Myoelectric Prosthetic Arm

Submitted to the Faculty of Engineering and Technology of
MGM University Ch.Sambhaji Nagar431003

In partial fulfillment of the requirement for the award of the degree

of Bachelor of Technology In Electronics and Computer Engineering
by

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JAWAHARLAL NEHRU ENGINEERING COLLEGE MGM UNIVERSITY CHH.SAMBHAJI NAGAR (M.S.), INDIA.

Year 2024-2025

MGM University

JAWAHARLAL NEHRU ENGINEERING

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CERTIFICATE

This is to certify that the Project Stage- I/ II report entitled **" Myoelectric Prosthetic Arm "**has been submitted by **Miss.Riya Thakur, Mr.Lokesh Bhavsar, Mr.Atharva Garajkar** with PRN **No. 202101104011, 202101104021, 202101104022** in partial fulfillment for the award of the degree of Bachelor of Technology in **Electronics and Computer Engineering** from Jawaharlal Nehru Engineering College, MGM University, Chh. Sambhajinagar .

The matter embodied in this project report is a record of **Miss.Riya Thakur, Mr.Lokesh Bhavsar, Mr.Atharva Garajkar** own independent work carried out by **Dr.Vandana Malode** under my supervision and guidance. The matter embodied in this report has not been submitted to any other University or Institute for the award of any degree or diploma.

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Project Approval Certificate

Practical oral examination for above project work is conducted on and the work is approved for the award of Bachelor of Technology in Electrical and Computer Engineering.

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c. Whenever I have used materials (data , theoretical analysis ,and text)from other sources, I have given due credit to them by citing them in the text of the project report and giving their details in the references.

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ACKNOWLEDGEMENT

We would like to express my sincere gratitude to Dr.Vandana Malode, at Jawaharlal Nehru Engineering College,MGMU, for her invaluable guidance and support throughout this project. Her insights and expertise have been instrumental in shaping the direction of this work.
We would also like to thank Dr. S.N. Pawar , H.O.D Electronics and telecommunication Department, for providing me with the necessary resources and materials to carry out this project. His generosity has been crucial in enabling me to conduct my research.
Furthermore, We would like to extend my appreciation to Dr.H.H.Shinde, Dean,Faculty of Engineering and Technology, MGMU.
Lastly, We would like to thank my family and friends for their unwavering support and encouragement throughout this project. Their love and motivation have been a constant source of inspiration for me."

We would like to thank all the Teachers & our class mates for their encouragement given to make this project a reality.

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ABSTRACT

Losing an upper limb can drastically affect a person's ability to perform daily tasks and significantly diminish their quality of life. Traditional myoelectric prosthetics, which use muscle signals to control the artificial limb, offer a solution but are often prohibitively expensive. The high cost, often running into tens of thousands of dollars, creates a significant barrier, leaving many without access to this life-changing technology. This financial hurdle is especially pronounced in low-income regions and for individuals without comprehensive health insurance, severely limiting their options and autonomy.

In response to this pressing issue, our project introduces an innovative and affordable solution: a myoelectric prosthetic arm built primarily from 3D printed parts and utilizing readily available electromyography (EMG) sensors. 3D printing technology revolutionizes this field by enabling the rapid and cost-effective production of custom-fitted prosthetic components. This approach not only slashes manufacturing costs but also allows for highly personalized prosthetics tailored to the unique anatomical and functional needs of each user. The ability to customize these prosthetics enhances comfort and usability, making them more adaptable to individual requirements and vastly improving the user experience.

At the heart of our work is the goal to create a cost-effective, user-friendly prosthetic arm. EMG sensors are key to this system, detecting residual muscle contractions in the user's arm and translating these signals into control commands for the prosthetic limb. This mechanism allows for intuitive and responsive control, closely mimicking natural limb movements. By leveraging affordable and accessible technologies, we aim to democratize access to advanced myoelectric prosthetic arms, offering a lifeline to those who have been excluded due to cost. Our approach not only tackles the financial barriers but also strives to enhance the independence and quality of life for individuals with upper limb loss, bringing hope and improved daily functioning within reach.

The potential impact of this project extends beyond just the individuals directly benefiting from the prosthetic arms. By significantly lowering the cost and increasing the accessibility of advanced prosthetic technology, we hope to set a new standard in the field of prosthetics. Our use of 3D printing and readily available EMG sensors demonstrates that high-quality, functional prosthetic limbs do not have to come with a prohibitive price tag. This innovation can inspire further research and development in affordable assistive technologies, potentially leading to a broader range of cost-effective solutions for various disabilities. Additionally, the open-source nature of our design encourages collaboration and sharing within the global community, fostering advancements that can benefit countless others. Ultimately, our goal is to contribute to a future where everyone, regardless of financial constraints, has access to the tools they need to live a full and independent life.

NOMENCLATURE

1) **EMG** :   Electromyography

2) **PLA** : Polylactic Acid

3) **CAD** : Computer-Aided Design

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1.1 INTRODUCTION

The loss of an upper limb can have a profound impact on an individual's ability to perform everyday tasks, drastically affecting their quality of life. Traditional myoelectric prosthetics, which are controlled by electrical signals generated by muscles in the residual limb, provide an advanced solution by enabling natural and intuitive movements. Despite their advantages, the high cost of these devices remains a substantial obstacle for many potential users. This is particularly true in developing countries or among socioeconomically disadvantaged populations, where access to such technology is often limited.

1. 1.1 Overview of Myoelectric Prosthetics

A myoelectric prosthetic arm is a type of prosthetic device that uses electrical signals generated by muscles in the residual limb to control the movement of the device. These prostheses harness the electrical potentials produced during muscle contractions, translating these signals into precise movements of the prosthetic limb. This technology allows for a range of functions, from basic grasping to more complex manipulations, offering users a significant degree of autonomy.

Myoelectric prostheses have several advantages over body-powered devices. These include a reduction in the need for harnessing, which can be uncomfortable and restrictive for the user. Additionally, they provide access to effortless strength and multiple grip patterns, making tasks easier and more efficient. The natural hand movements enabled by myoelectric control offer a more intuitive user experience, improving overall satisfaction and functionality. These benefits make myoelectric prosthetics a preferable option for many individuals, yet their cost continues to limit their widespread adoption.

1.1.2 Innovations in Low-Cost Myoelectric Prosthetics

Recent advancements in technology have opened new avenues for reducing the cost of myoelectric prosthetic arms. One significant development is the use of 3D printing to produce prosthetic components. 3D printing allows for the rapid and cost-effective production of customized parts, tailored to the specific anatomical and functional needs of each user. This method not only reduces manufacturing costs but also shortens production times, making it feasible to produce prosthetics at a fraction of the traditional cost.

Another key innovation is the utilization of affordable electromyography (EMG) sensors. These sensors detect the electrical activity of muscles, which is then used to control the prosthetic device. By leveraging widely available and cost-effective EMG sensors, it is possible to maintain the functionality of high-end myoelectric prosthetics while significantly reducing the overall cost.

1.1.3 Bridging the Accessibility Gap

The integration of 3D printing and affordable EMG sensors in the development of myoelectric prosthetic arms represents a significant step forward in making these devices more accessible. By lowering the cost, these innovations have the potential to bridge the gap in accessibility, providing more individuals with the opportunity to benefit from advanced prosthetic technology. This is especially crucial for individuals in developing countries and those from socioeconomically disadvantaged communities, who are often left without viable options due to financial constraints.

1.2 LITERATURE SURVEY

The high cost of traditional myoelectric prosthetic arms is a significant barrier for many amputees, particularly in developing countries and for individuals with limitedfinancial resources. This survey explores the growing field of low-cost myoelectric prosthetic arms, aimed at providing affordable and functional options for this underserved population.

1.2.1 Key Technologies and Approaches:

3D Printing: This technology enables cost-effective and customizableprosthetic designs, often utilizing open-source models and readily availablematerials.
A Embedded Systems: Microcontrollers like Arduino offer affordable platformsfor processing myoelectric signals and controlling prosthetic movements.
B Open-Source Hardware and Software: Leveraging open-source resourcesreduces development costs and fosters collaboration among researchers andmakers.
C Surface Electromyography (sEMG): Non-invasive electrodes capture muscleactivity signals, providing a cost-effective way to control the prosthetic.
D Focus on Functionality: While initially offering fewer degrees of freedom andfeatures compared to high-end prosthetics, low-cost designs prioritize essentialfunctions like grasping and basic manipulation.Control Strategies:
E Conventional vs. Pattern Recognition: Traditional methods map musclesignals to specific movements, while pattern recognition algorithms attempt tointerpret user intent for more intuitive control. Both approaches have theiradvantages and limitations, and research continues to improve both.
F EMG Signal Processing: Advanced techniques like machine learning andartificial intelligence are being used to extract more information from EMGsignals, enabling finer control and more natural movement patterns.
G Sensory Feedback: Integrating tactile or force sensors into the prosthesis canprovide crucial feedback to the user, improving their ability to grasp objectsand interact with the environment.

1.2.2 Functionality and Performance:

A Degrees of Freedom: Modern myoelectric arms offer increasinglysophisticated movement capabilities, including multiple joints, individualfinger control, and even wrist rotation.
B Grip Patterns: Replicating the diversity of human grips remains a challenge,but studies explore new actuation technologies and control strategies to offermore adaptable grasping for everyday tasks.
C Cosmesis and User Acceptance: The appearance and comfort of theprosthesis play a significant role in user acceptance. Material developments anddesign innovations are focusing on creating more natural-looking andlightweight prostheses.

1.2.3 Challenges and Future Directions:

A Cost and Accessibility: Myoelectric arms remain expensive, limiting accessfor many amputees. Research is exploring ways to reduce costs and developmore affordable options.
B Battery Life and Power Consumption: Longer battery life and efficientenergy management are crucial for practical use.
C Integration with Neural Interfaces: Direct neural interfaces hold promise foreven more intuitive and natural control, but ethical and technical challengesremain.

1.2.4 Key Research Areas:

A Improved Signal Processing: Enhancing the accuracy and robustness ofsEMG signal interpretation for reliable

Factors to be Considered

When comparing existing prosthetic products with the proposed myoelectric prosthetic arm, several factors highlight the advancements and innovations in the new design:

1. Pattern Recognition
In existing products, traditional methods are used to map muscle signals to specific movements. Our product enhances this by not only mapping muscle signals but also learning the user's most frequently performed daily movements, providing a more intuitive experience.

2. EMG Signal Processing
Existing prosthetic arms rely solely on basic EMG signal processing to execute movements. In contrast, our design employs advanced techniques such as machine learning and artificial intelligence to extract more nuanced information from EMG signals, resulting in improved functionality and adaptability.

3. Sensory Feedback
Existing solutions provide basic capabilities for grasping objects and interacting with the environment. Our product improves upon this by enhancing the ability to grasp larger objects and interact more effectively with diverse environments.

4. Degrees of Freedom
Traditional prosthetic arms often have restricted movement capabilities, offering limited degrees of freedom. Our modern myoelectric arm includes advanced movement features such as multiple joints, individual finger control, and wrist rotation, greatly enhancing mobility and usability.

5. Cosmesis and User Acceptance
Existing designs use materials like metals, plastics, and composites, focusing on creating durable yet basic prostheses. Our product uses materials such as ABS or PLA+ for 3D printing, enabling the creation of lightweight, natural-looking prostheses that enhance user comfort and acceptance.

6. Cost and Accessibility
Current myoelectric arms remain prohibitively expensive for many, with prices ranging between ₹50,000 and ₹1,00,000. Our product addresses this issue by being priced under ₹10,000, potentially extending up to ₹15,000, while maintaining quality and functionality.

7. Cost Comparison (Material)
Existing prosthetic components are made using materials like aluminum, stainless steel, or titanium, which increase costs. Our design uses PLA (Polylactic Acid), a cost-effective material commonly used in 3D printing, significantly reducing production expenses.

8. Cost Comparison (Sensors)
Some existing products use brainwave sensors to read signals from the user’s brain, which adds to their cost and complexity. Our design opts for electrodes to detect electrical signals generated by muscle contractions, providing reliable control at a fraction of the cost.

9. Cost Comparison (Shipping)
Many existing prosthetics are imported from developed countries like the UK, incurring high shipping charges. Our prosthetic arm is manufactured indigenously, eliminating these additional costs and making it more affordable and accessible.

Factors to be consider	**Existing product**	**Our product**
Pattern Recognition Author:- Stephanie L. Carey Derek J. Lura M. Jason Highsmith	Traditional methods map muscle signals to specific movements	Map muscle signals to specific movements as well as the daily most done movements
EMG Signal Processing Author:- Stephanie L. Carey Derek J. Lura M. Jason Highsmith	In this only the emg signal is performed through which only the movements has been done	Advanced techniques like machine learning and artificial intelligence are being used to extract more information from EMG signals
Sensory Feedback Author :- Manfredo Atzori Henning Müller	Their ability to grasp objects and interact with the environment as on basic version.	Now improving their ability to grasp bigger objects and interact with the environment.
Degrees of Freedom Author :-Manfredo Atzori Henning Mülle	The existing products don't offer all such freedom of movement's they are having restricted towards to movement.	Modern myoelectric arms offer increasingly sophisticated movement capabilities, including multiple joints, individual finger control, and even wrist rotation.
Cosmesis and User Acceptance Author:- Stephanie L. Carey Derek J. Lura M. Jason Highsmith	The existing Material developments and design innovations are focusing on creating metals, plastic's and composite material prostheses.	The Material like ABS or PLA+ develop and design innovations like focusing on creating more naturallooking and lightweight prostheses.
Cost and Accessibility Author:- Stephanie L. Carey Derek J. Lura M. Jason Highsmith	Myoelectric arms remain expensive, limiting access for many amputees. The price of the existing product are appox. Upto 50k or 1 lakh.	The ways of exploring to reduce costs and develop more affordable options the product we made is under 10k (it can be exceed upto 15k also for further modification and updates).

1.3 PROBLEM STATEMENT

Table 1.3.1 Identify client's objectives

Sr. No	Objectives
1	Enhanced Grip Strength and Versatility
2	Natural Aesthetic Design
3	Confidence and Empowerment
4	Improved Musical Abilities
5	Enhanced Participation in Sports:
6	Improved hand movements and co-ordination

Table 1.3.2 Order the list into sets.

Title: Low cost myoelectric prosthetic arm		
Category 1: Performance	Category 2: User-Friendly	Category 3: Safety
Automatic	User Friendly	Shock proof
Efficient	Durable	Water proof
	Light weight	
	Interface	

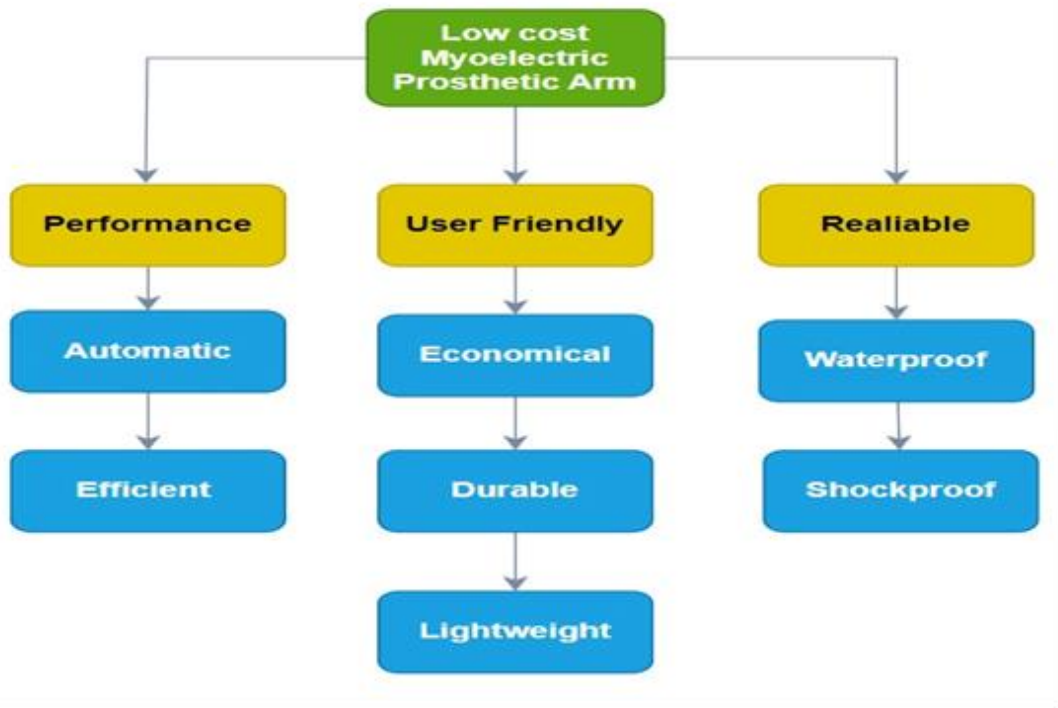


Figure3.1 Objective Tree - Objectives on which the model was made

Table 1.3.3 Priorities among various objectives is using a technique called Pair-wise Comparison Chart (PCC)

Objectives	Automatic	Economical	Aesthetics	lightweight	Durable	Reliable	Score
Automatic	*	0	1	1	1	1	4
Economical	1	*	1	1	1	1	5
Aesthetics	0	0	*	0	0	0	0
lightweight	0	0	1	*	1	0	2
Durable	0	0	1	0	*	0	1
Reliable	0	0	1	1	1	*	3

1.3.1 Rank the objectives in order of decreasing value of importance and the list is:

1. Economical
2. Automatic
3. Reliable
4. lightweight
5. Durable
6. Aesthetics

Based on the information gathered through interaction with client initial survey and completing phase 3.1, the problem statement is formulated as follows:

Problem Statement making Version 1.1

Design a Economical, Automatic, Reliable and Lightweight Prosthetic arm which is Durable.

1.3.2Identify constraints

1. Budget
2. Mobility
3. Maintenance

Problem statement making version 1.2

Design a Economical, Automatic, Reliable and Lightweight Prosthetic arm which is Durable. Within the Limitations of Budget, Mobility and Maintenance.

1.3.3 Establish functions

1. Grip Strength
2. Daily Activities
3. Outdoor and Other Activities
4. Customization

Problem statement

Design a Economical, Automatic, Reliable and Lightweight Prosthetic arm which is Durable. Within the Limitations of Budget, Mobility and Maintenance and Functions like various grips, Daily and Outdoor activities and Customization

2.1 CONCEPTUAL DESIGN

The conceptual design for a low-cost myoelectric prosthetic arm aims to integrate advanced functionality, user-friendly features, and an aesthetically pleasing design while maintaining affordability. Here is an overview of the key components and features:

2.1.1. Customizable 3D-Printed Components:

- The prosthetic arm's main structure and components are designed to be customizable and easily 3D-printed.
- This allows for personalized fitting to the user's residual limb and ensures comfort and functionality.

2.1.2. EMG Sensor Integration:

- The prosthetic arm incorporates electromyography (EMG) sensors strategically placed on the residual limb to detect muscle signals.
- These sensors enable intuitive control of the prosthetic arm by translating muscle signals into movement commands.

2.1.3. Enhanced Grip Strength and Versatility:

- The prosthetic hand features multiple grip patterns and strong grip strength to handle various tasks with ease.
- This includes pinch grips, power grips, and precision grips, providing versatility for everyday activities.

2.1.4. Natural Aesthetic Design:

- The exterior of the prosthetic arm is designed to resemble a natural limb as closely as possible, with customizable covers available in different skin tones.
- This aesthetic design feature helps the prosthetic arm blend seamlessly with the user's body, reducing self-consciousness and enhancing confidence.

2.1.5. User-Friendly Interface:

- The control interface is designed to be intuitive and easy to use, allowing users to switch between grip patterns and adjust settings effortlessly.
- This ensures a smooth user experience and minimizes the learning curve for operating the prosthetic arm.

2.1.6. Lightweight and Comfortable Design:

- The prosthetic arm is constructed from lightweight materials to reduce fatigue and discomfort during extended wear.
- Special attention is paid to ergonomics and weight distribution to ensure maximum comfort and usability.

2.1.7. Durability and Reliability:

- The prosthetic arm is engineered to be durable and reliable, capable of withstanding daily wear and tear as well as occasional impacts.
- Shockproof and waterproof features are integrated to protect internal components and ensure

longevity.

2.1.8. Easy Maintenance and Troubleshooting:

- The prosthetic arm is designed for easy maintenance and troubleshooting, with accessible battery compartments and modular components.
- Users are provided with clear instructions and support resources for routine maintenance tasks and minor repairs.

2.1.9. Portability and Ease of Use:

- The prosthetic arm is designed to be portable and easy to transport, allowing users to carry out daily activities and travel with ease.
- Quick-release mechanisms and adjustable straps facilitate easy attachment and removal of the prosthetic arm.

2.1.10. Affordability and Accessibility:

- The overall design prioritizes affordability without compromising on functionality or quality.
- By utilizing cost-effective materials and manufacturing processes, the prosthetic arm remains accessible to a broader population.

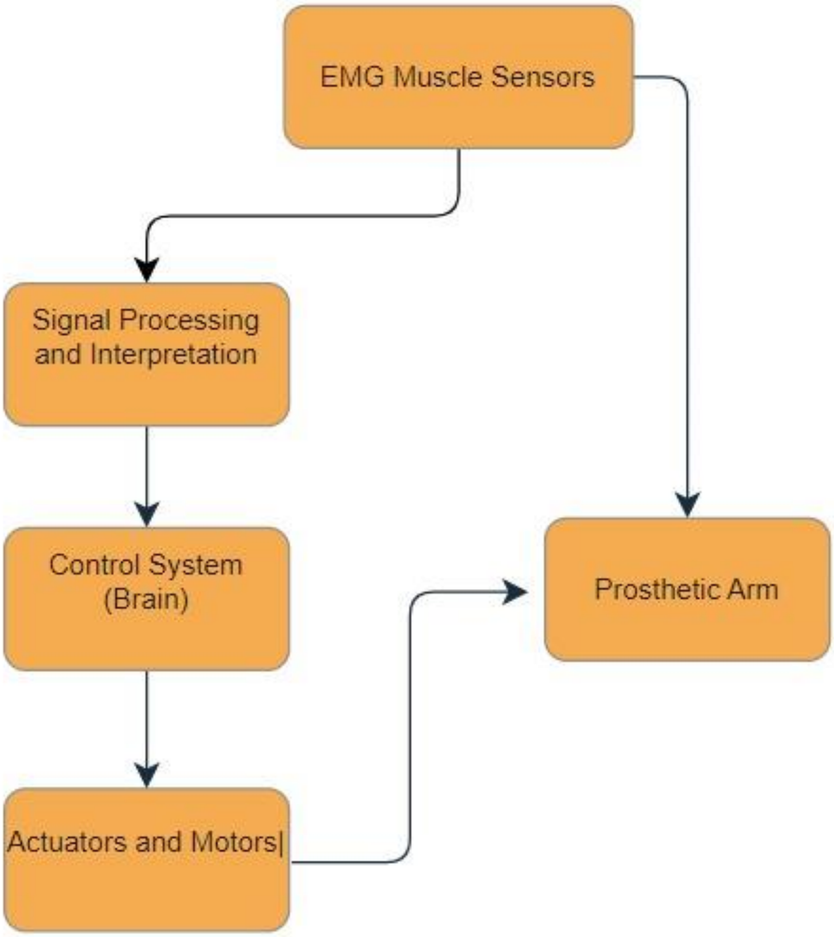


Figure 4.1 - Conceptual design Flow chart - Explaining the flow of working

Concept 1:

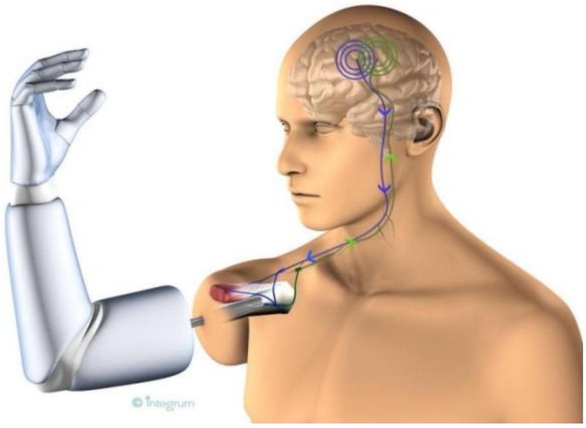


Figure 4.2 Mind Controlled Permanently Attached Prosthetic Arm

Concept 2:

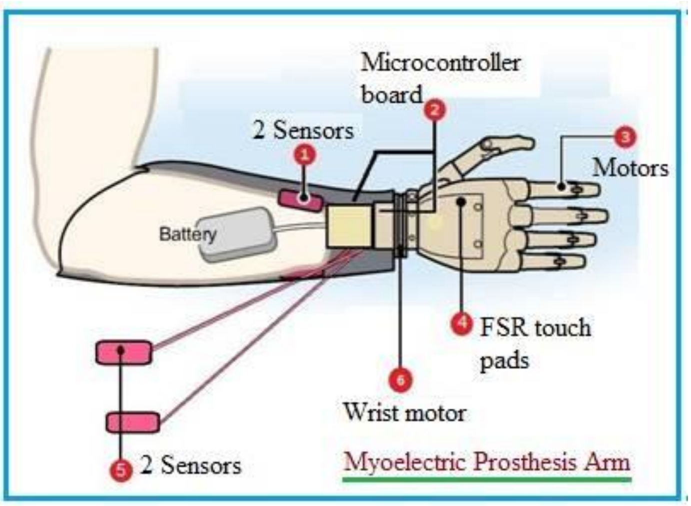


Figure 4.3 Myoelectric Prosthetic Arm

Concept 3:

Figure 4.4 Passive Prosthetic Arm

METHODOLOGY

3.1 Design

The conceptual design for a low-cost myoelectric prosthetic arm aims to integrate advanced functionality, user-friendly features, and an aesthetically pleasing design while maintaining affordability. Below are the systematically detailed components and features:

3.1.1 Customizable 3D-Printed Components

- **Objective**: To enable personalized fitting and functionality for each user.
- **Features**:
    - The main structure and components are customizable and easily produced using 3D printing technology.
    - Allows for precise fitting to the user's residual limb, ensuring optimal comfort and functionality.
    - Modular design supports flexibility in component replacement or upgrading.

3.1.2 EMG Sensor Integration

- **Objective**: To provide intuitive control based on user muscle signals.
- **Features**:
    - Electromyography (EMG) sensors are strategically placed on the residual limb.
    - Sensors detect muscle signals and convert them into commands for prosthetic movements.
    - Enables natural and seamless interaction between the user and the prosthetic arm.

3.1.3 Enhanced Grip Strength and Versatility

- **Objective**: To perform a variety of tasks effectively.
- **Features**:
    - Multiple grip patterns, such as pinch grips, power grips, and precision grips.
    - Strong grip strength ensures reliable handling of objects.
    - Provides versatility for everyday activities, from simple tasks to more complex maneuvers.

3.1.4 Natural Aesthetic Design

- **Objective**: To enhance user confidence and acceptance.
- **Features**:
    - Designed to closely resemble a natural limb.
    - Customizable covers available in a variety of skin tones.
    - Aesthetic design helps the prosthetic blend seamlessly with the user's body.

3.1.5 User-Friendly Interface

- **Objective**: To ensure ease of use and minimal learning curve.
- **Features**:
    - Intuitive control interface allows users to switch grip patterns and adjust settings effortlessly.
    - Simple navigation and operation enhance the overall user experience.

3.1.6 Lightweight and Comfortable Design

- **Objective**: To ensure comfort during extended use.
- **Features**:
    - Constructed from lightweight materials to reduce fatigue.
    - Ergonomic design optimizes weight distribution for enhanced comfort.
    - Focus on long-term wearability.

3.1.7 Durability and Reliability

- **Objective**: To ensure long-term performance and robustness.
- **Features**:
    - Engineered to withstand daily wear and occasional impacts.
    - Integrated shockproof and waterproof features protect internal components.
    - Designed for reliable operation over extended periods.

3.1.8 Easy Maintenance and Troubleshooting

- **Objective**: To facilitate convenient upkeep for users.
- **Features**:
    - Accessible battery compartments and modular components simplify maintenance.
    - Clear user instructions and support resources provided for routine tasks and minor repairs.

3.1.9 Portability and Ease of Use

- **Objective**: To enhance mobility and usability.
- **Features**:
    - Quick-release mechanisms and adjustable straps for easy attachment and removal.
    - Portable design ensures convenience during daily activities and travel.

3.1.10 Affordability and Accessibility

- **Objective**: To make the prosthetic arm accessible to a broader population.
- **Features**:
    - Cost-effective materials and manufacturing processes ensure affordability.
    - Emphasis on maintaining high functionality and quality without excessive cost.

3.1.11 Improved Energy Efficiency

- **Objective**: Optimize battery life for extended usage.
- **Features**:
    - Low-power components reduce energy consumption.
    - Rechargeable batteries support prolonged operation.
    - Energy-efficient design lowers maintenance costs.

3.1.12 Advanced Sensory Feedback

- **Objective**: Enhance user interaction and control.
- **Features**:
    - Incorporation of sensory feedback for tactile sensations.
    - Allows users to perceive grip strength and object textures.
    - Improves task precision and overall experience.

3.2 Workflow

The workflow for the development of the prosthetic arm involves a structured approach to ensure a user-centric, functional, and cost-effective solution.

The process begins with **Needs Assessment and Conceptual Design**, where a comprehensive understanding of the target user population is established. In-depth interviews and surveys are conducted with individuals with upper-limb amputations to gather insights into their specific needs, preferences, and limitations. This information is critical to shaping a design that aligns with their functional and aesthetic requirements. A virtual prototype of the prosthetic hand is developed using 3D modeling software, enabling the exploration of various design options. These options include different grip patterns and finger configurations, and the iterative design process ensures continuous refinement to optimize functionality and enhance the user experience.

The next stage, **Integration of EMG Sensors and Signal Processing**, focuses on creating an intuitive control mechanism for the prosthetic arm. EMG sensors are strategically positioned on the residual limb to capture muscle signals. Advanced signal processing algorithms are developed to accurately interpret these signals and convert them into specific hand movements. This stage emphasizes building a robust mapping system between muscle activity and the corresponding hand actions, ensuring precise and responsive control of the prosthetic arm.

Finally, the **Mechanical Design, Fabrication, and Electrical Systems** phase ensures the physical structure and internal systems of the prosthetic arm are designed for optimal performance. The arm is engineered to balance weight, strength, and durability while keeping manufacturing costs low through techniques like 3D printing and injection molding. Modular components are incorporated to facilitate straightforward assembly, maintenance, and customization, making the prosthetic arm adaptable and user-friendly.

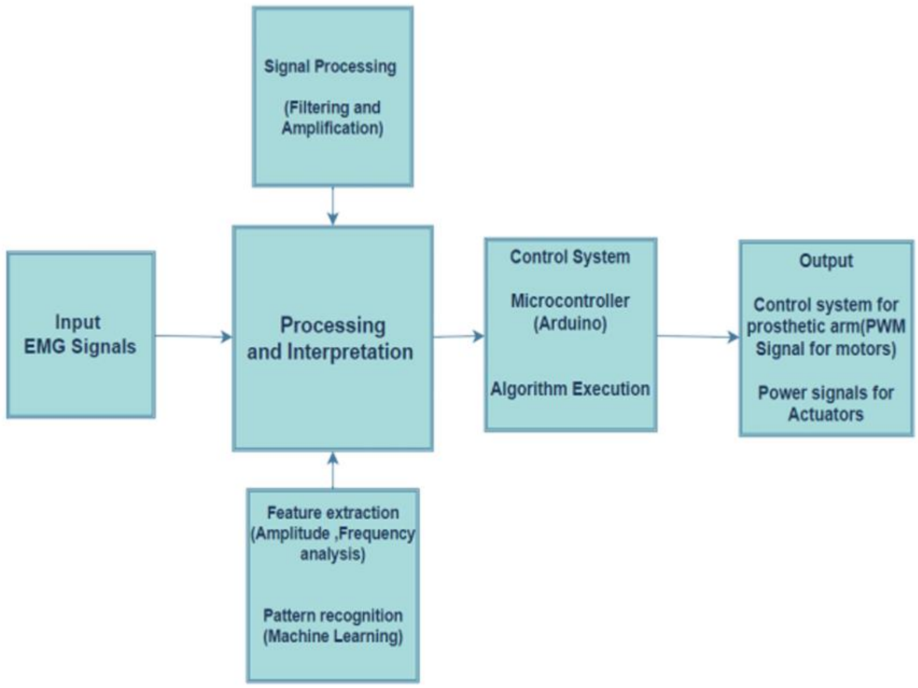


Fig. Signal Processing Glass Box - Shown the signals as from inputs signals to final output signals processing

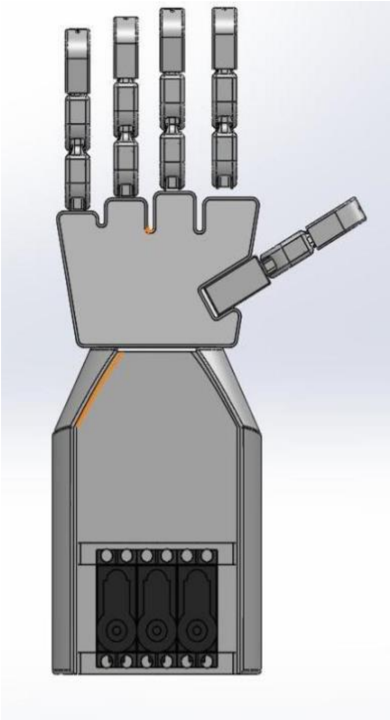
Result and Discussion

1. The image below shows a real-time graph displaying muscle signals recorded through an electromyography (EMG) sensor. These signals reflect variations in muscle activity, which are used to control a prosthetic arm or other assistive devices. The peaks and troughs in the graph represent different levels of muscle contraction and relaxation, which are crucial for interpreting the intent behind movement. This data is processed to allow precise control of prosthetic limbs, enabling them to replicate natural hand or arm movements in response to the user's muscle activity.

Here we have to set a threshold value which acts as a switch for the prosthetic arm, The controller will only read a value if the graph crosses that certain threshold value, Thereafter that signal will be given to servo motor which is responsible for the movement of the arm.

Fig. 3.2.1 Signal Graph - Shows the signal of Muscles
Analytical Output Waveforms Of EMG Sensor
(the spike waveforms of the sensor as working on the moments like contraction and relaxation)

2. The below image is a prosthetic hand model that moves using muscle signals from an EMG sensor. The EMG sensor captures electrical activity generated by muscle contractions, and these signals are processed to control the movements of the prosthetic hand. By interpreting the intensity and pattern of the muscle signals, the prosthetic hand can perform various tasks, such as grasping or releasing objects, mimicking natural hand movements. This technology provides a functional and intuitive solution for users, allowing them to control the prosthetic hand through their own muscle activity.



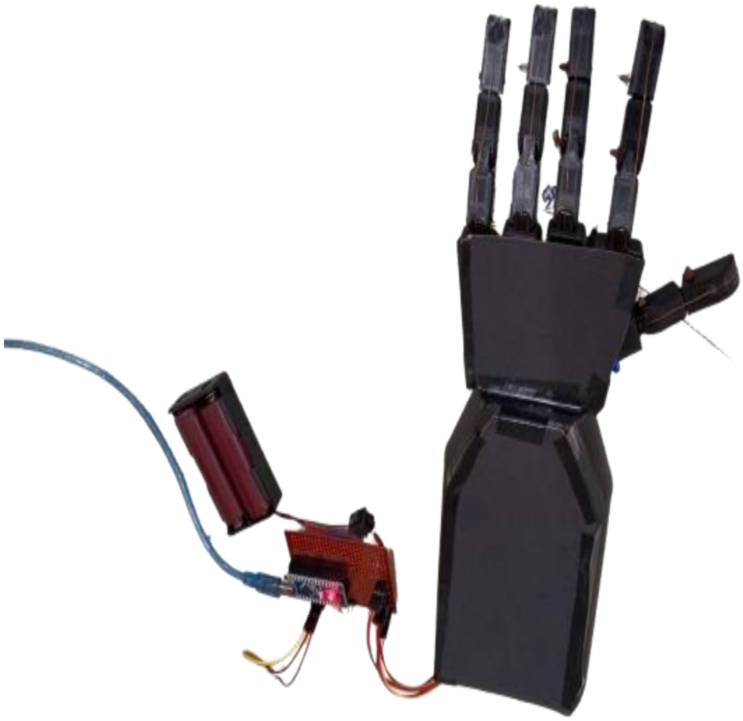


Fig 3.2.2 - 3D Model - 3D model made from PLA

3. The below image shows a person using a myoelectric prosthetic arm controlled by EMG signals. The EMG signals are captured from the person's muscle activity and processed by an Arduino, which controls the servos that move the prosthetic arm. The system is connected to a laptop, allowing real-time monitoring and adjustment of the arm's movements. This setup demonstrates the integration of EMG technology with microcontrollers and motors, enabling precise and responsive control of the prosthetic limb based on the user’s muscle signals.

Fig. 3.3.3 - Electronics - Shows the electronics used in the system

4. The below image shows a person using a myoelectric prosthetic arm, with EMG sensors attached to the forearm and connected to a laptop displaying real-time muscle signal visualization. The setup includes an Arduino board, a prosthetic hand, and a servo system controlled by the EMG signals.

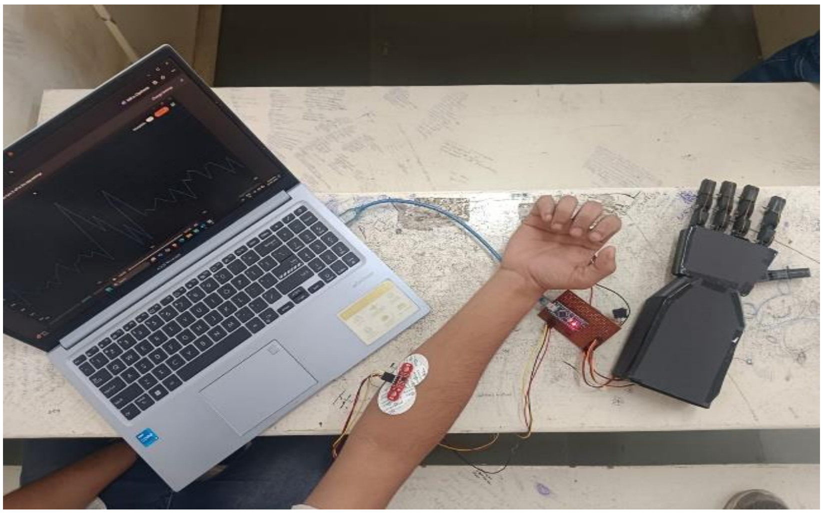


Fig.Final Prototype

(including EMG sensor, 3D printed arm, microcontroller, circuit working, output waveforms,etc.)

When the muscles in the arm contract, they generate electrical signals as a natural result of muscle activity. These signals are detected by highly sensitive electromyography (EMG) sensors placed strategically on the user's residual limb. The sensors capture these electrical impulses and translate them into actionable commands for the prosthetic arm. Once the strength of the signal exceeds a carefully predefined threshold, the system interprets it as a directive to move the prosthetic arm in a specific direction. This movement is precise and immediate, ensuring that the prosthetic responds in real-time to the user's muscle contractions. When the muscles relax, the signal strength diminishes and falls below the set threshold, prompting the prosthetic arm to move in the opposite direction. This bidirectional control allows the prosthetic arm to mimic the natural biomechanics of hand movements with impressive accuracy.

Moreover, this real-time interaction between muscle signals and prosthetic movements allows users to regain a sense of normalcy and independence in their daily lives. Whether performing complex tasks or simple actions, the system provides a level of control and functionality that closely resembles the natural movement of a biological arm. This advanced integration of EMG sensors with the prosthetic arm ensures a smooth and reliable operation, offering the user not only practical benefits but also psychological confidence and comfort in their mobility. The intuitive nature of this design removes the need for extensive training, empowering users to adapt quickly and use the prosthetic efficiently from the outset.

The seamless coordination between muscle activity and prosthetic response also makes the device suitable for a wide range of activities, from basic tasks like picking up objects to more delicate actions requiring precision, such as typing or handling small items. This advanced functionality, combined with the real-time responsiveness of the EMG sensor system, makes the prosthetic arm an exceptional tool for improving the quality of life for its user

4.1 CONCLUSION

In conclusion, the development of a low-cost myoelectric prosthetic arm represents a significant step forward in the field of assistive technology. By integrating innovative design approaches, such as 3D printing and affordable EMG sensors, with user-centric features and functionality, this prosthetic arm offers a viable solution to address the accessibility gap faced by individuals with upper-limb amputations. Through direct engagement with users and clients, key objectives and constraints have been identified, ensuring that the design prioritizes performance, user-friendliness, safety, and affordability.

The conceptual design outlined for the low-cost myoelectric prosthetic arm embodies these principles, offering customizable 3D-printed components, intuitive EMG sensor integration, enhanced grip strength, and a natural aesthetic design. User-friendly features such as a lightweight and comfortable design, easy maintenance and troubleshooting, and portability further enhance the prosthetic arm's usability and accessibility. By addressing users' needs and concerns while maintaining affordability, this design strives to empower individuals with upper-limb amputations, enabling them to regain independence and confidence in their daily lives.

Moving forward, continued research, development, and collaboration are essential to further refine and optimize the design of low-cost myoelectric prosthetic arms. By leveraging emerging technologies and innovative approaches, we can continue to improve the functionality, affordability, and accessibility of assistive devices, ultimately enhancing the quality of life for individuals with disabilities worldwide. Through a commitment to inclusivity and innovation, we can ensure that everyone has access to the tools and support they need to thrive and participate fully in society.

4.2 FUTURE SCOPE

4.2.1 Advanced Control Systems:

A Brain-Computer Interfaces (BCI): Integrating BCI technology could revolutionize prosthetic control by enabling direct translation of brain signals into movement commands, offering users unprecedented levels of control and autonomy.

B Machine Learning and Artificial Intelligence (AI): Leveraging AI algorithms to enhance EMG signal recognition and control can lead to more natural and precise movements, adapting in real-time to the user's needs and preferences.

4.2.2 Enhanced Functionality:

A Multifunctionality: Developing modular prosthetic designs that allow users to interchange different terminal devices (hands, hooks, tools) based on specific tasks and activities, enhancing versatility and adaptability.

B Sensory Feedback: Integrating sensory feedback systems into prosthetic arms to provide users with tactile sensations, enabling them to better interact with their environment and objects.

4.2.3 Integration with Advanced Materials:

A Smart Materials: Exploring the use of smart materials that can adapt to different environments or user intent, such as variable stiffness for improved grasping or gripping capabilities.

B Biocompatible Materials: Researching biocompatible materials for improved osseointegration, facilitating a more secure and natural attachment between the prosthetic arm and the user's body.

4.2.4 Focus on Specific Needs:

A Myoelectric Prosthetics for Children: Designing age-appropriate and adaptable prosthetic solutions for children, considering their unique anatomical and developmental needs.

B Prosthetics for Specific Activities: Developing specialized prosthetic devices tailored to the requirements of musicians, athletes, or individuals with specific professions, optimizing performance and functionality for their respective activities.

APENDICES

Appendix A: **Technical Specifications and Components**

In this section, we discuss about what makes the low-cost myoelectric prosthetic arm tick. The design is all about combining cutting-edge tech with user-friendliness and affordability. Here's a breakdown of the key components:

1. Microcontroller Unit (MCU): At the heart of the prosthetic is a high-performance microcontroller that processes signals from the EMG sensors. This little powerhouse uses machine learning to ensure accurate and responsive control.

2. Actuators and Motors: The arm's joints and fingers are driven by precision actuators and motors, designed to provide strong, smooth, and natural movements.

3. Power Supply: The arm runs on rechargeable lithium-ion batteries, striking a balance between power and weight. An efficient power management system keeps things running smoothly and alerts users when the battery is low.

4. User Interface: We've made controlling the arm straightforward with an intuitive user interface. Users can easily switch between different grip patterns and adjust settings via a mobile app or physical controls on the arm itself.

Appendix B: User Feedback and Testing Protocols

Creating a prosthetic arm that truly meets users' needs requires listening to their experiences and making continuous improvements. Here's how we did it:

1. User Surveys and Interviews: We started by talking to potential users through detailed surveys and interviews. They shared their daily challenges and what they wanted in a prosthetic arm, which helped shape our design priorities.

2. Prototyping and Iterative Design: We developed multiple prototypes and tested them . Each testing round provided valuable feedback, leading to continuous improvements in comfort, usability, and functionality.

3. Performance Metrics: To measure the arm's effectiveness, we set up various performance tests. These included assessing grip strength, how quickly the arm responded to EMG signals, battery life, and its durability in different conditions.

Through these appendices, we've detailed our comprehensive approach to developing a low-cost myoelectric prosthetic arm. By blending advanced technology with a deep understanding of user needs, our goal is to create a prosthetic that significantly enhances the lives of those with **upper-limb amputations.**

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