PROSTHETC HAND FOR DISABLED PERSON

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A Project Report Submitted to the Electrical Engineering Department in partial fulfillment of the requirements for the degree of Bachelors of Science inElectrical Engineering

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CERTIFICATE OF APPROVAL

It is certified that the project titled "PROSTHETC HAND FOR DISABLED PERSON" carried out by Maira Rashid Reg.No.F19603029 and Kashif Altaf Reg.No.F19603010 and Arshad Kamal Amir Reg.No.F19603027.Under the supervision of Dr. Abdullah Waqas, National University of Technology (NUTECH), Islamabad, is fully adequate in scope and in quality, as a capstone project for the degree of BS of Electrical Engineering.

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Thanks for all your encouragement!

DECLARATION

It is declared that this is an original piece of our own work, except where otherwise acknowledged in text and references. This work has not been submitted in any form for another degree or diploma at any university or other institution for tertiary education and shall not be submitted by me in future for obtaining any degree from this or any other University or Institution.

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ABSTRACT:

The prosthetic hand is a tool used by amputees to enable them to do daily tasks. A cost-effective five-finger prosthetic hand is designed from 3D printing, modeled and controlled using surface Electromyography (EMG) signals, which are obtained from the human body. The size of the five-finger hand is similar to an adult male human hand, and it is capable of reproducing most of movements. Disability does not discriminate based on an individual's income or capacity, thus most of them should be able to afford it. In the west, there are several nations that can produce prosthetics at a reasonable cost, but they have better economies and labor markets than we do. Therefore, a project like this can have an impact. The concept partially fulfilled the goals and targets set at the outset of the project. The prosthetic arm is made up of PLA material. The motion of five fingers of the hand is controlled by five motors, fitted inside the arm. Electrodes are placed on patient's body at selected muscles and EMG signals from the muscles .The feature detection & extraction algorithm is implemented in the Arduino controller, which tells the motors to move in accordance with the type of motion to be performed.

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MCI	muscle-computer interface
EMG	Electromyography
PLA	Polylactic Acid
MVC	Maximum Voluntary Contraction
RMS	Root Mean Square

Chapter 1

INTRODUCTION

Prosthetics are difficult to obtain in places like Pakistan, and those that are available are frequently expensive since they are imported from places like Germany. For the typical person who cannot afford such prosthetic limbs, this is a serious problem. In addition, the offered alternatives are mostly aesthetic upgrades rather than functional upgrades and lack meaningful utility. However, recent technical developments have created new opportunities in the realm of prosthetics, giving people who have lost limbs or are disabled hope.

Prosthesis is an artificial device made to replace lost limbs from an accident or disease and restore some functional ability. Upper extremity amputation is taken into consideration in this study. In contrast to western countries, the number of amputations occurs far more frequently in developing nations. Reasons for it include a lack of medical expertise, resources, or treatments for diseases that are curable in industrialized nations. Physical, psychological, and financial disabilities are all consequences of amputation of a limb. Artificial limbs were developed in order to lessen these effects. Prosthetics are produced by a large number of companies. Some just serve an aesthetic purpose, while others attempt to re-establish a lost limb's functionality so they can assist with actions like picking up objects.

For those who have had their upper limbs amputated, the prosthetic hand is a unique artificial device that is intended to mimic some of the capabilities of a real hand. Due to inadequate medical infrastructure and the persistence of diseases that have been successfully treated in more developed countries, developing countries, like Pakistan, have a greater prevalence of amputees. The effects of losing an upper limb are severe, not just physically but also socially and psychologically.

There are several types of commercial prosthetic hands available on the market, including designer aesthetic hands, split hooks, and myoelectric hands that use body power, however the majority of these alternatives are prohibitively costly, sometimes costing hundreds or even lakhs of rupees. Even prostheses created merely for cosmetic purposes have a high cost. As a result, the difficulties with distribution and upkeep further restrict the availability of prostheses for amputees in underdeveloped nations. The main goal of our research is to solve this problem by designing a more affordable prosthetic hand that is made especially for amputees using 3D printing technology.

The suggested prosthetic hand make use of a typical myoelectric control system, in which EMG surface electrodes are affixed to the amputee's residual limb and collect myoelectric signals that are converted into hand motions, allowing the hand to open and close. Trans-radial prostheses may now be produced at a low cost while yet providing durable characteristics thanks to advancements in 3D printing technology.

The goal of this undergraduate thesis is to create a prosthetic hand that is 3D printed and can be operated by EMG impulses. We want to get agreement on the critical characteristics and create a prosthetic hand that satisfies practical criteria, even if it may be hard to perfectly recreate all the parameters and output requirements of a normal hand with present technologies. To do this, we look at the natural hand's functionality and gauge its most typical grabbing behaviors.

Our initiative is to empower people who have lost limbs by tackling the pricing and accessibility issues related to prosthetic hands in developing nations, allowing them to reclaim their freedom and actively engage in everyday activities. By utilizing 3D printing technology and incorporating effective control systems, we want to provide an affordable and practical solution that greatly raises the standard of living for amputees in Pakistan and beyond.

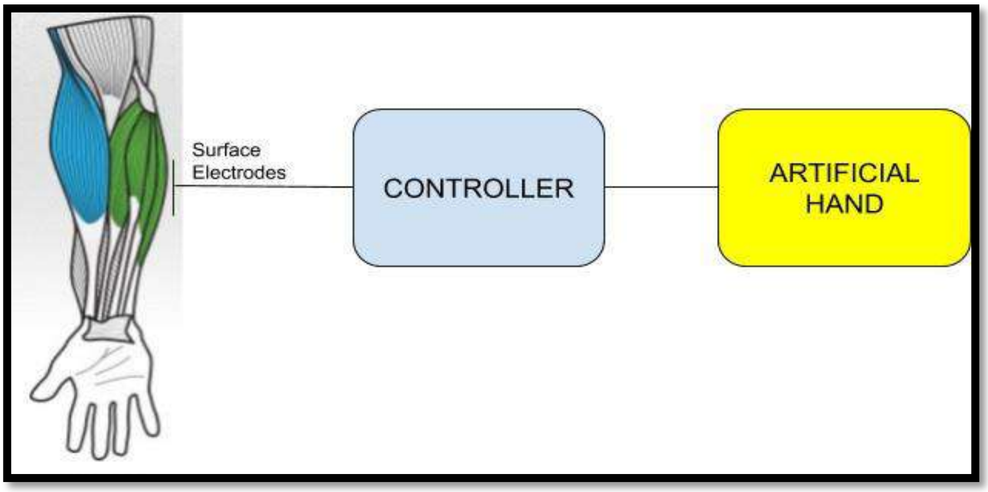


Figure 1.1: Artificial Hand

1.1 Overview

The goal of our project is to create a prosthetic hand that is lightweight and has functioning finger and thumb movements. The main goal is to develop a practical and effective solution that increases independence and raises quality of life for those who have lost their upper limbs.

The prosthetic hand is created to mimic normal hand movements, such as gripping, pointing and positioning things, to enable users to carry out necessary everyday tasks. Users are able to resume performing actions that are essential for living their daily lives as a result.

The electromyography (EMG) signals produced by the bicep and triceps muscles are used to drive the prosthetic hand's control system. These signals are analyzed and interpreted to operate the servo motors that move the fingers after being captured by surface electrodes positioned on the residual limb. This novel method guarantees a smooth and simple control system that enables users to operate the prosthetic hand with their remaining limb.

By lowering physical stress on consumers and maximizing comfort, this strategy hopes to lessen weariness. Individuals will be able to use the prosthetic hand for longer periods of time, fostering more independence all day long.

Our research intends to provide people a prosthetic hand that is not only effective and useful but also economical and accessible by merging control mechanisms, simple user interfaces, and lightweight construction. We are aware that the high price and restricted supply of prostheses present serious problems, particularly in underdeveloped nations like Pakistan.

The successful completion of this project ultimately empowers those who have lost limbs, enabling them to reclaim their freedom and actively participate in daily activities. The prosthetic hand's capacity to mimic crucial hand functions and its simple control scheme greatly improve users' quality of life and aid in their return to independence. We hope to have a good influence and help create a more empowered and inclusive society by offering an effective prosthetic hand.

1.2 Statement of Problem

We want to solve the issue that people with upper limb problems or amputations don't have access to affordable, lightweight prosthetic hands. The functionality, weight, price, and control methods of current prosthetic choices are frequently constrained, making it difficult for users to accomplish basic everyday tasks.

Limited Functionality: Conventional prosthetic hands frequently fall short in their attempts to mimic the complex motions and skills of natural hands. They are unable to manipulate items with accuracy and dexterity while grasping, pointing, and positioning them.

Heavy and Bulky Design: A lot of the prosthetic hands that are currently on the market are heavy and bulky, making the user uneasy and worn out. This makes it more difficult for them to use the prosthetic hand effectively and for long periods of time.

Cost and accessibility: For the typical individual in poor nations like Pakistan, existing prosthetic hands purchased from rich countries are frequently unaffordable. As a result, people have restricted access to prosthetic limbs, which prevents them from regaining their independence and engaging fully in everyday life.

For people with impairments or limb loss, the combination of these difficulties makes it very difficult for them to restore their independence and lead happy lives. Therefore, there is an urgent need to create a lightweight, useful prosthetic hand that tackles these problems and gives people an effective, practical way to carry out basic everyday tasks.

By creating a prosthetic hand with functionality, a lightweight design, simple control systems, and affordability, our project intends to solve these issues.

1.3 Proposed solution

We suggest the following ways to deal with the issues mentioned in the problem statement:

Enhanced functionality: Each finger on our prosthetic hand has three joints, allowing for a larger range of motion and enhancing the hand's capacity to grasp and operate items. Users have the ability to carry out daily task with better accuracy and dexterity thanks to this improved capability, which will closely mimic the capabilities of a normal hand.

Lightweight Construction: When making the prosthetic hand, we'll give special consideration to using lightweight materials. We want to reduce the prosthetic hand's total weight by utilizing innovative lightweight components, improving user comfort and reducing fatigue. Individuals will be able to wear the prosthetic hand without discomfort for extended periods of time thanks to this.

Cost-Effectiveness and Accessibility: Our project's focus is to develop a lower-cost prosthetic hand that is affordable and accessible, particularly for individuals in developing countries like Pakistan. By leveraging advancements in 3D printing technology, we can reduce production costs and make the prosthetic hand more economically viable for a wider population. This contributes to increasing accessibility and availability for those who need it.

By putting these suggestions into practice, we want to create a light and useful prosthetic hand that not only overcomes the shortcomings of the current alternatives but also provides affordability, accessibility, and simple control. With the help of this all-encompassing strategy, people who have lost a limb or are disabled will be better able to restore their independence, enhance their quality of life, and successfully reintegrate back into society.

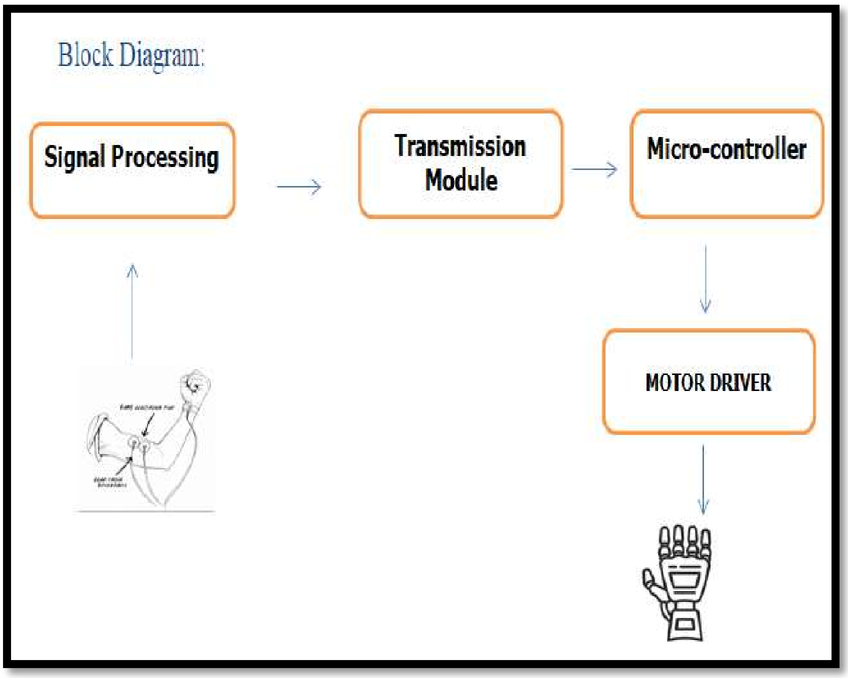


Figure 1.2: block diagram of working model of project

1.4 Benefit of the project:

We hope to solve the drawbacks of current options and provide various advantages to those with disabilities or limb loss by creating a lightweight and practical prosthetic hand:

Enhanced Functionality: Our prosthetic hand provide users the ability to carry out a variety of crucial daily tasks, such as precisely pointing, and placing objects in the right place. Users will be given the ability to reclaim their freedom and take an active role in their everyday life thanks to this capability.

Intuitive Control System: Our prosthetic hand provides a more natural and intuitive control mechanism by using EMG signals produced from the bicep and triceps muscles. Users' remaining limbs will be able to control the hand's motions, resulting in a fluid and responsive user interface.

Lightweight design: We are aware of how crucial it is to create a prosthesis that is as light as possible and eases the user's physical strain. Without sacrificing strength or utility, we put a lot of emphasis on employing lightweight materials. The prosthesis may now be used for longer periods of time with less fatigue and an increase in user comfort.

Cost-effective remedy: An essential component of our project is accessibility. We want to develop a prosthetic hand that is more economical than current options by leveraging low-cost manufacturing processes and widely accessible components. We can provide technology to a wide spectrum of individuals who need it thanks to its accessibility.

Improving quality of life: Quality of life will ultimately be improved for those who have lost limbs or are incapacitated as a result of the successful design and production of our prosthetic hand. A prosthetic hand can greatly enhance quality of life by restoring lost function and fostering independence, enabling people to carry out their daily tasks with more assurance and comfort.

1.4 Summary

Our project seeks to deliver prosthetic hands for persons with disabilities and amputees by utilizing a creative design approach that integrates control mechanisms, lightweight construction, and intuitive functioning. By offering effective and useful solutions, we empower people, reclaim their freedom, and assist them in looking into new possibilities for a better future. In summary, the project's main goal is to create an electric control system-equipped prosthetic hand that is both inexpensive and 3D printed. By doing this, the availability, cost, and functioning barriers remove, allowing people who have their upper limbs amputated to reclaim their independence and take an active role in daily activities.

Chapter 2

LITERATURE REVIEW

2.1 Related Studies/Research

In many countries, research is being conducted to introduce Prosthetic hand as a way of encouraging weight of hand and material use and consumer demand responsiveness. We have reviewed many related studies some of them are mentioned below.

2.1.1 Myoelectric prosthetic hand:

The paper "Improvement of a Myoelectric Prosthetic Hand with Tactile Input" presents a review that spotlights on upgrading the usefulness and convenience of prosthetic hands by coordinating tangible criticism instruments. The specialists expect to create a myoelectric prosthetic hand that empowers clients to see contact and strain sensations, subsequently working on their connection with the climate. [1]

Figure 2.1: myoelectric prosthetic hand

Functionality:

The usefulness and ease of use of prosthetic hands have been huge areas of examination, intending to give people upper appendage removals a more normal and natural experience. While myoelectric prosthetic hands offer better smoothness by using electromyography signals from leftover muscles, the shortfall of tactile input has restricted their adequacy.

The review acquaints an original methodology with address this constraint by coordinating tactile input into a myoelectric prosthetic hand. By integrating material sensors and tension sensors inside the prosthetic hand, clients can encounter the vibe of touch and strain on the counterfeit appendage. This combination considers a more regular and instinctive connection with objects and the climate.[2]

The advancement cycle of the myoelectric prosthetic hand with tactile criticism is depicted exhaustively in the paper. The scientists frame the plan contemplations, sensor arrangement, and sign handling methods used to catch and decipher tactile input. Furthermore, the paper examines the improvement of a UI to permit clients to control and tweak the tangible input by their inclinations and requirements.

The review incorporates assessments and client input to survey the viability and client acknowledgment of the myoelectric prosthetic hand with tactile criticism. The outcomes show positive results, with clients detailing further developed usefulness and a more reasonable tactile experience. The joining of tactile criticism not just improves the client's capacity to control protests yet additionally gives a more prominent feeling of encapsulation and presence with the prosthetic hand.

All in all, the paper features the meaning of coordinating tactile criticism into myoelectric prosthetic hands for people with upper appendage removals. The improvement of a myoelectric prosthetic hand with tactile input offers promising possibilities for working on the usefulness, convenience, and in general client experience of prosthetic gadgets. This examination adds to the progression of prosthetic innovation, giving an establishment to additional investigations and headways in the field.

2.1.2 A novel muscle-computer interface for hand gesture recognition using depth vision:

This study presents a unique muscle-computer interface (MCI) that blends hand gesture detection with depth perception technologies. The suggested method makes use of a depth camera to record depth maps of the hand, which enables precise monitoring of hand motions in three dimensions. Convolutional neural networks (CNNs), in particular, are used to classify the hand motions based on the characteristics that can be retrieved from the depth maps. Numerous tests show that the system is more accurate and resilient than existing vision-based and electromyography-based techniques for real-time hand gesture identification. In virtual reality, gaming, and assistive technologies, the muscle-computer interface employing depth vision may be used to improve user engagement. Accurate and simple hand gesture detection is a key component of this process.[3]

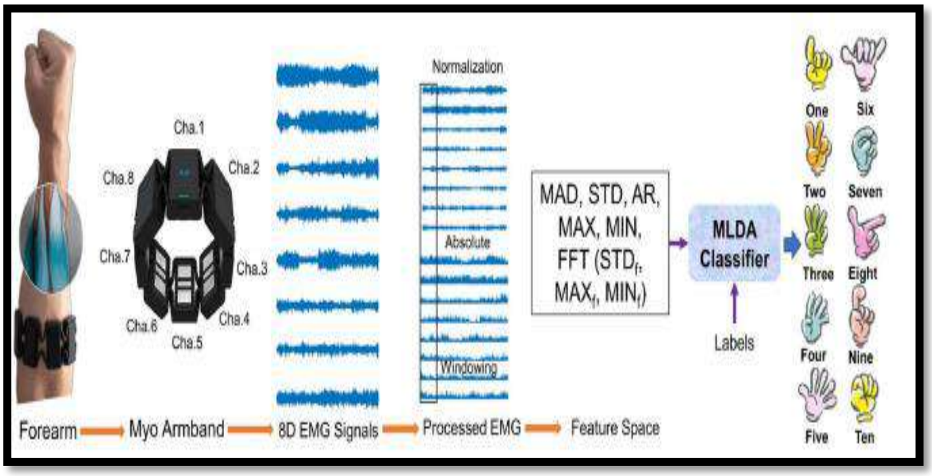


Figure 2.2: Schematic Diagram of hand gesture recognition

Functionality:

Depth Vision Capture: The suggested method makes use of a depth camera to take depth maps of the hand, which give detailed details on the hand's movements and spatial arrangement.

Extraction of Relevant characteristics for Gesture Recognition: The acquired depth maps are processed to extract pertinent characteristics. To extract discriminative characteristics that reflect various hand motions, a variety of methods are used, including image processing and computer vision algorithms.

Gesture Classification: Based on the retrieved characteristics, hand motions are classified using convolutional neural networks (CNNs), a machine learning model. The CNN model learns the patterns and traits of various gestures by training on a dataset of labeled hand gestures.

Gesture Recognition in Real Time: The suggested muscle-computer interface system is built to recognize gestures in real time. By offering real-time feedback or control based on the recognized gestures, it guarantees rapid and smooth interaction between the user and the computer system.

Evaluation of Performance: Extensive experiments are carried out to assess the system's performance. To demonstrate the benefits of the suggested technique, the precision and reliability of gesture recognition are evaluated and contrasted with those of existing vision-based and electromyography-based approaches.

Potential Uses: The depth-vision-based muscle-computer interface has the potential to be used in a variety of settings. It can improve user engagement in virtual reality settings, make games easier to understand and more immersive, and help with the creation of assistive devices for those with motor disabilities.

In order to allow precise and immediate hand gesture identification, the study "A novel muscle-computer interface for hand gesture recognition using depth vision" introduces a ground-breaking method that blends muscle-computer interfaces with depth perception technology. The system outperforms conventional approaches in terms of performance, and it has a wide range of possible applications.

2.1.3 Prosthetic Hand Using EMG

A prosthetic hand is an artificial device created to provide people who have lost their upper limbs functioning. Due to a lack of medical facilities and common ailments, developing nations have a larger percentage of amputees than wealthy nations. Losing an upper limb has effects on one's physical, social, and mental health. Commercial prosthetic hands on the market come in a variety of mechanical designs, signaling systems, and power sources, however they are sometimes pricy and unavailable in underdeveloped nations. The goal of our research is to create a 3D-printed prosthetic hand that is less expensive and can be controlled by an EMG input. This concept connects to the forearm using advances in 3D printing and uses EMG electrodes to capture signals for control. To create a prosthetic hand that works well, one must have a thorough understanding of the anatomy and physiology of the human hand. While it is difficult to completely duplicate a natural hand, we may create a useful prosthetic hand by taking into account the hand's functional capabilities and typical gripping habits.[4]

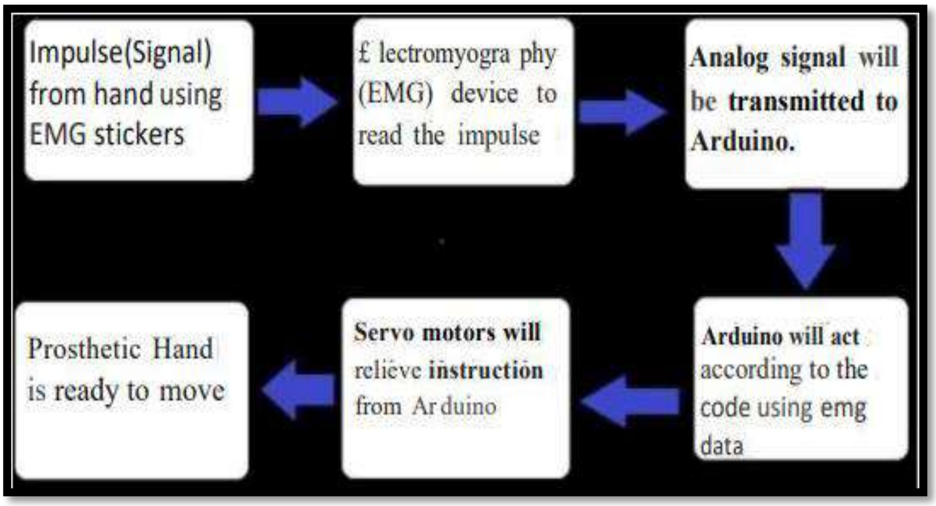


Figure 2.3: Design and Implementation of the Prosthetic Hand Using EMG

Functionality:

This study paper's functionality focuses on creating a prosthetic arm that amputees can control, enabling them to carry out regular daily tasks like gripping and releasing items. The prosthesis has to be light and the right size because it will be fastened to the amputee's forearm. The project's creation of a cheap prosthetic hand for amputees with limited financial resources is another goal.

The study discusses the development of a prototype prosthetic hand with minimal functionality, a control unit, and a sturdy and lightweight construction thanks to 3D printing. The modeling, production, and assessment processes for radial 3D printed Trans prostheses are covered in the study.

The prosthetic hand works by intercepting the amputee's electrical impulses. To do this, electrode stickers are attached to the amputee's forearm and used to interpret the electrical pulses that the muscles produce. Anatomical factors and academic research are used to carefully choose the position and orientation of the muscle sensor electrodes.[5]

Depending on how strongly a muscle contracts, electromyography (EMG) signals—electrical impulses that are detected on the skin's surface—have varying frequencies. To pick up these impulses, EMG sensors are placed across the forearm. The strength and effectiveness of the signal are influenced by where the sensors are situated, and the electrodes are positioned in the muscle's middle in line with the direction of the muscle fibers.

The EMG signals are converted to digital form and delivered to an Arduino that has servo motor control software. Finger actuation is accomplished with a servo motor, more precisely an SG90 servo motor. The Arduino moves the servo motor in a certain direction as soon as the EMG signal reading exceeds a threshold. The selected SG90 servo motor is small, light, and reasonably priced. It has a built-in gearbox and can rotate 180 degrees.[6]

The overall goal of this research programmed is to create an EMG-controlled prosthetic arm that is both affordable and lightweight. It focuses on integrating EMG sensors, Arduino, and a servo motor to provide amputees with fundamental hand functioning.

2.1.4 Cost-Effective Prosthetic Hand Controlled by EMG

The Approximately 1 in every 200 people in the United States has had an amputation, which is a considerable frequency rate. With over 156,000 people having amputation surgery every year, the country currently has over 1.7 million amputees. Amputations from trauma and cancer have been declining, but there has been an increase in amputations from vascular illnesses, notably diabetes.

Depending on functionality and features, prosthetic hand designs and prototypes range in price from $1,500 to $36,000 in order to meet the demands of amputees. Based on characteristics like as cost, size, feedback sensing, grip strength, weight, and movement capabilities, these prosthetic hands may be divided into two classes. High-end prosthetic hands that closely mimic human hands in terms of size and movement make up the first category. High-end prosthetic hands that closely imitate the shape and motions of a normal human hand make up the first category. These concepts, which are best shown by Steeper's Be Bionic hand, provide natural-looking aesthetics, reliable sensing and feedback systems, and adequate strength for daily tasks. But they are expensive. One example is the $36,000 Be Bionic hand, which can grasp in 14 different ways, has finger sensors, and a back magnet for increased strength and speed. The second category contains of hands that vary in size, some coming close to a natural hand's measurements, but have weak gripping abilities. Low-cost alternatives, including 3D-printed hands, frequently lack feedback sensing capabilities.[7]

In general, this article examines the landscape of artificial hand designs and prototypes, looking at the variety of features and functionalities offered. It sheds light on the trade-offs between affordability and performance in prosthetic hands, including both sophisticated commercial models and more affordable 3D printed alternatives, by highlighting the price discrepancies and variations in size, strength, and feedback sensing.[8]

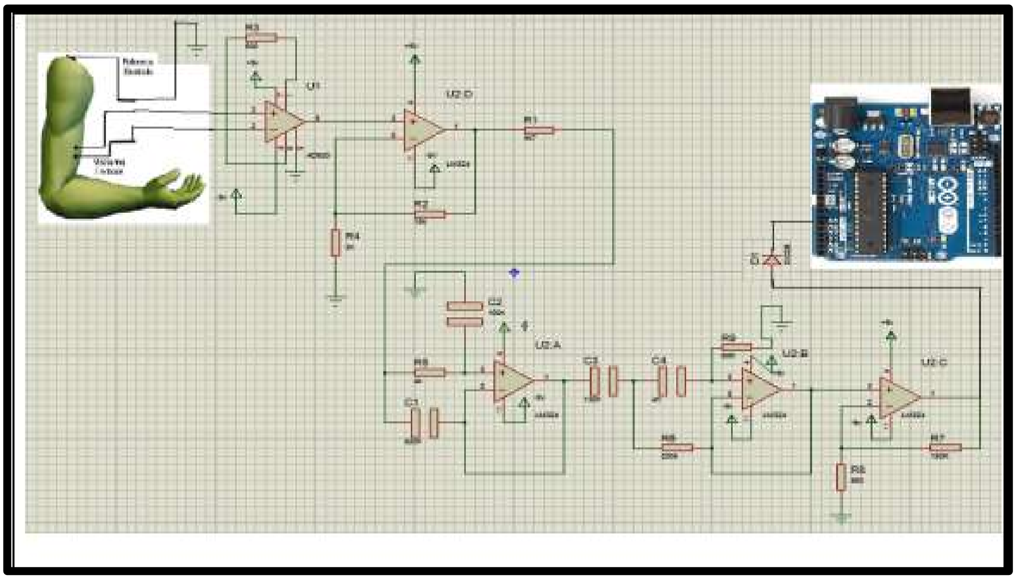


Figure 2.4: Circuit diagram of cost effective prosthetic hand

<u>Functionality</u>:

The control portion of the prosthetic hand design, including the feedback from each finger and the modeling of finger movements, is the main topic of this study. The procedure entails identifying signals from the amputee's arm muscles and converting them so that they are compatible with the Arduino UNO, the project's controller. The Arduino then uses the signals it has received to operate the fingers. Each finger is controlled by five servo motors, and a force sensor is attached to the tip of each finger to sense contact. The sensor detects when a finger is touched and provides a signal to turn on or off a transistor switch. This transistor switch in turn controls a vibration motor that is linked to the amputee's arm and gives them a feeling of touch. The V-rep programmed is also used to simulate the hand's movements using a Simulink model.

The selected controller unit should have at least five analogue input pins for the finger signals and five output pins for servo motor control in terms of hardware connections. Due to its fourteen digital input/output pins, user-friendly software, and capability to show data on the screen, the Arduino UNO is chosen as the controller. Its affordability and simplicity of changing individual components, if necessary, were other deciding consideration.

Chapter 3

PROJECT DESIGN

This chapter explains the design of our project.

3.1: Design of the Project Hardware

Our project's prosthetic hand design was acquired from the open source InMoov website.

Using the Solid Works software, the dimensions of each component and its component parts were shown.

The whole arm required the following elements:

Following is a list of the parts and the number of prints needed for one right hand and forearm.

- 1x Thumb
- 1x Index
- 1x Majeure
- 1x Ring Finger
- 1x Auricular (Pinky)
- 1x Bolt_entretoise
- 1x Wrist large
- 1x Wrist small
- 1x top surface
- 1x cover finger
- 1x robcap3
- 1x robpart2
- 1x robpart3
- 1x robpart4
- 1x robpart5
- 1x Elbow Shaft Gear (if you built the bicep)

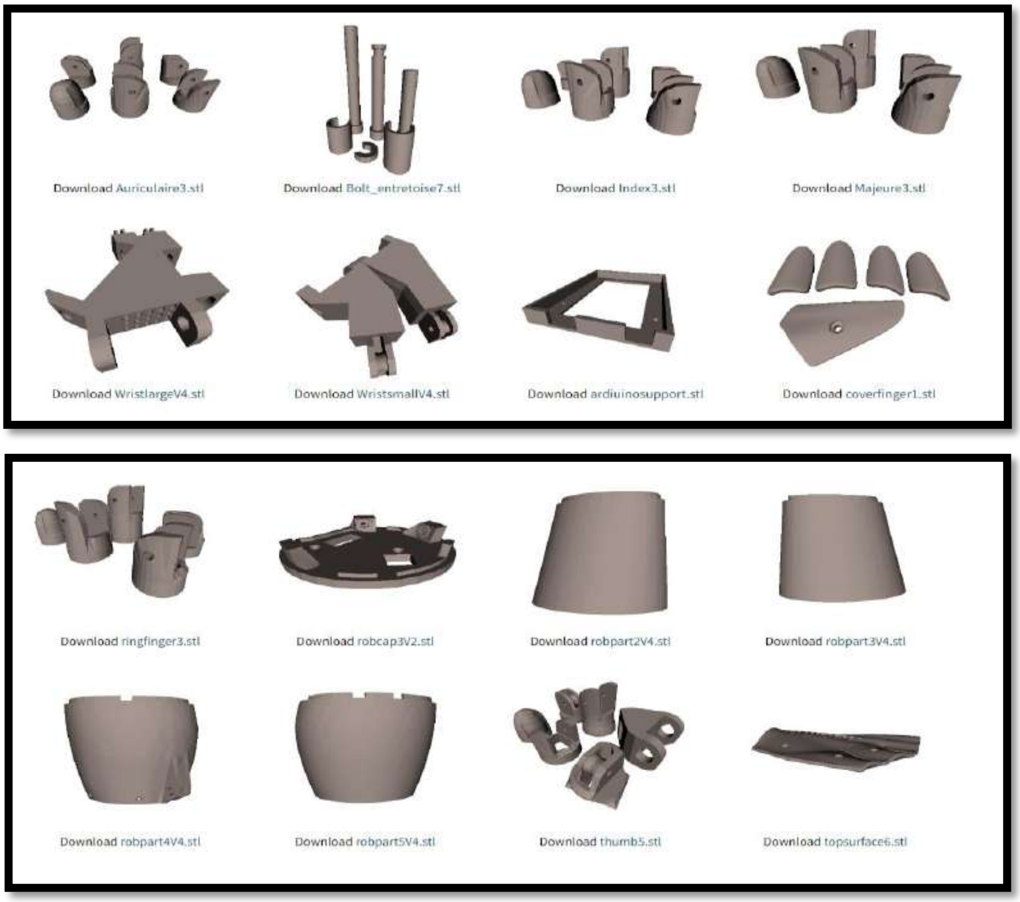


Figure 3.1: 3D model of hand Parts

Here is the list of parts and the number of prints needed for 1 right wrist:

- 1x rotawrist2
- 1x rotawrist1
- 1x rotawrist3
- 1x Wrist Gears
- 1x CableHolderWrist

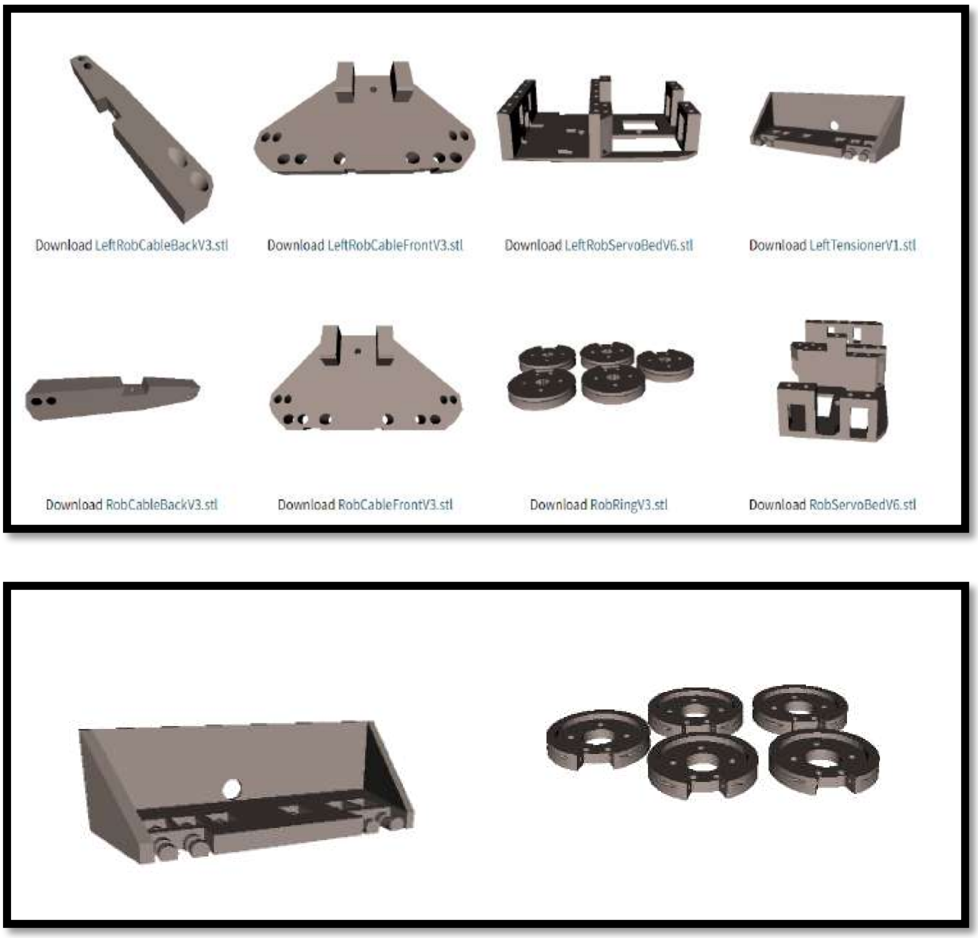


Figure 3.2:3D model hand design parts

3.1.1. 3D-Printing of Parts:

We made the parts for our project using a MakerBot 3D printer. MakerBot is a well-known business that produces durable and user-friendly 3D printers. We used the exact same model as the MakerBot Replicator+.

The MakerBot Replicator+ is a well-liked desktop 3D printer for use in corporate applications. It has an excellent build volume and is compatible with a variety of materials, including as PLA and ABS. We were able to print components for our project that were different sizes and levels of intricacy with the use of these tools.

We were able to print the pieces required for our project with accuracy and good quality using the MakerBot Replicator+. The printer's user-friendly interface and dependable performance helped to ensure a seamless printing process and accurate, repeatable outcomes.

1. **Specifications:**

- **Build Volume:** The MakerBot Replicator+'s build volume is around 29.5 x 19.5 x 16.5 cm (11.6 x 7.6 x 6.5 inches). It can thus print on objects that fit within certain dimensions, according to this.
- **Filament Compatibility:** A variety of filament materials, including PLA (Polylactic Acid), ABS (Acrylonitrile Butadiene Styrene), and others, is compatible with the Replicator+. Be sure to list the precise filament materials you employed for your undertaking.
- **Layer Resolution:** The printer's ability to reach a layer resolution as little as 100 microns helps it produce prints that are extremely accurate and detailed.

User Interface and Software:

- **User-Friendly Interface**: An intuitive user interface on the MakerBot Replicator+ makes it simple to access and manage the printer's settings.
- **MakerBot Print Software:** We can set up my 3D models for printing, modify parameters like print quality and infill density, and keep track of the status of your prints with this exclusive software offered by MakerBot.

3. **Connectivity and File Formats:**

- **Connectivity Options:** Multiple communication methods, including USB, Ethernet, and Wi-Fi, are supported by the Replicator+, making file transfers and monitoring simple.
- **File Formats:** The printer can import and print 3D models in a variety of commonly used file formats, including STL, OBJ, and Thing verse.

4. **Reliability and Performance:**

- **Smart Extruder+:** The Smart Extruder+ mechanism, which delivers increased dependability and lowers the likelihood of filament clogs while printing, is a feature of the MakerBot Replicator+.
- **Fast and Reliable Printing:** The printer is renowned for its dependable and constant performance, effectively producing prints of excellent quality. To guarantee precise layer adhesion and dimensional correctness, it makes use of cutting-edge printing technology.

5. **Applications and Use Cases:**

• **Professional Prototyping:** For quick prototyping and iterative design processes, the MakerBot Replicator+ is frequently used.

• **Education and STEM:** It is a popular option in educational settings for introducing 3D printing and promoting creativity because of its user-friendly nature.

Figure 3.3: MakerBot 3D Printer

3-1-2: Material Used for 3D printing:

One of the most often used materials for 3D printing is PLA (Polylactic Acid) filament. It is a thermoplastic biodegradable material made from renewable materials like sugarcane or corn flour. Here are some essential details and features of PLA filament:

1. User-Friendliness: PLA is recognized for being user-friendly, making it appropriate for novices and hobbyists. It prints at a lower temperature than other filaments, which lessens the chance of warping and allows it work with a variety of 3D printers.

2. Environmental friendliness: Due to its biodegradable properties and renewable source material, PLA is regarded as an ecologically benign filament. It is a popular option for sustainable applications since it decomposes more quickly under composting conditions.

3. Printability: The superior extrusion characteristics of PLA make for a smooth and reliable printing process. Although some printers can print PLA without a heated print bed, it usually needs one. Comparatively speaking to other filaments, PLA is less likely to clog nozzles.

4. Aesthetics: PLA filament comes in a variety of brilliant colors, making it perfect for producing prints that are aesthetically pleasing. The glossy sheen further enhances the printed products' overall visual appeal.

5. Stability and Strength: While PLA is not as stiff and strong as certain other filaments, such as ABS (Acrylonitrile Butadiene Styrene), it still delivers respectable stability and strength. It is appropriate for printing functional components that are not subjected to high temperatures or stresses, as well as prototypes, ornamental items, artistic models, and functional parts.

6. Limitations: There are some PLA restrictions to take into account. Because it has a lower melting point than filaments like ABS, printed items may soften and distort in hot environments.

Overall, PLA filament is a popular choice for a wide range of 3D printing applications due to its ease of use, environmentally friendly nature, and aesthetic appeal. It is particularly well-suited for projects where strength, high temperatures, or flexibility are not critical requirements.

Figure 3.4: PLA material (Polylactic Acid)

3-1-3: Assembly of Parts:

A hand and wrist made of 3D printed pieces must be put together in a number of processes.

We double-checked that we had all the required printed parts, including pieces for the wrist, palm, and fingers. Make sure the printing is precise and in good shape.

1. Prepared the tools: Gather the assembly-related equipment you'll need, including screwdrivers, Allen wrenches, pliers, and any other special tools specified in the assembly instructions or included with the 3D-printed pieces.

2. Clean the components: If necessary, wash the 3D-printed components with water and a mild detergent. Eliminate any printing-related debris or support structures. Before continuing, give the components time to thoroughly dry.

3. Examined the directions for assembly: Read the assembly instructions that come with the 3D printed pieces very carefully. Learn the assembly sequence as well as any special instructions or suggestions.

4. Tested fit the parts: Before final assembly, test the fit of the parts to make sure everything lines up correctly and moves easily. This stage gives you the chance to make any required improvements, such as sanding if the pieces are too tight or need minor tweaks.

5. Put the fingers together: The fingers should first be joined to the palm portion. This can need putting in screws, pins, or other connectors that came with the 3D printed pieces, depending on the design. Follow the directions for each finger, making sure to position it correctly and secure the connections in accordance with the guidelines.

6. Connected the palm to the wrist: After the fingers are joined, connect the palm portion to the wrist section by following the assembly instructions. To determine the precise method of connection for this stage, see the instructions. It may require screws, bolts, or other fasteners.

7. Tested the joint movement: Carefully tested the joint mobility of the hand and wrist after the primary assembly has been completed. Make sure there are no blockages or misalignments, and that all the fingers move as they should. Adjust as necessary to guarantee smooth functioning.

Figure 3.5: Prosthetic hand printed parts

3.2 Summary

This Chapter of our project explains the design process, specifically focusing on the hardware design and assembly of the prosthetic hand. Solid Works software was used to visualize and calculate the sizes of each component needed for the arm and wrist using the design, which was taken from the open-source InMoov website.

The chapter opens with a list of the components required for the right wrist, forearm, and prosthetic hand. It then goes into depth on how these pieces were made via 3D printing. The 3D printer used was a MakerBot Replicator+, which is renowned for its dependability and user-friendly design. The printer's parameters are supplied to offer a general idea of its capabilities, including the build capacity, filament compatibility, and layer resolution.

The chapter also covers the MakerBot Replicator+'s user interface and software, emphasizing its user-friendly design and the MakerBot Print Software, which is used to create models and keep track of prints. Additionally listed are the printer's supported file types and connectivity choices.

The chapter also includes information about PLA (Polylactic Acid) filament, a material used in 3D printing. PLA is renowned for being simple to use, eco-friendly, and aesthetically pleasing. Its attributes, including printability, strength, and restrictions, are well detailed.

The step-by-step assembly instructions for the 3D printed pieces are provided. It involves getting the required tools ready, cleaning the components, going over the assembly guidelines, picking out and test-fitting the individual pieces, attaching the fingers to the palm, joining the palm to the wrist, testing joint mobility, and fastening any loose components.

The MakerBot Replicator+ printer, the choice of 3D printing materials, and the detailed instructions for assembling the printed pieces are all covered in-depth in this chapter's overall review of the hardware design and assembly process for the prosthetic hand project.

Chapter 4

TOOLS AND TECHNIQUES

4.1 Hardware Used with Technical Specifications

The project is composed of number of modules each responsible for specific task. Following are the hardware modules/tools used in project:

4.1.1 Arduino Uno

The ATmega328 chip is used in the microcontroller board known as the Arduino Uno. It has 14 digital input/output pins, six of which can be used as outputs for pulse width modulation (PWM). It also has a USB connection, a power jack, an ICSP header, 6 analogue input pins, a 16 MHz ceramic resonator, and a reset button. All the parts required to support the microcontroller are on this board. It may be operated using a battery or an AC-to-DC adaptor that is linked to a computer.

The Arduino Uno differs from its forerunners in that it is not dependent on the FTDI USB-to-serial driver chip. In its place, a USB-to-serial converter built into the Atmega16U2 (or Atmega8U2 for older generations) is used. In addition, new pins like SDA and SCL, which are close to the AREF pin, as well as two more pins known as IOREF, were introduced to the board in version 1.0. Shields (extension boards) may now adjust to the voltage supplied by the board thanks to these improvements. Shields will eventually work with both the 3.3V-powered Arduino Due and the AVR-based Arduino boards that run at 5V.

Figure 4.1: ArduinoUno

4.1.2 Servo Motors (MG-996R)

A servo motor is a small motor with an output shaft that may be rotated at precise angles in response to a signal that has been programmed. Once the signal is there, the servo keeps moving in the appropriate direction. The shaft angle of the servo likewise varies as the signal does. In order to regulate the bending and retracting action of the hand's fingers, we used five servo motors in our project, one for each finger.

Figure 4.2: Servo motor MG-996R

Table 1: wire configuration of Servo motor MG-996R

Wire no	Wire Color	Description
1	Orange	PWM signal is given through this wire
2	Brown	Ground wire connected to ground
3	Red	Power the motor +5

Features of MG996R Servo Motor

1) Operating voltage is +5V.

2) At 4.8V 9.4 kg/cm of stall torque

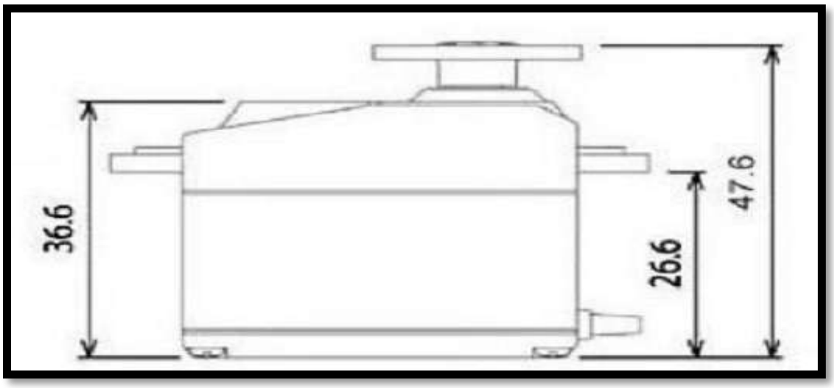
3) The maximum stall torque 11 kg/cm (6V)

4) Operating speed Metal gear of 0.17 s/60°

5) Motor weight: 55gm

6) Rotation: 0°–180°

7) The package contains screws and gear horns.



4.3Dimensions of the MG996R Servo Motor

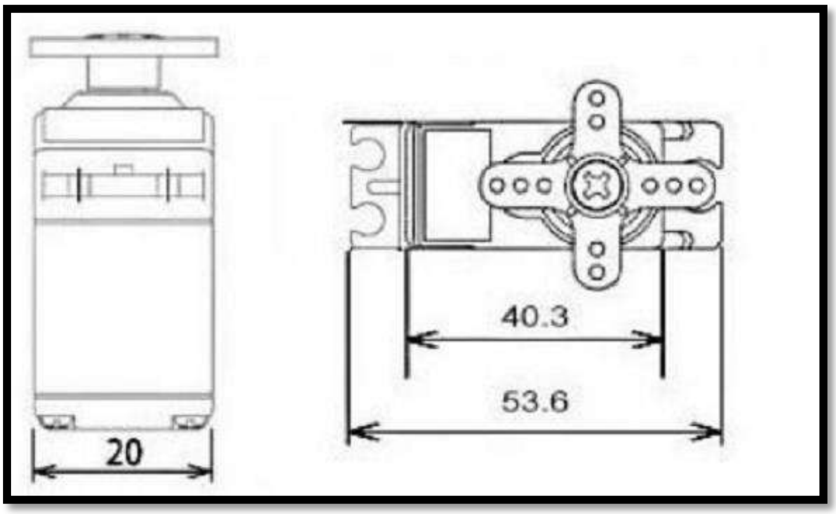


Figure 4.4: Dimensions of Servo motor MG-966R

Choosing a servo motor:

There are several servo motors on the market, and each one has a unique purpose and set of uses. The majority of hobby servo motors run between 4.8 and 6.5 volts; however, they are often operated at +5 volts. The higher the voltage, the more torque we can produce. Due to their gear arrangement, almost all hobby servo motors can rotate only from 0° to 180°, so make sure your project can handle the half circle; if not, you can choose a 0° to 360° motor or modify the motor to make a full circle.

The torque at which the motor runs is the following and most crucial metric. Again, there are numerous options here, but we'll go with the MG996R Motor-compatible one that has a 2.5 kg/cm torque. The motor can move a weight of 2.5kg when it is hanging at a distance of 1cm thanks to its 2.5kg/cm torque. Therefore, if you suspend a load at 0.5 cm, the motor can pull a load of 5 kg; however, if you suspend a load at 2 cm, it can only pull 1.25 kg. The motor with the right torque can be chosen based on the load that you utilize in the project.

How to Operate a Servo Motor:

As far as we are aware, this motor has three wires going from it. This motor needs to be powered with +5V via the Red and Brown wires, and PWM signals need to be sent to the Orange color wire in order to make it rotate.

Therefore, in order to make this motor operate, we need a device that can produce PWM signals. This device might be anything from a 555 timer to another microcontroller platform like Arduino, PIC, ARM, or even a CPU like the Raspberry Pi.

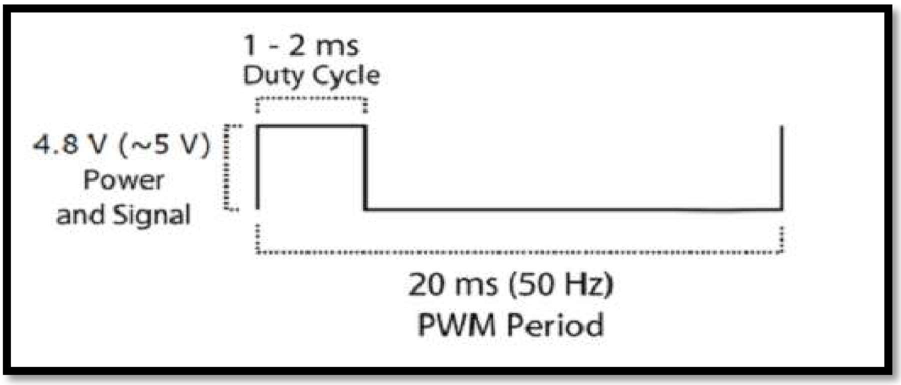


Figure 4.5: PWM signal of Servo motor MG-966R

From the image, it is clear that the created PWM signal should have a frequency of 50Hz, meaning that the PWM period should be 20ms. From which the On-Time might range from 1 to 2 milliseconds. As a result, the motor will be at 0° when the on-time is 1ms, 90° when it is 1.5ms, and 180° when it is 2ms. Therefore, the motor may be controlled from 0° to 180° by adjusting the on-time from 1ms to 2ms.

4.1.3 Muscle sensor V3.

The Electromyography (EMG), a technique used by the Muscle Sensor V3 to quantify muscle activity, is the detection of the electric potential created by muscle cells. The complicated electrical impulses from the muscles are amplified, processed, and changed into a straightforward analogue signal that can be quickly read by a microcontroller equipped with an analog-to-digital converter. An on-board gain potentiometer allows the user to modify the relationship between the output voltage and muscle activity when the target muscle group contracts. It includes a cable that connects three electrodes to the sensor board; the cable has snap-style connections for electrode attachment on one end and a 3.5 mm audio connector on the other. The Muscle Sensor V3 operates on 5V and has a compact size suitable for microcontrollers. It is designed for applications such as video games, robots, medical devices, wearable/mobile electronics, and powered exoskeleton suits.

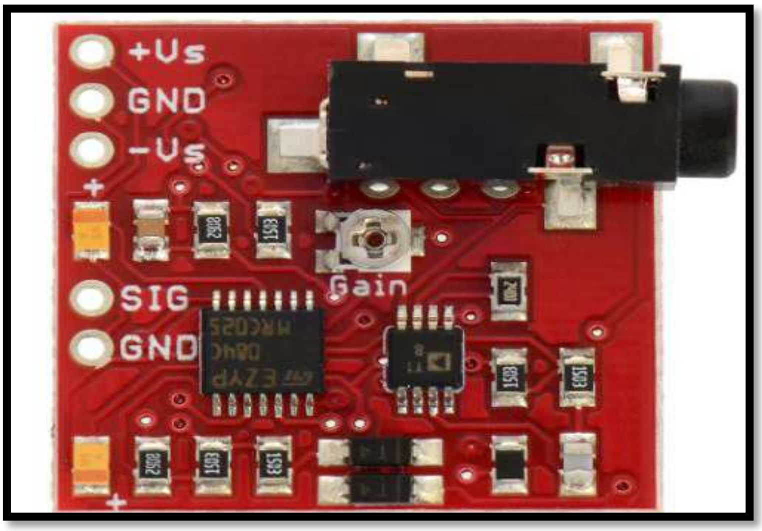


Figure 4.6: Top view of EMG muscle V3

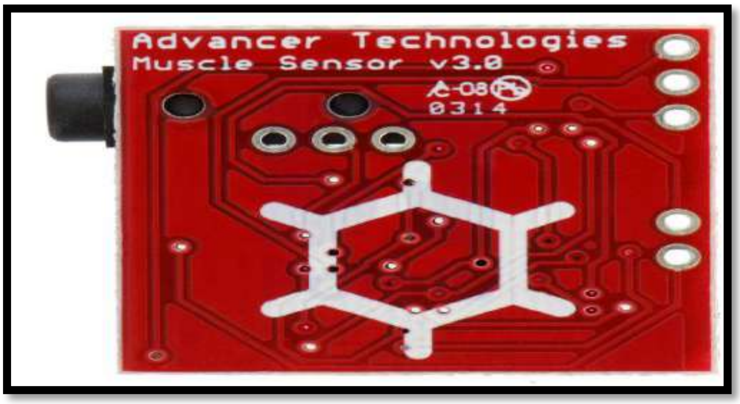


Figure 4.7: Bottom view of EMG muscle V3

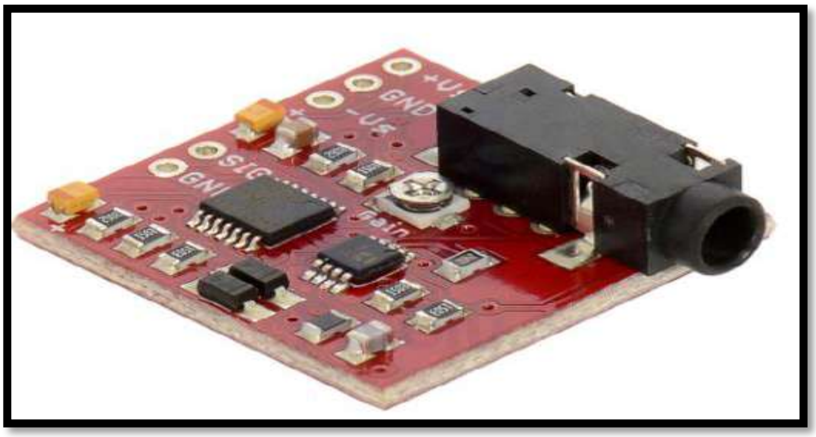


Figure 4.8: EMG muscle sensor V3

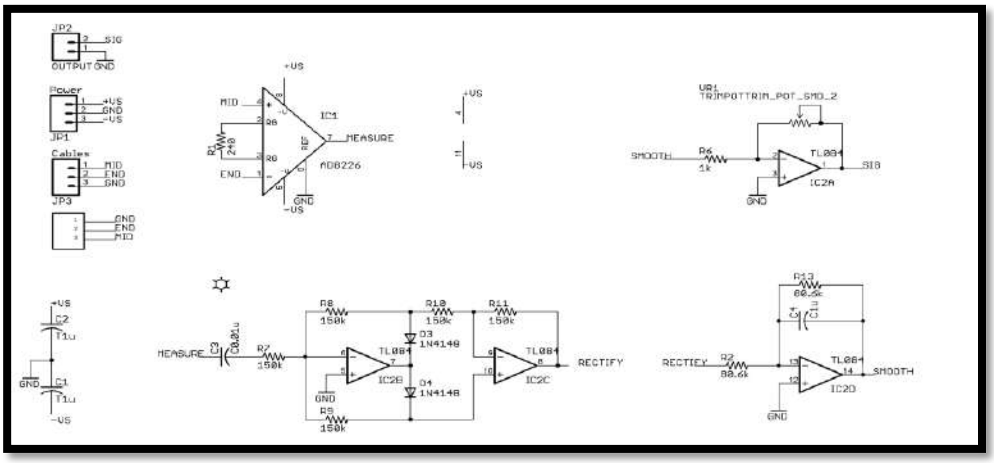


Figure 4.9: Schematic Diagram of EMG muscle sensor V3

Table: 2: Parameter specification of EMG V3

Parameter	**Minimum**	**Type**	**Maximum**
Power supply (V)	±3.5V	±5V	±18V
Gain Setting Gain=207*(X/1 kΩ)	0.01 Ω (0.002x)	50kΩ (10,350x)	100kΩ (20,700x)
Output signal Voltage	0V	--	+Vs
Differential Input Voltage	0 Mv	2-5Mv	+Vs/Gain

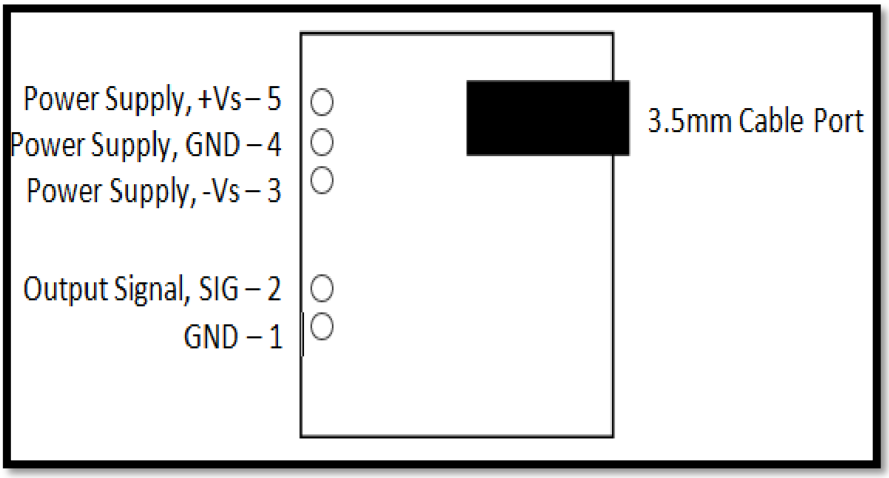


Figure 4.10: Pin Layout of EMG muscle sensor V3

FEATURES

- Small Form Factor
- Designed Specially for Microcontrollers
- Adjustable Gain – Improved Ruggedness
- New On-board 3.5mm Cable Port
- Pins Fit Easily on Standard Breadboards

The more recent MyoWare Muscle Sensor from Advancer Technologies has taken the place of this sensor. It offers a number of enhancements, such as single-supply functioning (no need for a negative voltage supply) and built-in snap connectors for electrodes. But MyoWare is more expensive so we use the electrode patches for our project.

4.1.4 Battery 9V

Higher currents are turned into correspondingly smaller currents in current transformers. The ammeter can securely monitor the high current flowing via transmission lines because it can convert high voltage current into low voltage current. The current transformer is employed if the current to be measured is so large that a meter or instrument coil does not have the carrying capacity to handle the current.

We have used CT with maximum current carrying capacity of 100A. It operates at 230V AC and has 1550 ratio. Maximum secondary current is 40A. Optimal operating frequency is 50Hz. Physical dimensions are 10.2 X 28.5 X 23.5 (I.D. X O.D. X H in mm).

Figure 4.11: 9V battery

4.1.5 6V Rechargeable NI-CD AA battery

For many different gadgets, the CL Ni-Cd AA 3500mAh 6v battery pack is the ideal addition. All of your AA battery-powered devices, such as digital cameras, wireless keyboards, remote controls, and flashlights, are compatible with these batteries.

Three batteries are included in the CL Ni-Cd AA 3500mAh 6v battery pack so you can always have a backup battery on hand. Your devices will remain fueled for hours by these durable batteries. The ideal accessory for every home is the CL Ni-Cd AA 3500mAh 6v battery pack.

SPECIFICATION:

- Ni-Cd battery cell construction
- Output Voltage: 6v Current Capacity: 3500mAh
- Modal: AA*5-Cell with Two-Pin SM Connector
- Chargeable: Yes
- Product Dimensions: 70.5(L)x50(W)x14.3(H) (in mm)

Figure 4.12: 6V Rechargeable NI-CD AA battery

4.1.6 Arduino Servo Shield:

The Arduino Servo Shield is an expansion board designed to work with shield-compatible Arduino boards such as UNO, Leonardo, Mega R3+, and ADK R3+. It connects directly to the Arduino board and provides convenient connections for controlling servos and other I2C devices.

To use the Servo Shield, you need to connect the Ground, 5V, SDA (Serial Data Line), and SCL (Serial Clock Line) pins. For older Arduino models, SCL is connected to A5 and SDA is connected to A4. UNO models already have these connections on board. However, if you're using a Leonardo or Mega and want to use the A4/A5 pins, you may need to cut the traces on the top of the board between A4 and A5, along with the adjacent pins labeled SCL/SDA.

In the case of a Mega or ADK R2 or earlier, you will need to solder a wire from SCL to D21 and SDA to D20 for proper functioning.

There are two power sources for the Servo Shield. The PWM (Pulse Width

Modulation) chip is powered by the Arduino's 5V output, which also serves to determine the I2C logic level and the PWM signal logic level. When this power source is on, the shield's red LED will glow. You must connect a separate V+ power supply—which should be 5 or 6 VDC—through the blue terminal block in order to power the servos. It's vital to note that it is not advised to power the servos with the Arduino's 5V pin since this might result in electrical noise, brownouts, and unpredictable behavior.

Most servos have a standard 3-pin female connection for connecting them. Simply align the plug with the ground wire (usually black or brown) on the bottom row and the signal wire (usually yellow or white) on the top row of the headers on the Servo Driver.

As long as their addresses do not clash with the Servo Shield's default address of 0x40, it also allows you to connect additional I2C devices. Additionally, there is a location on the PCB for adding an electrolytic capacitor, which might be helpful when using a power supply to drive numerous servos when the power supply dips when the servos are moving.

The power needs of the servos must be taken into account since they can use a large amount of current, particularly when many or high-torque servos are being used. To guarantee steady servo operation, it is advised to use a suitable power source, such as a switching power supply or rechargeable battery packs.

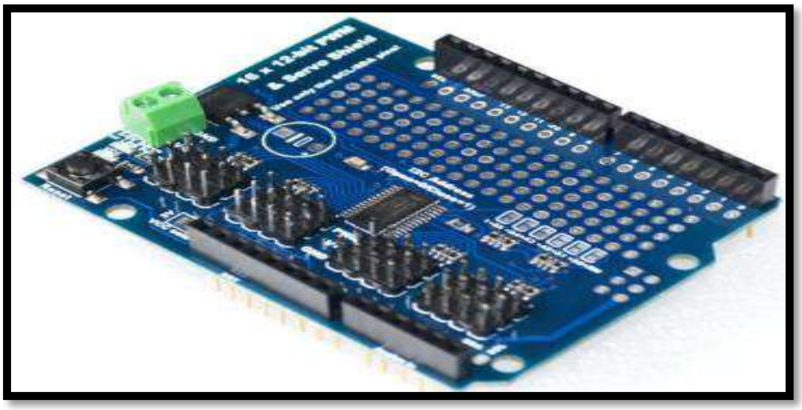


Figure 4.13: Arduino servo shield

4.2Software(s), simulation tool(s) used

Software's are used in the project for design, simulation and programming purposes. Following are the software and their details that are used in the project.

4.2.1 Proteus Professional 8.10

The software is used primarily for design and simulation of measurement unit. It is a software program for modeling virtual systems and simulating circuits. Co-simulation of microcontroller-based designs is simplified through the use of mixed mode SPICE circuit simulations, animated components, and microprocessor models. The Proteus software is also capable of simulating analog and digital electronics connected to a microcontroller. Moreover, it simulates all peripherals present on each supported processor such as inputs, outputs, interrupts, timers, USARTs, and many more.

Figure 4.14: Proteus

4.2.2 Arduino IDE

Writing code and uploading it to the Arduino board is simple with Arduino's open source software (IDE). Any Arduino board can be used with this software. A GitHub repository hosts Arduino's active development. Like most programming platforms, Arduino can use libraries to extend its capabilities. Sketches can use libraries for extra functionality, such as manipulating data or working with hardware. Library downloads and creations are available, as well as the IDE's libraries.

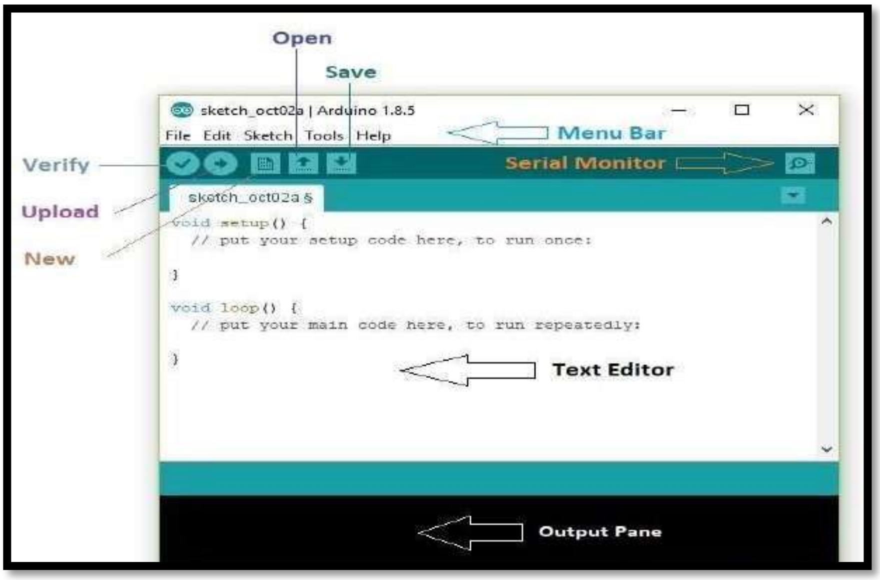


Figure 4.15: Arduino IDE basic sketch with labeling

4.3 Analysis of the prosthetic hand's cost:

One of the project's goals was to make prosthetic hands that patients in developing nations could afford like my country Pakistan. The project's hand-developed hand is still in the prototype stage. Therefore, a cost analysis is required to determine the prosthetic hand's price per unit and projected expenses. The current price per unit is 2lac. It is possible to decrease the number of EMG sensors from three to one in order to reduce the cost of a prosthetic hand. However, more sophisticated signal processing algorithm development is required to maintain the same functionality as with three sensors. Contrary to lowering cost, the cost will rise during the prototype stage. Although the cost of the Myo ware is more than the EMG electrode patches so we use the EMG V3 module instead of Myo ware which is the latest version.

The objective of developing a low-cost prosthetic hand has been accomplished in comparison to present myoelectric prosthetics cost of two lac.

Table: 3: Our Prosthetic hand Project Cost

Ser No	Name	Quantity	Price
1	EMG Muscle Sensor	2	12000
2	Servo Motors	5	6000
3	3D-Printing of Fingers	5	6000
4	Arduino Nano	1	1200
5	6v battery	1	500
6	6v Adapter	1	350
7	Solder 40w	1	2000
8	Vero board	2	800
9	Male, Female Headers	5	200
10	soldering wire & Paste	1	220
11	Electrode Patches	50	1500
12	Arduino servo shield	1	1200

13	9v Dc Batteries	2	800
14	9v Rechargeable batteries	2	2000
15	9v Batteries Charger	1	1000
16	Fishing Thread, wires		1000
17	Arduino Cable, power supply	1	980
18	Report Printing	1	1500
19	Boucher	30	3000
20	Panaflex	1	2500
21	Glue gun	1	500
22	Glue Rods	10	250
23	Nuts	20	200
24	Misc		6000
	TOTAL		**51700**

4.4: Summary

In order to complete this project, a variety of hardware elements were used, including an Arduino Uno, EMG sensors, servo motors, power supply, electrodes, and wires. Software tools such the Arduino IDE, libraries for signal processing, CAD programmers, simulation tools, and testing/debugging tools were used. The goal of the research was to create an EMG-controlled prosthetic hand for amputees. Muscle signals were recorded by the Arduino board and EMG sensors and then processed utilizing signal processing methods. The prosthetic hand's movements were managed by servo motors. The mechanical parts were designed using CAD software. Tools for testing and simulation helped to guarantee that systems functioned correctly. Overall, the experiment was a success in proving that integrating EMG sensors for prosthetic hand control is both feasible and promising.

Chapter 5

PROJECT IMPLEMENTATION

5.1 Introduction to Electromyography

We have integrated each component individually with Arduino to test if individual part is working correctly. Integration of each part is disused below.

Etymology:

The term "Electromyography" originated from Lipmann's capillary electrometer in 1876, which was one of his numerous contributions to the field of kinesiology.

Definition: Electromyography is a method for recording and analyzing the electrical activity of skeletal muscles.

Types of EMG:

EMG is often divided into two kinds based on how the electromyography signal was acquired:

Surface Electromyography

In surface electromyography (SEMG), electrodes are positioned on the skin with a focus on the muscles that produce noticeable EMG signals.

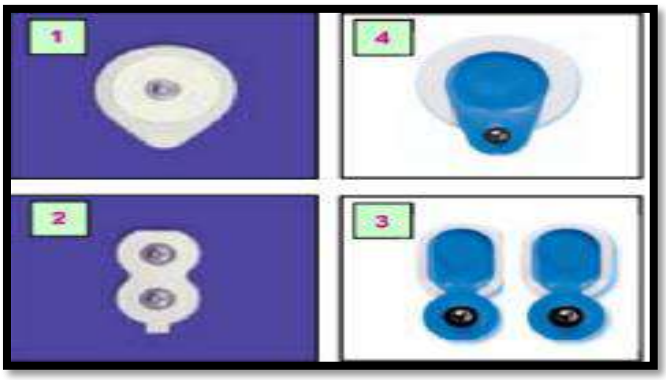


Figure 5.1: Use electrode for surface electromyography

Fine wired Electromyography:

In contrast, Fine Wire Electromyography involves making a surgical incision in the skin and inserting electrodes into deep muscles and nerves.

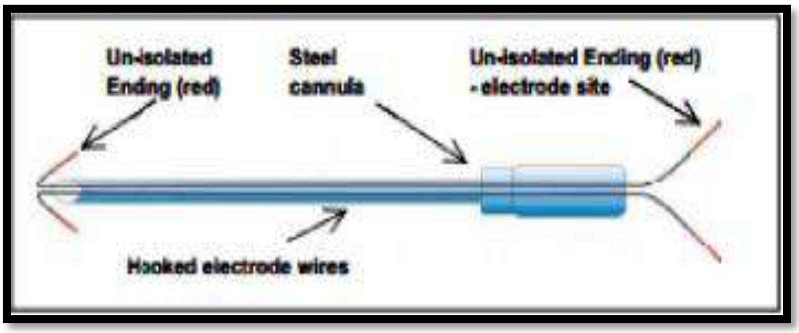


Figure 5.2: Used electrode for fine wire electromyography

5.1.1 Hand motions and control.

EMG signals are used to control the hand. EMG sensor Electrode patches is put on skin surface above target muscle to read these impulses. Correct placement of the sensor over muscle is necessary for the highest signal quality. The effect of moving the sensor's placement above the biceps muscle

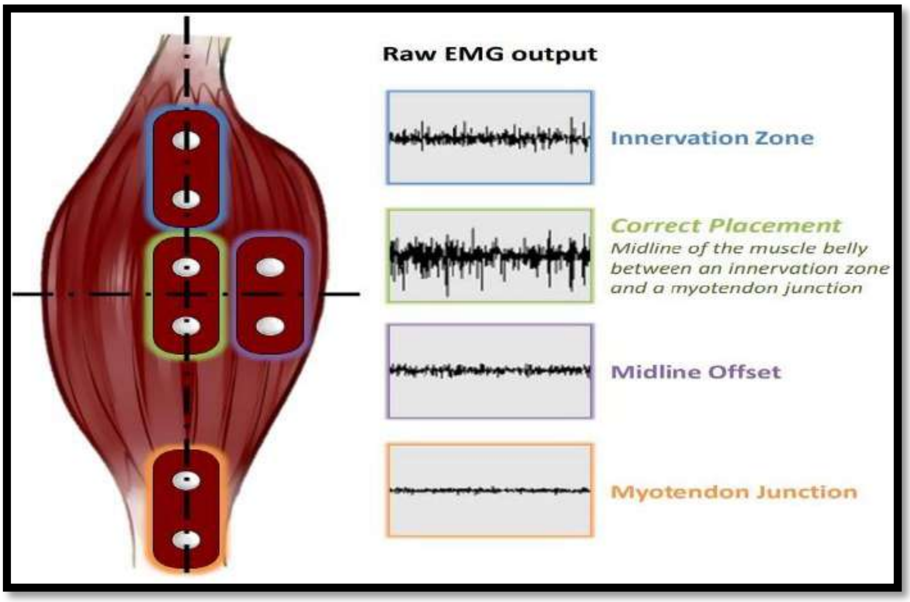


Figure 5.3: Placement influences the output of an EMG sensor.

5.1.2 Identification/Placement of Muscle:

There are various phases involved in locating the precise muscle from which to obtain EMG data. First, based on the goal of the study or evaluation, the practitioner or researcher chooses the target muscle or muscles. The next stage entails placing the electrodes correctly after the muscle has been chosen.

Electrodes are often placed on the skin just above the muscle of interest for surface electromyography (SEMG). The precise location of the electrodes is determined by the target muscle and the desired recording conditions. Bipolar and monopole electrode designs are often utilized.

In the case of fine wire electromyography, electrodes are placed through a surgical incision right into the deep muscles and nerves. This invasive technique is frequently employed in research or clinical situations when better resolution is necessary because it enables more exact recording from particular muscle fibers.

Overall, selecting the muscle for EMG signal extraction requires careful consideration of the study's or evaluation's goals, the use of the proper electrode implantation methods, and adherence to accepted standards and best practices.

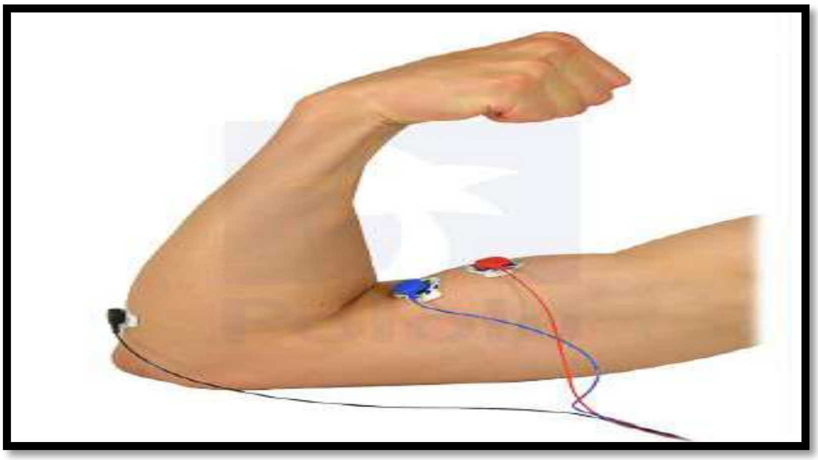


Figure 5.4: Placement of electrode patches

Due to the intricate bone and muscular structure of the human hand, it is capable of performing a wide variety of complex gestures. Five gestures can be performed by the prosthetic hand that was constructed for this project.

1. All fingers are open.
2. All fingers are close.

3. All fingers are close except the index and pinky finger.
4. All fingers are close except the index finger.
5. All three fingers close except the ring and pinky finger.

It must be calibrated before the patient can use the prosthetic hand. Calibration is accomplished by choosing the calibration mode. Device reading data from five various hand movements and relaxed muscle. This logs the information produced by each gesture's muscle activity. The user then chooses the operation mode. One of the five previously recorded motions will be recognized by the hand when the user makes it.

No.	The Real Hand Pose	Description	The Prosthetic Hand Pose	Description
1.	 Fist	All five fingers close	 Fist	All five fingers close
2	 Fist and wrist flexion	All five fingers close and wrist flexion	 Point	All four fingers close except index finger
3	 Wrist flexion	Wrist flexion	 Rock	All three fingers close except index and pinky fingers
4	 Wrist extension	Wrist extension	 Pinch	All three fingers close except ring and pinky fingers
5	 Rest	All five fingers open	 Rest	All five fingers open

Figure 5.5: hand gestures along with their corresponding prosthetic hand gestures

5.1.3 Exploring the Origins of EMG Signals:

The motor unit, which acts as the smallest functional unit to clarify how the brain regulates muscle contraction, includes the cell body and dendrites of a motor neuron, the many branches of its axon, as well as the muscle fibers it innervates.

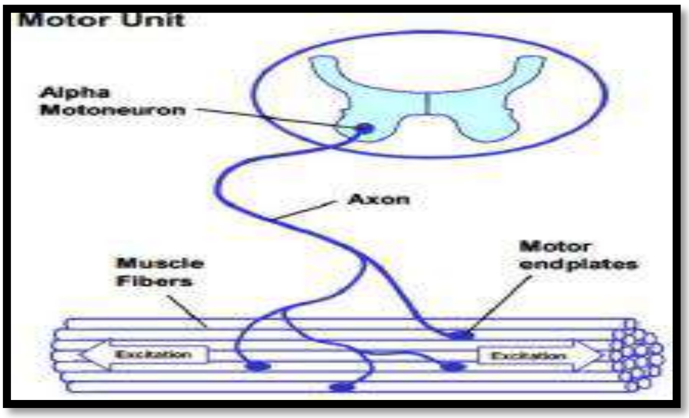


Figure 5.6: Motor unit

The electrical characteristics involved in this event can be described. A membrane potential is produced by the ionic balance between the inner and exterior spaces of a muscle cell. A negative intracellular charge compared to the outside surface maintains this membrane potential.

An action potential is set off when sodium ions ($Na+$) transcend the membrane's threshold level. This action potential is characterized by a monopole electrical burst with a maximum potential of 30 mV, which is swiftly followed by a repolarization phase that returns the membrane potential. A tubular arrangement helps the action potential spread along the muscle fiber in both directions. Calcium ions are released into the cellular environment as a result of this stimulation.

Linked chemical processes, known as electro-mechanical coupling, occur as a result. These processes ultimately produce a shortening of the contractile elements within the muscle cell. The phenomenon can be elucidated through a model involving a semi-permeable membrane and its electrical properties. Within a muscle cell, an ionic equilibrium exists between the inner and outer spaces, establishing a resting potential at the muscle fiber membrane, typically ranging from approximately -80 to -90 mV when the muscle is not contracted.

This potential difference is upheld by physiological processes, such as ion pumps, resulting in a negative intracellular charge relative to the external surface.

When the influx of sodium ions (Na+) surpasses a specific threshold level, the membrane depolarizes, initiating an action potential that rapidly transitions from around -80 mV to approximately +30 mV. This monopole electrical burst is promptly restored through the repolarization phase, followed by an after hyperpolarization period of the membrane. The action potential propagates along the muscle fiber in directions, originating from the motor end plates and extending through a tubular system within the muscle fiber. This excitation triggers the release of calcium ions within the intracellular space. Subsequently, linked chemical processes known as electro-mechanical coupling take place, ultimately resulting in the contraction of the muscle cell's contractile elements.

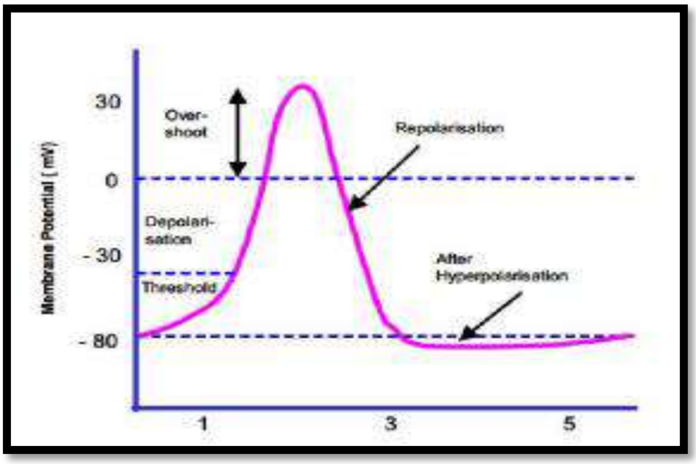


Figure 5.7: Action of Muscle sensor

5-1-4: Nature of Electromyography Signal:

The Unprocessed EMG Signal:

In its unfiltered and unprocessed state, the EMG signal is referred to as the raw EMG signal. In the provided figure, a raw SEMG recording was performed during three static contractions of the biceps brachia muscle. When the muscle is at rest, a relatively noise-free baseline of the EMG signal can be observed. The level of raw EMG baseline noise is influenced by various factors, including the quality of the EMG amplifier, environmental noise, and the detection conditions employed.

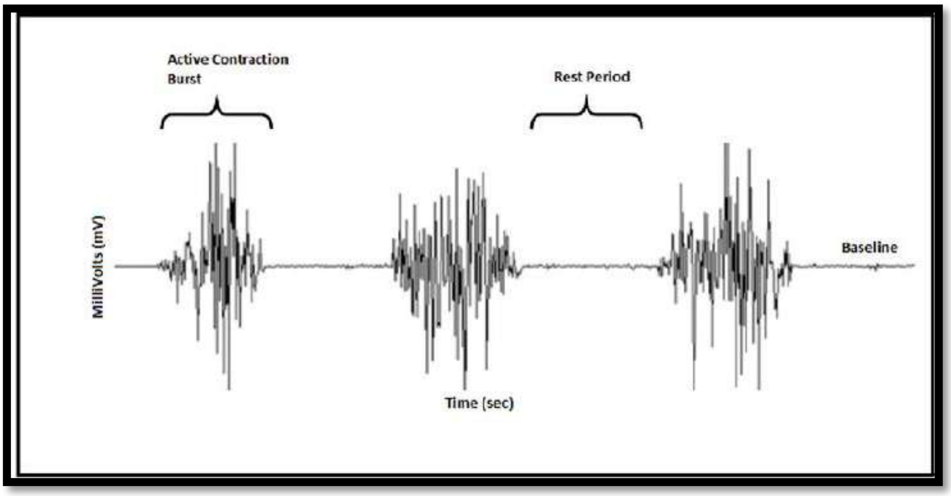


Figure 5.8: Raw EMG signal

Common Techniques for Processing EMG Signals:

Several techniques are commonly employed to condition the raw EMG signals. These techniques include full wave rectification, smoothing, digital filtering, and amplitude normalization.

Full wave rectification involves converting all negative amplitudes to positive amplitudes. The primary benefit of full wave rectification is that it enables the application of standard statistical techniques such as mean, median, and min/max analysis on the waveform.

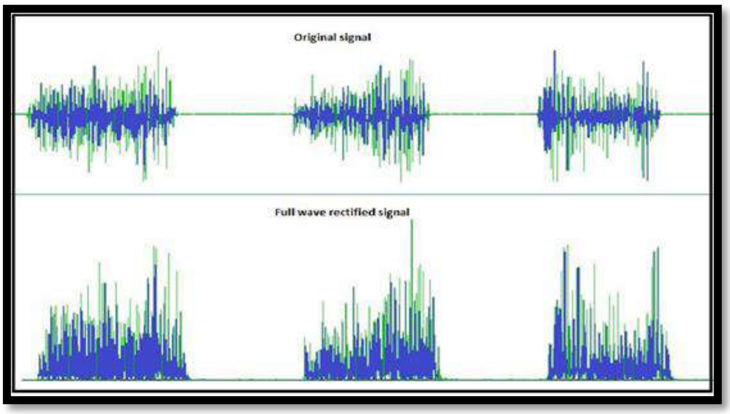


Figure 5.9: Full wave Rectification

Smoothing aims to establish the mean trend of the EMG signal, as it may not repeat the exact same pattern in subsequent trials. Digital smoothing algorithms outline the mean trend of signal development. Two popular algorithms are the Moving Average (MAVG) and Root Mean Square (RMS).

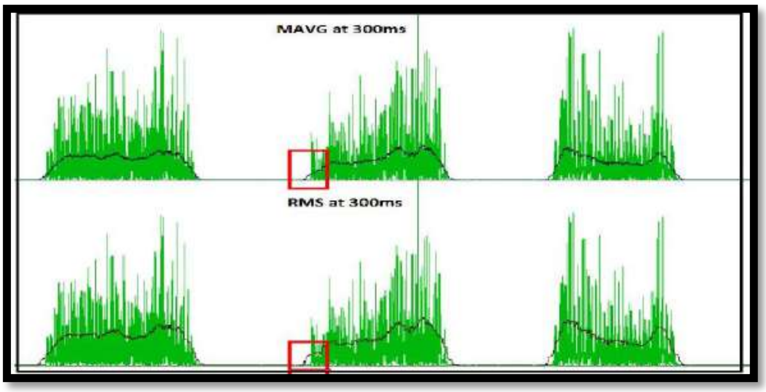


Figure 5.10: MAVG & RMS

One significant challenge in EMG analysis is that amplitude data (in microvolts) are strongly influenced by the specific detection conditions. These values can vary considerably between electrode sites, subjects, and even day-to-day measurements of the same muscle site.

One approach to address the uncertainty associated with microvolt-scaled parameters is normalization to a reference value, such as the Maximum Voluntary Contraction (MVC) value obtained from a reference contraction. The fundamental concept is to calibrate the microvolt value to a unique calibration unit with physiological relevance, representing the "percent of maximum innervation capacity" in that particular context. Other methods involve normalizing to the internal mean value of a given trial or to the EMG level of a specific submaximal reference activity. The primary effect of all normalization methods is the elimination of the influence of detection conditions, resulting in rescaled data from microvolts to percentages of the selected reference value. It is important to note that amplitude normalization does not alter the shape of the EMG curves, but only scales them on the Y-axis.

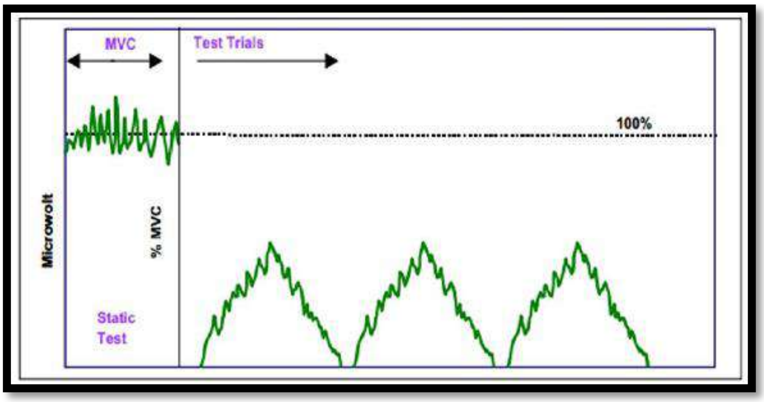


Figure 5.11: MVC amplitude normalization

5.2: Preparing the Skin for Surface Electromyography (EMG) Recording:

Preparing the Skin for Surface Electromyography (EMG) Recording Electrode Application.

The following procedures might be taken into consideration for skin preparation in order to guarantee ideal electrode adhesion and reduce impedance:

To remove hair:

Hair removal is crucial, particularly in humid weather, for people with sweaty skin, or while engaging in vigorous activity. This improves the electrode's skin-to-electrode contact.

Cleaning the Skin:

a) Method A: Special abrasive and conductive cleaning pastes are available, which effectively remove dead skin cells (which can cause high impedance) and cleanse the skin from dirt and sweat.

b) Method B: An alternative approach is to use very fine sandpaper. Applying gentle and controlled pressure in 3 or 4 sweeps is typically sufficient to achieve a good result. It is recommended to combine the use of sandpaper with an alcohol pad for optimal cleanliness.

c) Method C: Pure alcohol can also be used as an alternative, along with a soft-textured towel for gentle rubbing. This method may be suitable for static muscle function tests conducted in favorable conditions.

Regardless of the chosen skin preparation method and electrode application technique, properly conducted procedures typically result in a light red coloration of the skin. This serves as an indicator of good skin impedance condition, ensuring reliable EMG recording.

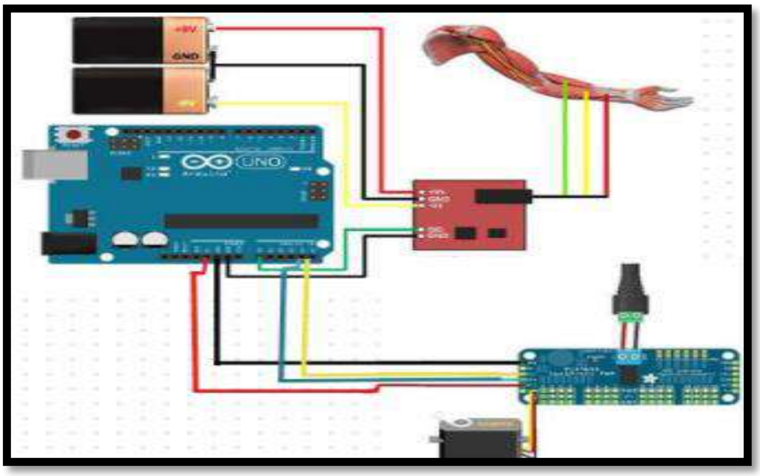


Figure 5.12: Schematic Diagram of Prosthetic hand

5.3 ARDUINO CODE:

```
#include <Wire.h>
#include <Adafruit_PWMServoDriver.h>

Adafruit_PWMServoDriver pwm =
Adafruit_PWMServoDriver();

#define MIN_PULSE_WIDTH 650
#define MAX_PULSE_WIDTH 2350
#define DEFAULT_PULSE_WIDTH 1500
#define FREQUENCY 60
const int sensorPin = A0;
const int threshold = 400; // Adjust the threshold value
according to your sensor readings
int pulseWidth(int angle)
{
int pulse_wide, analog_value;
pulse_wide = map(angle, 0, 180, MIN_PULSE_WIDTH,
MAX_PULSE_WIDTH);
analog_value = int(float(pulse_wide) / 1000000 *
FREQUENCY * 4096);
Serial.println(analog_value);
return analog_value;
}
```

```
void setup()
{
Serial.begin(9600);
pwm.begin();
pwm.setPWMFreq(FREQUENCY);

// Set initial position of servos to 90 degrees
for (int i = 0; i < 6; i++) {
pwm.setPWM(i, 0, pulseWidth(180));
}

delay(3000);
}
void loop()
{
int sensorValue = analogRead(sensorPin);

// If the sensor value is greater than the threshold, rotate
servos to 180 degrees
// Otherwise, rotate servos to 90 degrees
if (sensorValue >= threshold)
{
pwm.setPWM(1, 0, pulseWidth(0));
pwm.setPWM(2, 0, pulseWidth(0));
pwm.setPWM(3, 0, pulseWidth(0));
pwm.setPWM(4, 0, pulseWidth(0));

}
else if(sensorValue>=280 && sensorValue<= 360){
pwm.setPWM(0, 0, pulseWidth(0));
pwm.setPWM(1, 0, pulseWidth(0));
pwm.setPWM(2, 0, pulseWidth(0));
pwm.setPWM(3, 0, pulseWidth(0));
pwm.setPWM(4, 0, pulseWidth(0));

}
else if(sensorValue>=180 && sensorValue<= 250)
{

pwm.setPWM(0, 0, pulseWidth(0));
pwm.setPWM(3, 0, pulseWidth(0));
pwm.setPWM(4, 0, pulseWidth(0));

}
else {
for (int i = 0; i < 6; i++)
{
pwm.setPWM(i, 0, pulseWidth(180));
}
}
```

```
// Print sensor value to serial monitor
Serial.print("Sensor value: ");
Serial.println(sensorValue);

delay(100); // Adjust the delay as needed
                                    }
```

5.4 Summary:

Individual components were tested using integration with Arduino during project implementation. The technique of electromyography (EMG) was developed to capture and examine muscle electrical activity. Electrodes were applied to the skin and Surface Electromyography (SEMG) was used to record EMG signals. The central processing unit was the Arduino board. EMG signal transmission and acquisition accuracy were confirmed by integration. Prior to full integration, testing and modifications were conducted. The prosthetic hand control system was built on the basis created by this approach. Based on recorded EMG data, the implementation ensured accurate and dependable control of hand movements.

Chapter 6

PROJECT RESULTS AND EVALUATION

6.1Presentation of the Findings:

In our main objectives there are two main modules i.e. EMG v3 sensor, Arduino Nano. The EMG sensor takes the value from muscle accurately signals the output signal of EMG sensor goes into Arduino. The code in the Arduino reads the analog output of the EMG v3 sensor. It maps the sensor value to the servo motor range (0-180). The servo motors connected to digital pins will move accordingly. Adjust the pin numbers and servo connections based on your setup. We ensure proper power supply and connections between the components. Consider calibrating the EMG sensor and adjusting the mapping values for desired accuracy and servo motor response.

All of the modules have connected successfully and showed the desired results. Our prosthetic arm is designed to perform the some human hand gesture and perform simple task like human hand.

6.1.1 Hardware Results:

Hardware is splits into parts:

Sensing module:

Our sensing module is EMG sensor v3 we tested this module by measuring signal on different person muscles and got accurate reading as mentioned.

The efficiency of EMG v3 module is 70 %. Results are being monitored by using Arduino IDE using serial plotter.

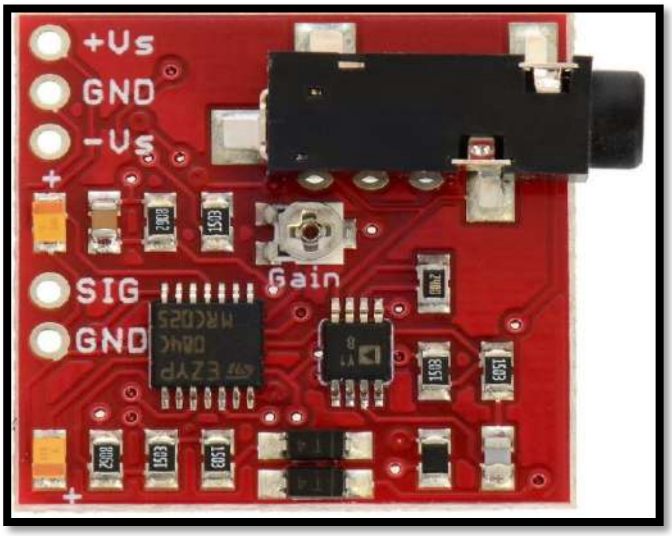


Fig 6.1: EMG v3 sensor module

PROCESSING MODULE:

The processing module is Arduino Nano. The processing is done by applying filters on EMG signal, and moves the servo motors according the given EMG signal the code is given as above. When the signal passes through the set threshold value the Arduino moves the servo motors according to given instructions. As the motors moves up to a certain angle after some delay the motors are move back to its initial position.

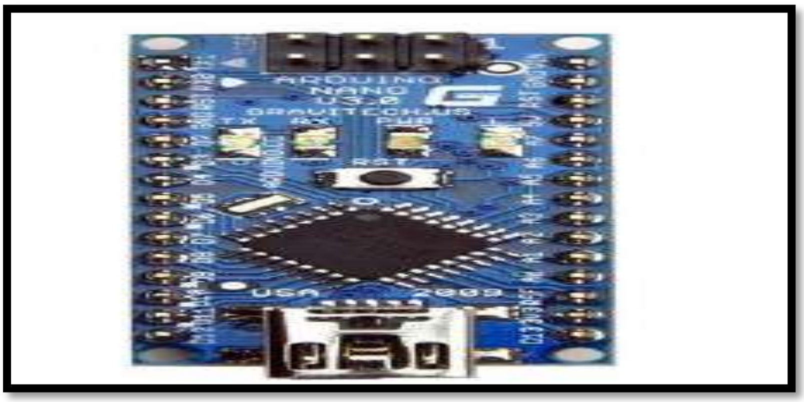


Fig 6.2: figure of Arduino Nano

6.1.2 Software Results

1. SENSING MODULE:

Software results of sensing module on Arduino serial plotter can be observed as well as on Matlab. Both of them are in consistent with hardware results. Hardware results show a little difference than simulation results but matches precisely with Arduino serial plotter results of serial plotter are given below.

2. PROCESSING MODULE:

Processing module can be simulated on proteus in proteus simulation we connected five servo motors with Arduino through coding we calibrated servo motor angles. The values we used in codding are measured from Arduino serial plotter. Through which we calibrated all servo motors angle of different gestures successfully.

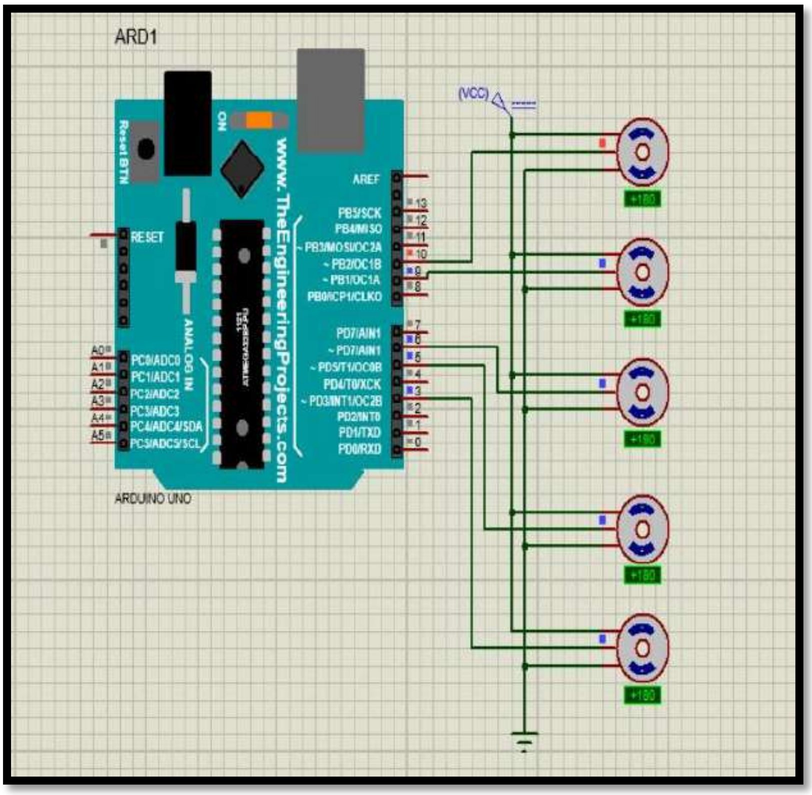


Fig 6.3: figure of Arduino with servo motors

6.2 COMPARISION & LIMITATION:

Table4: Comparison Between Different Prosthetic Hand

Hands	Weight	Cost	Gesture
Be Bionic Hand [1]	689grams	$30,000	14 different grips
Grippy Bionic Hand [2]	800 grams	$10,000	All finger open and close and wrist movement
Prothestic Artificial Myoelectric Hand [3]	250 grams	$2,000	Hold things, gripper
Low Price Prosthetic Hand Controlled by EMG Signal [4]	550 g	$7,000	Individual finger movement Straight and partially bent
Prosthetic Hand (Proposed)	600 g	$120	Open, close, individual finger movement

Our Project output our hand has 5 degree of freedom and can perform basic movements such as opening closing as well as the individual finger movements.Te cost of our project is affordable approximately 35000 PKR which is great for user who don't have access for the expensive prosthetic .The weight of our and is manageable 600grams, which should make it comfortable for the user to wear for extended period of time .Durability is also a key features our hand is able to last up to 5 years with battery maintenance .using the 3D printed PLA Material for our prosthetic hand also ensure increase durability with a lifespan of up to 15 years.

6.2.1 COMPARISION WITH INITIAL PROJECT SPECIFICATIONS:

Most of our projects are achieved with high accuracy. Measurements are accurate and motors are moving accurately. The hand is working properly in real-time. However there are some factors which can be improved.

1. Individual movement of fingers:

The individual movement of fingers can be improved by using more precise calibrated EMG sensor but this will increase the price of prosthetic hand. The sensor will record the signal with less noise which will help the motion of servo motors.

2. Lack of Sensory Feedback:

The inability of prosthetic hands to give users real-world sensory experience is a key drawback. However, they do not provide the same level of touch, pressure, or temperature sensitivity as natural hands, despite being able to restore the most fundamental grasp and movement. Users find it challenging to complete jobs that call for deft manipulation or exact control as a result.

3. Limited Dexterity and Fine Motor Skills:

It can be difficult for prosthetic hands to mimic the complex motions and dexterity of a genuine hand. People with prosthetic hands may find it difficult to perform tasks like tying shoelaces, fastening buttons, or handling small objects, especially if they have higher-level amputations.

4. Weight and Cumbersome Design:

Long-term use of some prosthetic hands might be painful due to their weight and bulk. Fatigue and restricted natural movement patterns may result from the weight and design. Bulky designs could also make it difficult to do specific jobs or fit into small areas.

6.2.2 REASONING FOR SHORT COMING:

The human hand is a remarkably complex and smart organ that can carry out a variety of delicate activities. Due to the complexity of the human hand's structure, its sensory capacities, and the fine synchronization of muscles and tendons, replicating a natural hand's full capability in a prosthetic device is difficult.

Commonly used materials for prosthetic hands include composites, metals, and plastics. These materials are strong and long-lasting, but they lack the flexibility, sensitivity, and natural movement of human tissues. For the development of more practical and effective prosthetic systems, advancements in materials science and engineering are required.

It's a challenging task to give prosthetic hands natural sensory feedback. Human hands have sensory receptors that continuously provide information to the brain, allowing us to feel touch, pressure, and temperature. Research on how to replicate this complex feedback loop in a prosthetic device is still ongoing, and current solutions frequently fall short of offering the same level of sensory sensation.

The expenses related to these procedures can raise the cost of modern prosthetic hands, making them unaffordable for many people. The availability and cost of prosthetic options might also be impacted by regulatory procedures and insurance coverage.

Whether it is through batteries, motors, or other systems, prosthetic hands need a source of power to function. The difficulty lies in juggling the prosthetic's weight and size restrictions with the requirement for power. To increase the functioning and durability of prosthetic devices, research is always being done on power efficiency and alternative energy sources.

6.3. Recommendation:

The incorporation of sensory feedback methods into prosthetic hands should be the subject of future study. Users can interact with their environment more naturally thanks to technologies like pressure sensors, temperature sensors, and artificial skin providing tactile input.

This might entail creating more sophisticated joint mechanics, better finger coordination, and stronger grips. Artificial intelligence and machine learning can assist prosthetics adapt to the unique demands and preferences of users.

To increase the battery life of prosthetic hands, research and development activities should concentrate on developing better batteries, power management systems, and energy-efficient components. Furthermore, investigating alternate power sources like cutting-edge energy storage systems or even bio-inspired power generation techniques could assist in resolving the power issues.

6.4. SUMMARY:

The EMG v3 sensor and Arduino Nano were integrated as part of the hardware implementation to operate servo motors. The Arduino code successfully translated the sensor data from the EMG sensor to servo motor motions, capturing the muscle impulses with accuracy. The hardware configuration effectively produced the intended outcomes and complied with the original project specifications. However, there can be some issues, such the need to calibrate and alter the mapping for better precision and servo motor responsiveness. It is advised that these problems be fixed in order to improve the prosthetic arm's functionality.

CHAPTER 7:

CONCLUSION:

In conclusion, our Final Year project focused on the development and implementation of a prosthetic hand for amputees using EMG (Electromyography) sensors. Throughout the project, extensive research was conducted to understand the challenges faced by amputees and the potential solutions offered by EMG technology.

The major goal of the research was to create a prosthetic hand that could be naturally manipulated by utilizing EMG sensors to record the electrical impulses produced by the user's muscles. The prosthetic hand might be configured to imitate natural hand movements by analyzing these signals, giving amputees a more natural and useful experience.

The project's main objectives were to develop a low-cost prosthetic hand that could be moved using an EMG signal from the muscles in the upper arm. All objectives have been completed with varying degrees of success.

The design and manufacture of the prosthetic hand, the incorporation of EMG sensors, the creation of signal processing algorithms, and the design of a user interface for controlling the hand movements were all significant aspects of the project. To provide accurate and dependable control, much work was invested into optimizing the system's accuracy and responsiveness.

Although the project achieved significant milestones, it’s important to recognize that there is still room for improvement. Future studies could concentrate on enhancing the system's robustness and adaptability, enhancing its capabilities, and tackling issues like signal interference and user adaptation.

Overall, by utilizing EMG sensors, this final year project advanced prosthetic hand technology for amputees. It is certainly possible to design prosthetic devices that are even more complex and successful with continuing research and development in this area.

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WEBSITES LINKS:

[1]https://bionicsforeveryone.com/ottobock-bebionic-hand/#price

[2]https://bionicsforeveryone.com/grippy-bionic-hand/#grip-patterns-control

[3]https://www.indiamart.com/proddetail/artificial-myoelectric-hand-24289790162.html

[4]https://www.sciencedirect.com/science/article/pii/S2405896321019005

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Originality Certificate

We, the undersigned members of the capstone design project group, hereby confirm that the group project titled "**Prosthetic Hand For Disabled Person**" has been undertaken and completed by us as a collaborative effort. The project report is prepared by the undersigned group members. Any external sources, including published or unpublished works, have been appropriately acknowledged and referenced in accordance with the guidelines provided by NUTECH University.

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Date: 9-AUG -2023