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# Development of a 3D Printed Prototype of a Robotic Arm

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**ABSTRACT:** This project focuses on the development of a cost-effective, 3D-printed robotic arm designed to assist individuals with upper limb disabilities. The prototype is built using Acrylonitrile Butadiene Styrene (ABS) for its strength and light weight. Electromyography (EMG) sensors detect muscle activity from the user's forearm, which is then processed by an Arduino Nano microcontroller. The processed signals control servo motors that drive finger movements through a cable mechanism. The system is powered by a rechargeable lithium-ion battery, offering a simple and functional solution to restore basic hand movements. This project aims to provide an affordable and customizable alternative to expensive commercial prosthetics, especially in resource-limited settings.

## I. INTRODUCTION

The development of assistive technologies has revolutionized the lives of individuals with disabilities. Recent advancements in robotics and materials science have led to the creation of innovative solutions, such as robotic arms. These devices are designed to empower individuals who have lost mobility due to accidents or diseases, enabling them to perform daily tasks independently.

This project focuses on designing and developing a prototype robotic arm that utilizes ABS material for its construction, ensuring durability, cost-effectiveness, and lightweight design, using FDM 3D printing process. The arm is integrated with electromagnetic sensors that detect and respond to muscle movements, allowing users to control the device with precision. By combining durable materials and sensor technology, this project aims to offer a practical, affordable, and environmentally friendly assistive device that significantly improves the lives of individuals with limited mobility.

## II. LITERATURE SURVEY

In recent years, the development of prosthetic hands has been revolutionized by the integration of 3D printing technologies and electromyography (EMG)-based control systems, enabling affordable and functional alternatives to traditional prostheses.

Shaikh et al. (2022) conducted a thorough review of the recent advances and future directions in 3D-printed prosthetic hands. Their study emphasizes the potential of additive manufacturing in addressing cost and customization challenges, particularly through the use of materials like ABS and PLA, which balance mechanical strength and affordability. The authors also discuss barriers such as mechanical reliability and lack of standardization, suggesting further research in bio-compatible, flexible polymers.

Vinciguerra et al. (2021) explored the lightweight design and fabrication of prosthetic hands using flexible 3D-printed materials. Their work demonstrates that using thermoplastic polyurethane (TPU) and flexible joint structures significantly enhances the ergonomics, wearability, and adaptability of prosthetic hands. The implementation of topology optimization in the design phase further contributed to material reduction and performance enhancement.

Advancements in EMG signal processing have paralleled improvements in hardware design. Huang et al. (2020) reviewed state-of-the-art EMG sensing systems and their role in human-computer interfaces for prosthetic applications. They highlight challenges such as signal noise, electrode placement sensitivity, and muscle fatigue, while also

presenting solutions such as high-density surface EMG arrays and deep learning models to enhance accuracy and responsiveness.

Kim et al. (2022) proposed a real-time adaptive grasping mechanism using EMG signals for robotic prosthetic hands. Their system utilizes machine learning algorithms to dynamically adjust grip patterns based on user intent, enabling intuitive and natural motion. The integration of feedback mechanisms and adaptive control improves both precision and user satisfaction.

### III. METHODOLOGY

The methodology outlines the step-by-step process followed to develop the 3D-printed robotic arm. It began with identifying the problem of expensive and inaccessible prosthetics. The design phase was carried out using Solid Edge software, followed by selection of cost-effective components like ABS material, EMG sensors, servo motors, and lithium-ion batteries. The parts were then fabricated using 3D printing. Afterward, EMG sensors were integrated to detect muscle signals. Finally, the entire system was assembled and programmed using Arduino to achieve controlled finger movements.

#### DESIGN

The design of the robotic arm was meticulously crafted based on anthropometric data, which provides detailed measurements of the human body, and a thorough understanding of human anatomy. Utilizing Solid Edge software, the design process enabled the creation of a precise and functional robotic arm structure that closely mimics the natural movement and proportions of a human arm.

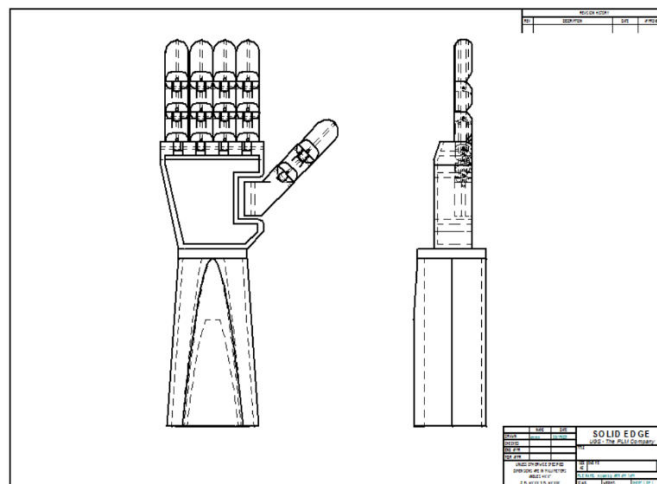


Fig : Assembly design of prosthetic

#### MODEL PREPARATION

Model preparation refers to the process of creating, refining, and optimizing a model to accurately represent a concept. components used

1. Kinematic joints
2. Servo motors
3. EMG electrodes (wet based)
4. Li-ion battery
5. EMG sensor module
6. Power converter
7. Arduino nano



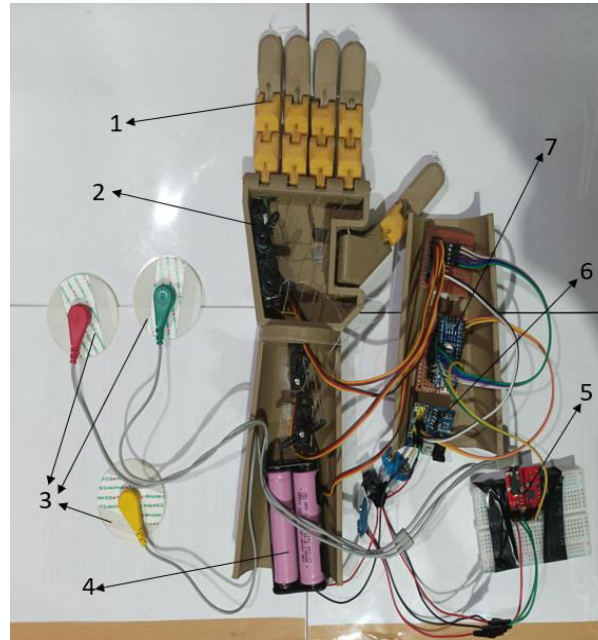


Fig : Explode view.

### 3D Printing:

The prototypes of the robotic arm is manufactured using a 3D printer with ABS (Acrylonitrile Butadiene Styrene) filament through the Fused Deposition Modeling (FDM) process. This method offers several benefits, including:

- **Rapid Prototyping:** 3D printing enables quick creation of complex designs, allowing for iterative testing and refinement.
- **Cost-Effectiveness:** FDM is a relatively affordable 3D printing technology, reducing production costs.
- **Customization:** 3D printing allows for tailored designs to meet specific user needs.

**Complex Geometries:** FDM enables creation of intricate designs and complex geometries

### Sensor Integration

Sensor integration is the process of combining multiple sensors, such as electrodes, into a single system or platform to enhance data collection and functionality, allowing for a more comprehensive analysis of physical phenomena. In our setup, we used three electrodes to accurately detect muscle signals. The placement of these electrodes was determined based on the specific arm movements required.

The electrodes were strategically placed on the human body to detect electrical signals. Specifically, the green electrode was placed on the extensor carpi ulnaris muscle, which extends and adducts the wrist. The red electrode was placed on the extensor digitorum muscle, responsible for extending the fingers and assisting in wrist extension. The yellow electrode was placed on the extensor carpi radialis longus muscle, which extends and abducts the wrist.

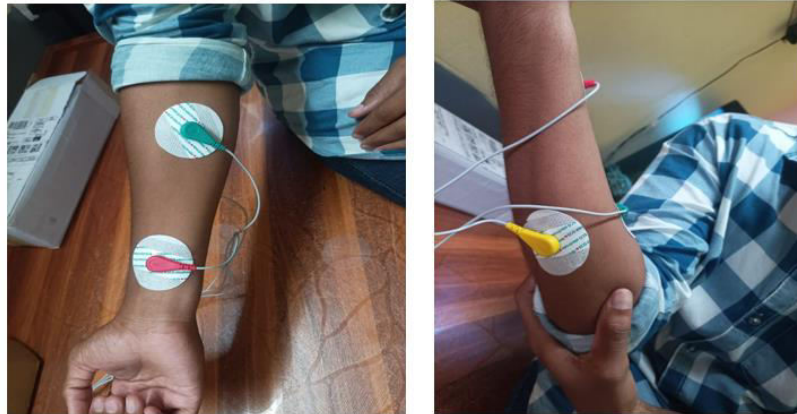


Fig : Electrodes placement on human body

#### IV. WORKING

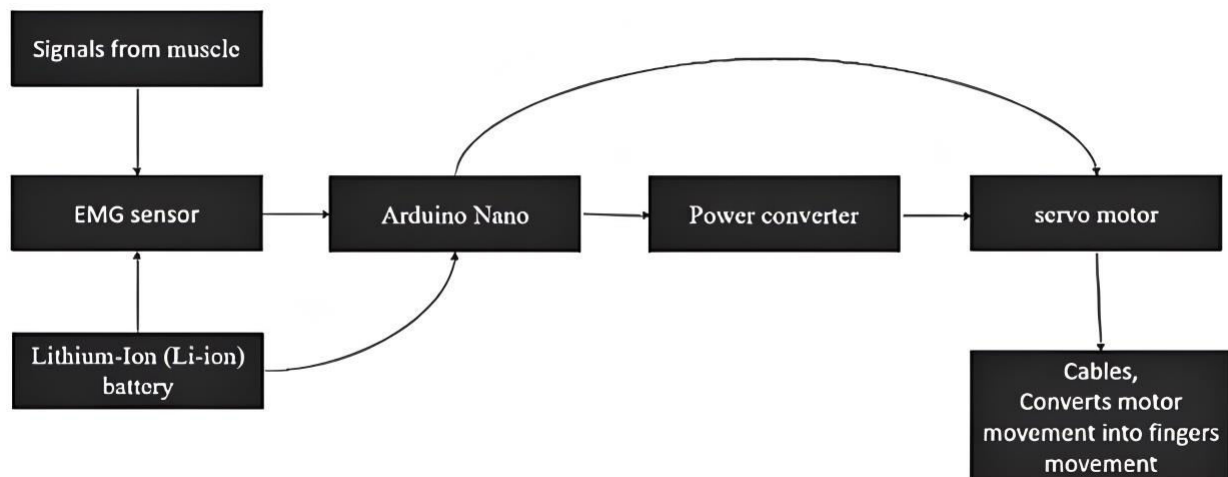


Fig : Block diagram representing working principle.

The prosthetic hand system operates by interpreting electrical signals generated by muscle contractions and converting them into controlled finger movements using a servo motor mechanism. Here's a step-by-step breakdown,

##### Muscle Signal Detection (Input)

- The user contracts specific muscles in the residual limb (e.g., forearm).
- These contractions produce low-voltage bioelectric signals.

##### EMG Sensor Processing

- The EMG (Electromyography) sensor detects these muscle signals.
- It amplifies and filters the signals to remove noise, producing a clean analog voltage proportional to muscle activity.

##### Arduino Nano Signal Interpretation

- The analog signal from the EMG sensor is sent to the Arduino Nano microcontroller.
- The Arduino processes the signal using predefined thresholds or algorithms.
- Depending on signal strength or pattern, it decides the required movement (e.g., open/close hand, flex fingers).

#### Power Supply and Conversion

- A rechargeable Lithium-Ion (Li-ion) battery powers the entire system.
- The power converter steps up or regulates the voltage to levels suitable for the servo motor and microcontroller (e.g., 5V or 6V).

#### Actuation via Servo Motor

- Based on Arduino output, the servo motor is actuated with a specific pulse-width modulation (PWM) signal.
- The motor shaft rotates to a defined angle.

#### Mechanical Transmission to Fingers

- The servo motor is mechanically connected to prosthetic fingers through cables.
- As the motor turns, the cables pull or release, mimicking natural finger movement (e.g., grasping or releasing an object).

#### Total Expenditure:

The breakdown of the total expenditure for the robotic arm project is as follows:

Table 3.6.1: Total expenditure.

Substances	Cost (in Rs)
Sensor	1800
Material	900
3D printing	2800
Hard ware (Servo motor, Arduino, battery, connecting wires, power converter)	2500
Other expenses	500
Total cost	8500

### V. CONCLUSIONS

The following points summarize the capabilities of the proposed prosthetic arm system.

- The project integrates 3D printing and EMG sensor technology to create a functional robotic arm for individuals with disabilities.
- EMG sensors allow intuitive control by translating muscle signals into arm movements.
- ABS material ensures the arm is lightweight, durable, and cost-effective.
- The design is customizable, supporting personalized prosthetic development.
- While it does not fully replicate the complexity of natural arm motion, it forms a strong base for future improvements in control and functionality.

### REFERENCES

1. Shaikh, M. I., et al. (2022). "3D Printing of Prosthetic Hands: Recent Advances, Challenges, and Future Directions." Materials.
2. Vinciguerra, G., et al. (2021). "Lightweight Design and Manufacturing of a Prosthetic Hand via 3D Printing and Flexible Materials." Journal of Manufacturing Processes.
3. Huang, H., et al. (2020). "Recent Advances in Electromyography Sensing and Human-Computer Interfaces for Prosthetic Control." Sensors.
4. Kim, J., et al. (2022). "EMG-Driven Robotic Prosthetic Hand with Real-Time Adaptive Grasp Control." IEEE Transactions on Industrial Electronics.

5. Xu, Z., et al. (2019). "Pattern Recognition for Myoelectric Control Based on High-Density Surface EMG: A Review." Journal of Neural Engineering.
6. Farrell, T. R., et al. (2022). "Transfer Learning for Adaptive Control in Myoelectric Prosthetic Systems." IEEE Transactions on Biomedical Engineering.
7. Ajiboye, A. B., et al. (2021). "Restoring Reaching and Grasping Movements Through a Brain-Machine Interface: A Clinical Trial in Tetraplegic Patients." The Lancet Neurology.





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