top of the finger. The point at which *M1* and *M2* are equal, the maximum load will be applied.

The stall torque is 11kg/cm or 1.1 N/m for the MG996r servos.

$$\tau_{servo} d0 = F2 \tag{3}$$

$$F2 = 1.1(\frac{N}{M}) \cdot 15mm \tag{4}$$

$$F2 = 16.5N\ tension\ in\ tendon \tag{5}$$

$$F1D1 = F2D2 \tag{6}$$

$$F1 = \frac{F2D2}{D1} \tag{7}$$

$$F1 = \frac{(16.5)(4.5)}{66} \tag{8}$$

$$F1 = 1.125N \tag{9}$$

This means that a force of 1.125N or a weight of 112.5g can be applied to the index finger when fully extended.

3.2.2 MyoWare Muscle Sensors

The MyoWare muscle sensor modules are used to detect the electromyographic signal in the user's arm. Biomedical sensor pads are attached to the MyoWare muscle sensors to allow it to be stick onto the user's arm so that the EMG signals can be read. These sensors are linked to the RedBoard circuit board to sends data to a computer.

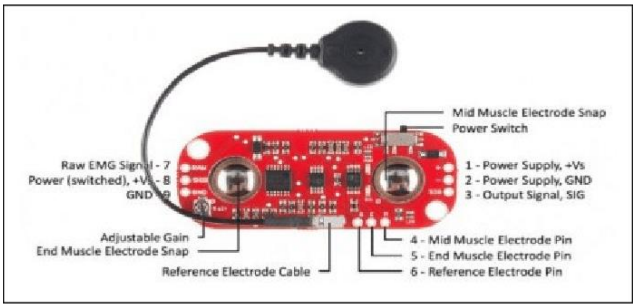


Figure 10: MyoWare muscle sensor[20]

3.2.3 SparkFun RedBoard

The SparkFun RedBoard is an Arduino compatible board as it has the Arduino Uno bootloader as well as having a micro-USB type B connection. It has an input voltage of 7 to 15 V which can power the EMG sensors but not the servo motors.

The servo motors are connected to the digital pins but take power from the power supply. The MyoWare sensors are connected to three of the analog pins to transmit the signals data.

4 Ethics

According to the United Nations (UN) sustainable development seventeen goals, the third goal of Good Health and Well-being states that it is to "Ensure healthy lives and promote well-being for all at all ages" [21]. This goal was kept in mind as the project progressed as something that could hopefully propel technology for people's wellbeing and comfort.

One of the primary insights from this thesis is that upper limb amputees face significant challenges in performing day-to-day tasks. Upper limb prosthetics can help restore some level of functionality to these individuals, but there are still many limitations to current prosthetic devices. Myoelectric prostheses offer more natural movement by using muscle signals to control the prosthesis, but they can be expensive and require regular maintenance.

5 Implementation

5.1 Printing and Assembly

Below in Fig. 12, all the component needed for the InMoov hand and forearm are shown. The files are all available online on the InMoov website to be printed. For this project, the Ultimaker 2+ and an Ender 3 printer were used to produce the components. The material that was predominantly used was PLA and the gears within the wrist were printed using ABS.

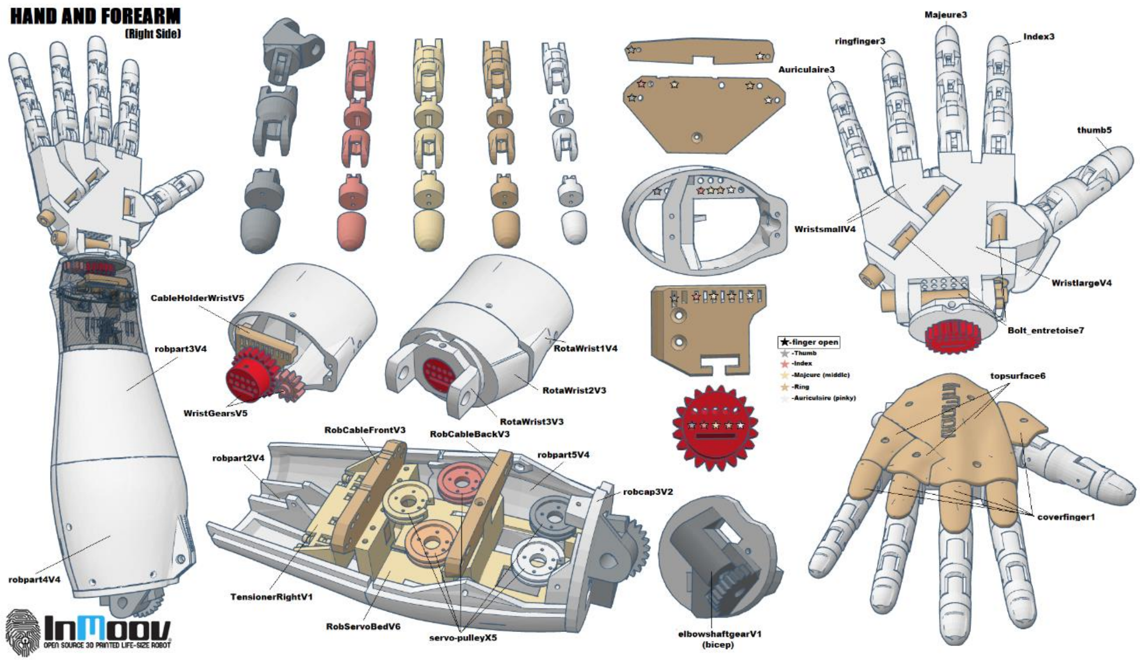


Figure 11: Assembly of InMoov hand by Gael Langevin[22]

Some adjustments that had to be made for this project in particular was for the MG996r servo motors in the forearm. In order for the pulley system to be functional, the servo pulleys had to be resized in order fit the servos used in this project. Through the use of Fusion 360 by Autodesk, it was possible to measure from models of the servo motor and adjust to a more suitable size.

Using Fusion 360, the gears that actuate the wrist were possible to adjust as well. The gears also were designed to fit a different servo motor than what was used in this project. It was possible to redesign the gear to fit the servo motor, allowing movement in the wrist. Aside from these larger issues hat came with the design, it was possible to ensure that each component fit correctly and allowed smooth movement where necessary by making small adjustments to resize and remove excess filament from the design.

The forearm was printed out first and holds the servo motors. To connect most of the support to each other, superglue was used wherever possible. The holes in which the servo motor holder was redrilled in order to screw in the holder to the forearm base. Next step was to print the wrist which didn't have enough supporting strength to stay attached to the forearm so a 2mm hole was drilled into it to give it as much strength as possible. For the gears of the wrist, a lubricant was used to ensure ease of actuation of the hand. In the design by Gael Langevin, there were bolts to allow movement of the thumb and for two of the hands digits which helps the hand make a more accurate fist.

To connect each joint of the digits, it was possible to use filament to secure through the joints by sealing the holes where each phalange ends.

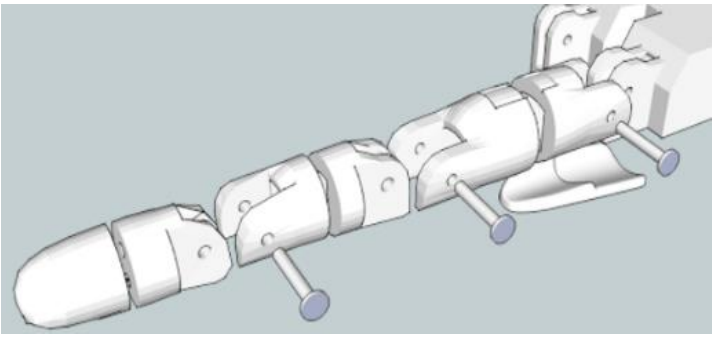


Figure 12: Assembling the finger joints[22]

Once all was printed and assembled, the tendons needed to be added. The fishing wire is passed through two holes at the tip of the fingertip, held by the wrist cable holder to be able to reach the servo motors in the forearm and to not get tangled when the wrist rotates. The fishing line is then wrapped around the servo pulley and knotted. At the tip of the finger, the two fishing wires that were passed through are tied to keep tension on the tendons.

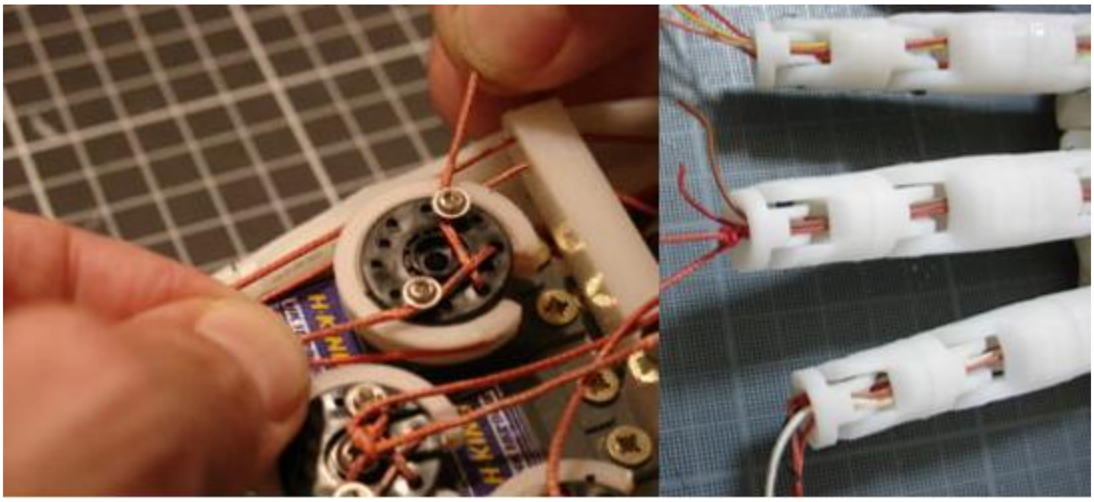


Figure 13: Tying the tendons to the servo motors(left) and tip of fingers(right) [22]

5.2 Mechanical and Software implementation

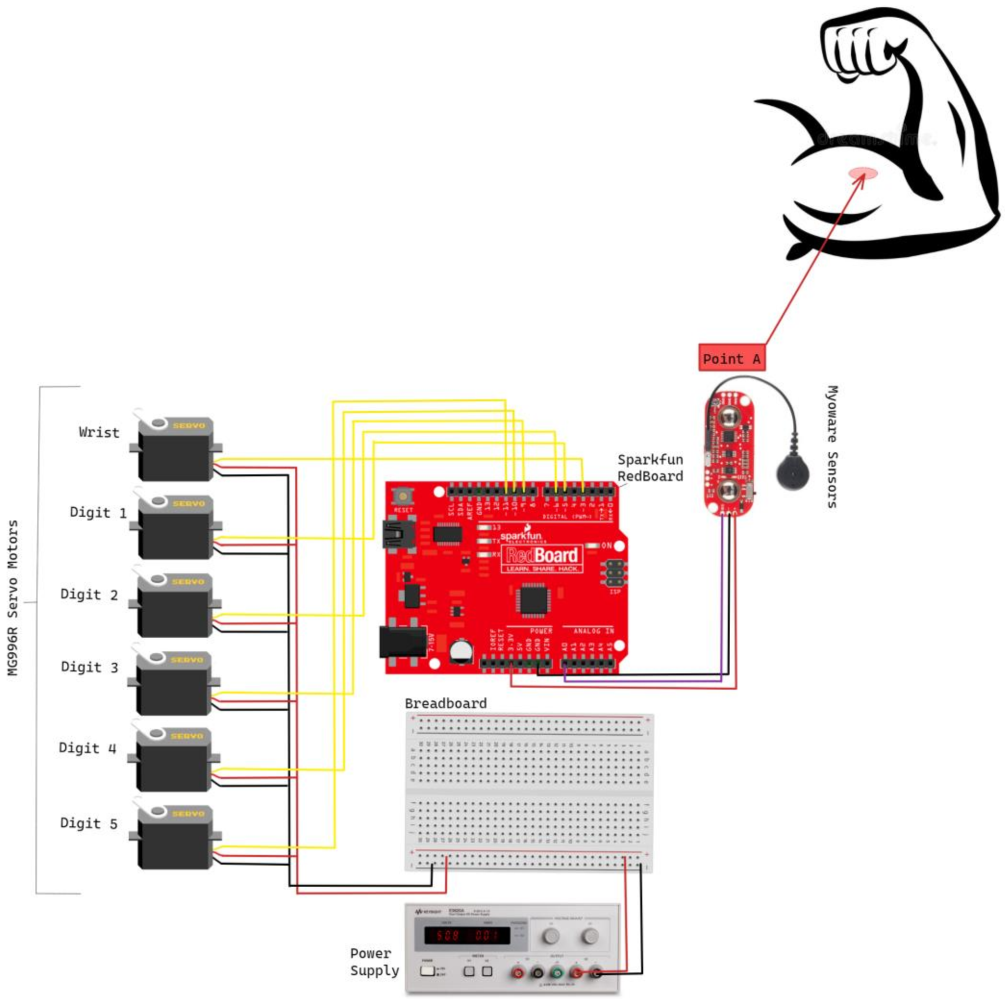


Figure 14: Circuit diagram for EMG control

Starting at the MyoWare sensors that are placed on the bicep, the arm is wiped with alcoholic wipes so the electrodes an attach easily onto the arm. To be able to attach the MyoWare sensor to the RedBoard, female to male connector pins had to be soldered onto where the signal, voltage in and ground are on the MyoWare sensor board. The ground wire is connected directly to the board and the voltage in in the 3.3V pin on the RedBoard. This will allow the EMG signals to be detected and transmit the data back to the user's computer to be able to read the serial plotter or monitor.

In the forearm of the InMoov arm, there is a tensioner with extension springs to pull on the tendons before they are fed through into the pulley system. When the servo motors turn, the pulleys that the strings are attached to turn to pull on the tendon that contracts the fingers. The servos are connected to the breadboard to power them as they need an external power supply, and the control is connected to the RedBoard's digital pins. The servos have a 6V from the power supply to be able to work correctly without damaging any of the components.

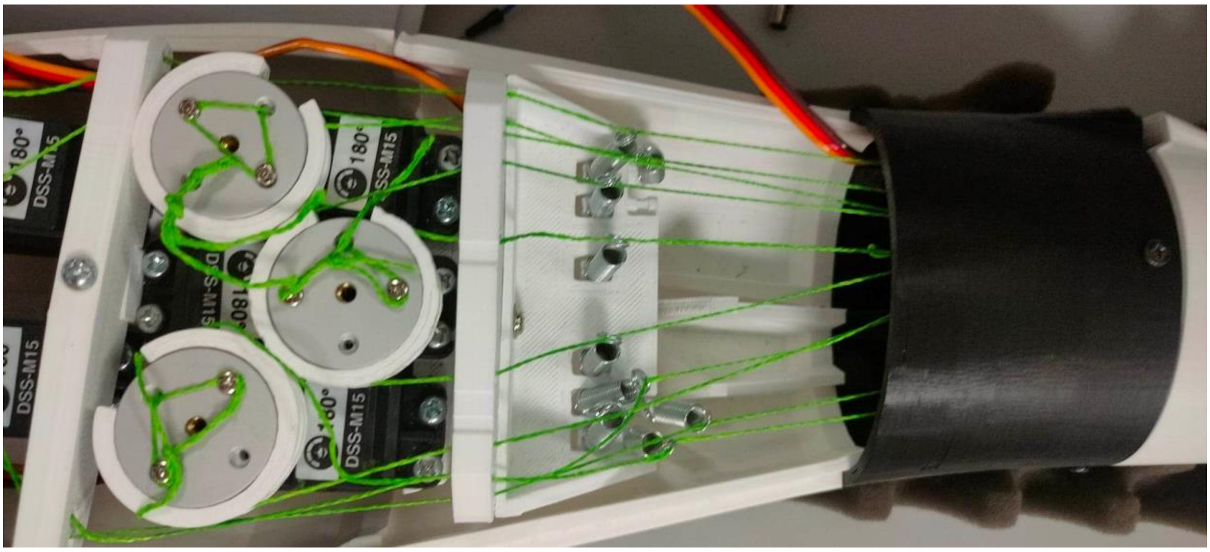


Figure 15: Extension springs adding tension in forearm.

All of the programming was in C++, using the Arduino IDE. The code was modified from the Roujin project to control the servos with the EMG sensors[23].

6 Evaluation

After the arm was assembled, the stability of the structure could be tested. The servo motors in the forearm were set to the 180 degrees to see if the tendons and wrist would be able to withstand the tension for a fully closed hand. At first, the wrist would break away from the forearm and to solve this issue a small 2mm hole was drilled through the wrist and the forearm to add a small screw for extra stability and strength.

The tendons under severe pressures would break at the servo pulley where most of the force would be on the fishing line. Through trial and error, it was possible to find at which length the fishing line ad to be to allow enough tension without damaging the arm itself. To ensure the tension on the tendons was correct on each side on the pulley, a separate Arduino file was used to test each servo from 0-180 degrees at different times so that each could be focused on independently. If there was too much tension on the tendons, it would either split or the servos would be strained and on the opposite side if there was too little tension on the fishing line, the digits wouldn't be able to contract properly.

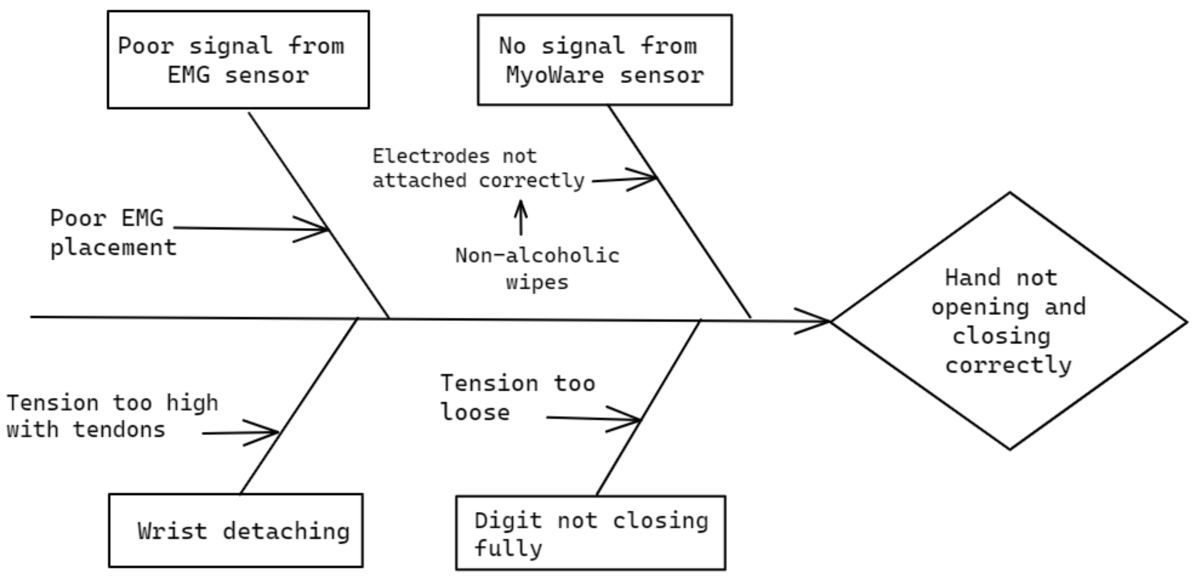


Figure 16: Cause and Effect fishbone diagram of project

Most of the issues that came up throughout the project were from detecting the EMG signals in the arm correctly. One of the first obstacles to overcome was trying to diagnose why there was a poor to no signal coming from the MyoWare muscle sensor to the RedBoard. As can be seen in the diagram above in Fig. 15, one of the reasons behind this was due to poor placement on the user's arm. This led to finding the best positions to attach the muscle sensors to have better results. The other reason behind a poor signal was due to the electrodes not staying attached to the user's arm. Before an EMG electrode is applied to a person's arm, the skin must be cleaned with alcoholic wipes. This is vital so that the oil and dirt that would naturally be on the skins surface isn't picked up by the electrode and causing it to detach from the arm.

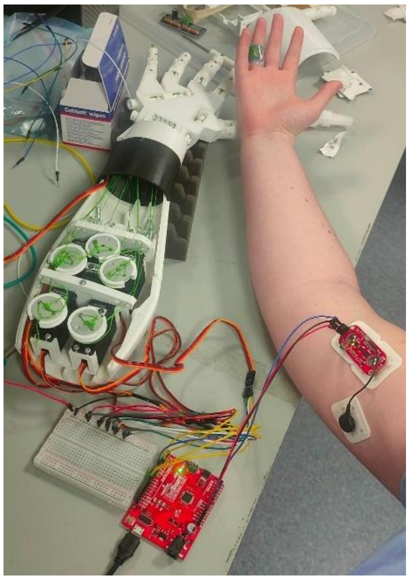


Figure 17: EMG muscle sensor on bicep to control 3D printed arm.

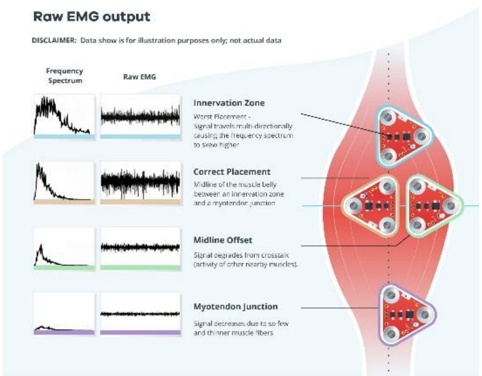


Figure 18: Placement of EMG sensor[24]

The other reason behind a poor signal was due to the electrodes not staying attached to the user's arm. Before an EMG electrode is applied to a person's arm, the skin must be cleaned with alcoholic wipes. This is vital so that the oil and dirt that would naturally be on the skins surface isn't picked up by the electrode and causing it to detach from the arm.

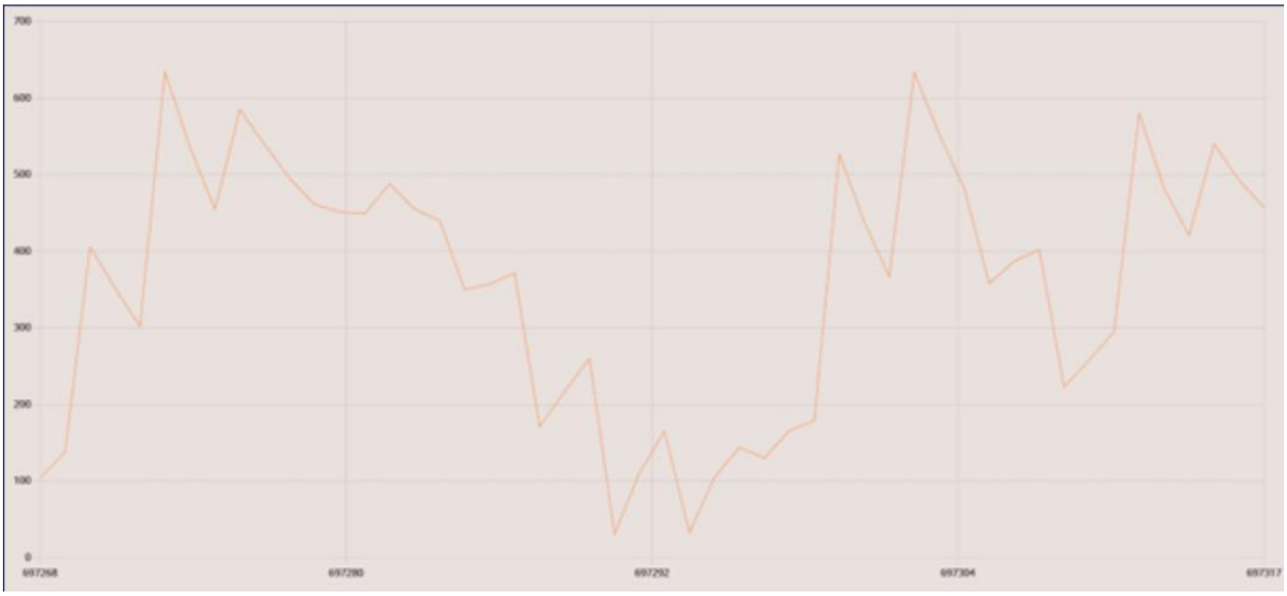


Figure 19: EMG signals on serial plotter in Arduino

In the graph above, the EMG signal that are received from the user's bicep from the MyoWare muscle sensor are shown to spike at two different points in particular. The sensor is very sensitive to movement and interference and the points in the graph where signals rise to over 300 shows where the muscle was contracted. This is the threshold for this particular user to flex the muscle that the EMG sensor is attached to. In the code for moving the servo motors, the signal must reach over a threshold that is pre-set. This moves the servos to follow the user's muscle activity and ensures it does not move each time the signal's value raises.

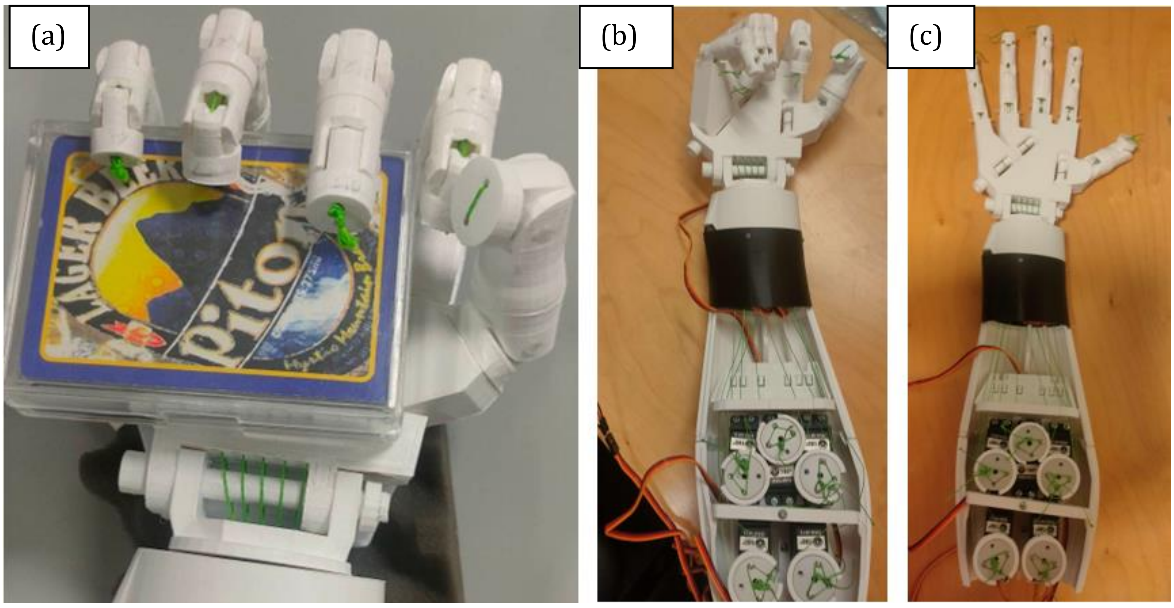


Figure 20: (a) 3D printed hand holding cards, (b) 3D printed hand closed, (c) 3D printed hand open.

7 Conclusion

The initial aim of this project was to develop a surface EMG controlled prosthetic hand that could be assembled using 3D printed components. The main goals of this project were to design and develop a low-cost alternative to current commercial prosthetics that can be used in developing nations and countries that are in conflict. The design is an open-source design that can be assembled providing there is access to a 3D printer allowing developing countries and countries that are in conflict to get quick access to prosthetics. The goals outlined were achieved, and it is hoped that this thesis will help allow further research into the field of myoelectric control for robotics and integration with prosthetics.

The final design for this project has been successful in finding a low-cost alternative to the current commercially available prosthetics through use of 3D printing. The various types of upper limb prosthetics available have been discussed, including myoelectric prostheses, and compared their respective advantages and disadvantages. Considerations for robotic upper limb prosthetics, such as degree of freedom and control methods has also been examined to ensure as that the hand can perform more effectively.

There are a few improvements that could be made to both the hardware design and processing of the EMG signals. One improvement that could be made is to use pattern analysis and classification to recognise the muscle movement that is detected in the user's arm. Another small improvement that could be made is to add silicone fingertips to be able to grip objects more easily. Finally, adding a ball in socket joint for the thumb could add greater actuation and lead to a higher number of degrees of freedom in the hand. However due to time constraints of this project, it was not feasible to apply these improvements to this project. It is hoped that future work will be able to extrapolate on the work done in this project.

In conclusion, while there are still many challenges to be addressed, the integration of robotics into upper limb prosthetics has the potential to revolutionize this field and improve the lives of millions of people around the world. This thesis has hopefully provided valuable insights into the current state of upper limb prosthetics and inspired further research in this important field.

8 Appendix

8.1 Code

git@github.com:brunobruen/FinalYearProject.git

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Risk Assessment

Departments of Computer Science and of Electronic Engineering, Maynooth University

Robotics and Intelligent Devices 4th YEAR PROJECT RISK ASSESSMENT FORM

STUDENT NAME: [redacted]	SUPERVISOR(S): [redacted]
PROJECT TITLE: EMG Based Pattern Recognition to Control a Hand Prostheses	
PROJECT LOCATION(S): Maynooth University	
BRIEF DESCRIPTION OF PROJECT: The aim of this project is to focus on using electromyographic sensors to have control over a prosthetic hand. Using the signals from the sensors, the hand should mimic the user's hand movements. This requires building a 3D printed robotic hand. This project will investigate other designs to help amputees in need of upper limb prosthesis and replicate the best design.	

Hazards, Risk (High(H) Medium (M) Low (L)), and Control Measures

HAZARD	Risk	Controls
Fumes from 3d printing filament	L	Keep printer in well-ventilated room
Breaking of 3d printed components	L	Do not apply too much weight to the arm
Overheating of motors	L	Allow ventilation and time to cool down
String breaking in arm	L	Do not apply too much weight to the arm

Identified risks should be discussed with your supervisor and a safe system of work agreed. A more in depth risk assessment may be required after initial review. Do not proceed until form is signed off.

WEEE Compliance & Recycling: Indicate below how you intend to manage and dispose of your projects material during and post project work.

Further Controls Required

SIGNATURE OF STUDENT: [redacted]____ DATE: 30/11/22

SIGNATURE OF SUPERVISOR(S): _[redacted] DATE: 30/11/22

____________________ DATE: ____________

Health and Safety signatures must be obtained based on where practical work will be conducted (see project locations above). If work will be conducted in both Computer Science and Electronic Engineering then signatures are required from both departments.

PRIMARY DEPT HEALTH AND SAFTEY COMMITTEE MEMBER: [redacted] DATE: __02/12/22____________

SECONDARY DEPT HEALTH AND SAFTEY COMMITTEE MEMBER: ______________________ DATE: ____________

I confirm that I have no medical condition that impedes safe working on my project and I will advise the signatories above if this status changes.

SIGNATURE OF STUDENT: [redacted]___ DATE: 30/12/22

EE496_CS_EE_RiskAssessmentForm_2021a25_jm