JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

# BIONIC ARM

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***Abstract:*** The Bionic Arm Project is an innovative attempt aimed at developing advanced prosthetic limbs that replicate the functionality and competence of a human arm. Through cutting-edge technology and engineering, this project seeks to enhance the quality of life for individuals with limb loss, providing them with improved mobility and a greater degree of independence. Prosthetic devices enhance the independence and well-being of countless people around the world. The main characteristic of bionic limbs is that they establish an interface between the biological residuum and an electronic device, providing not only motor control of prosthesis but also sensitive feedback. This paper explores the advancements in bionic arm technology, focusing on the integration of robotics and neural interfaces to enhance limb functionality.

**Keywords: Bionic, prosthetic, residuum, interface, innovative, integration.**

## I. Introduction

Bionic arm is an electromechanical device that attaches to human body and replicates the functionality and appearance of natural human arm. The bionic arms are advanced prosthetic devices designed to replace or enhance the functionality of a missing or impaired arm.

They use cutting-edge technology like sensors, motors, and microprocessors to mimic the movements of a natural arm. It is designed to help people who have lost their arm or have a disability in their arm to regain some of their mobility and independence. It is like a high-tech robotic arm that can be controlled by the user's muscles or through other methods like sensors or even brain signals.

The primary objective of this project is to design and create a bionic arm that closely mimics the functionality and appearance of a natural human arm. While similar devices are indeed on the market, our goal is to create a more costeffective alternative with relatively simpler components.

## II. Problem Identification

Individuals coping with upper limb amputations encounter diverse challenges spanning functional, emotional, and societal dimensions. The absence of hands significantly impedes functional independence, rendering basic activities like eating and dressing arduous and necessitating assistance.

The main problem with traditional prosthetic arms is their limited functionality and lack of natural movement. The problems with the already available bionic arm are:

- Cost of Development: Developing advanced bionic arms can be expensive, limiting accessibility for those who need them but cannot afford them.
- Natural Movement: Achieving natural and fluid movement in a bionic arm is a complex engineering challenge.
- Customization: Mass-produced bionic arms may not fit individual users' needs and preferences, necessitating better customization options.
- Durability and comfort are also the areas that can be improved upon. Overall, there is still room for advancements in terms of functionality and user experience.

## III. Existing System

The existing systems for bionic arms vary depending on the specific technology used. Some bionic arms use surface electromyography (EMG) sensors that detect muscle activity in the residual limb, allowing the user to control the arm's movements. Others may utilize pattern recognition algorithms to interpret muscle signals and translate them into specific actions. There are also bionic arms that can be controlled through nerve interfaces or even brain-computer interfaces.

Well, while bionic arms have come a long way, there are still some drawbacks to consider. One common challenge is the cost, as bionic arms can be quite expensive, making them less accessible to everyone who could benefit from them. Additionally, the weight and size of some bionic arms can be cumbersome, making them less comfortable to wear for extended periods. Battery life is another consideration, as some bionic arms require frequent charging. Finally, fine motor control and sensory feedback can still be limited compared to a natural arm.

## IV. Literature Survey

• Steffi Thomas, Rutu Kalhapure, Atharva Joshi, Deepraj Bhosale, Deepali Sonawane [1] proposed "Bionic ARM for Prosthetist" (2020). It is a comprehensive comparative analysis of different technologies and advancements in the field of prosthetic arm.

• Farhan Fuad Rupom, Shafaitul Jannat, Farjana Ferdousi Tamanna [2] proposed a paper on "EMG Controlled Bionic Robotic Arm using Artificial Intelligence and Machine Learning" (2020). Real data is collected through EMG signal. After receiving commands, corresponding gestures are performed. It is very precise as well as affordable system for most of the amputees which can make their life easier.

• Michael D. Paskett, Mark R. Brinton, Taylor C. Hansen, Christopher C. Duncan [3] developed a system in which a user could train the bionic arm to grasp objects of varying shapes and sizes. Once trained, the latching filter can lock the arm in the grip position until the user decides to release it, making it easier to hold objects securely. This combination could enhance the precision and functionality of the prosthesis, making it more effective for tasks like grasping, holding, and manipulating objects.

• Sahla Yoosuf Husain Ahmed [4] proposed a system "Bionic Hand" (2020). It is an externally powered prosthesis often controlled by myoelectric signals, meaning it uses muscle signals in the patient's residual limb to move the device. The user feels like an actual hand is touching the object, it feels real. Prolonged use of these devices can lead to muscle fatigue, potentially affecting the device's functionality.

• Valentina A. Yurova, Gleb Velikoborets, Andrei Vladyk [5] proposed "Design and Implementation of an Anthropomorphic Robotic Arm Prosthesis" (2021). In this paper, the robotic arm was developed in conjunction with a glove that will detect small movements in the user's hand to control the prosthesis as a manipulator.

• Marko Bumbaširević, Aleksandar Lesic, Tomislav Palibrk, Darko Milovanovic [6] provided a survey "The current state of bionic limbs from the surgeon's viewpoint" (2022). Surgeons can use this knowledge to counsel patients' needs, this knowledge can be used for further research and innovation. But these are Complex surgical procedures, expensive, technical challenges.

## V. Proposed System

Presented below is the project's block diagram, providing a comprehensive overview of the seamless integration among various project domains. The microcontroller, acting as the project's central hub, receives and interprets signals to govern appendage movement. Simultaneously, it transmits signals generated by the pressure sensor to the amputee, enabling the user to perceive feedback upon contact with an object or surface. This component stands out as one of the project's pivotal elements.

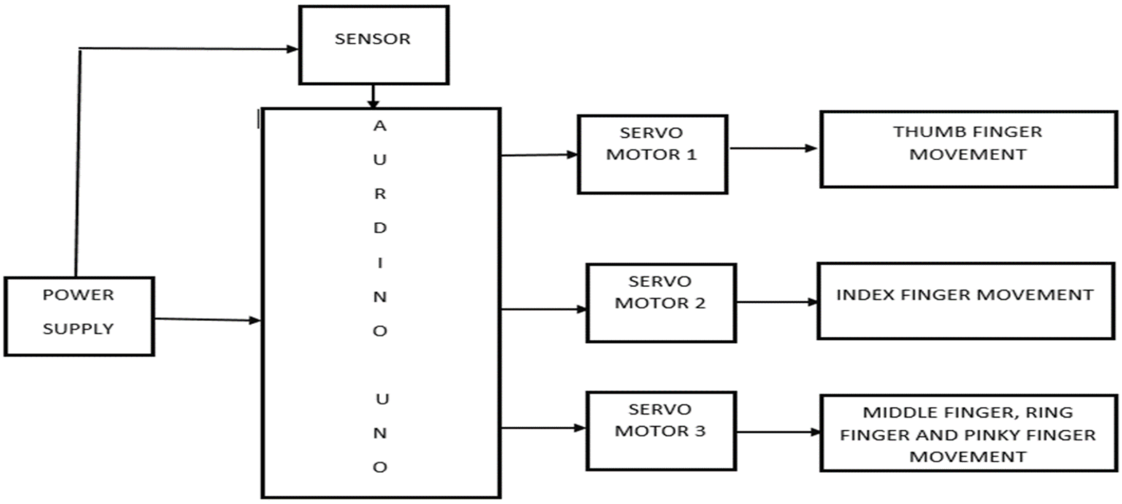
The battery serves as the power source for all prosthetic arm components. The battery protection circuit plays a crucial role in preventing overcharging, protecting against power surges, and providing indications of charging status or low battery levels. The flexible PCB/EMG pads are responsible for capturing signals from the amputee's muscles, specifically detecting firing neurons. Amplifying these signals through the EMG amplifier facilitates the microcontroller in its analysis. Utilized for sending an electrical pulse back to the skin, the 'TENS' unit acts as feedback to the user, contributing to a more immersive and responsive user experience with the prosthetic arm.

TASK DECOMPOSITION:

- Mechanical area:
  - 3D Prototype of Hand - Collaborate with biomechanical experts to design and develop a 3D prototype of the prosthetic hand for initial testing.
- Electrical area:
  - Motherboard Design - Develop the electrical motherboard to host and manage all electronic components of the prosthetic hand.
  - Power Delivery System - Design and implement an efficient power delivery system to optimize energy usage and enhance battery life.
  - Flexible PCB Design - Develop flexible printed circuit boards (PCBs) for the prosthetic hand, ensuring adaptability and ease of integration.
  - Touch Sensors Integration - Integrate touch sensors into the prosthetic hand, enabling responsive interactions and feedback for the user.
  - EMG Reader/Amplifier Integration - Implement an EMG reader/amplifier system for detecting and interpreting muscle signals, enhancing control capabilities.
- Software area:
  - Signal Processing - Develop signal processing algorithms to interpret data from touch sensors and EMG reader, enabling precise control.
  - Touch Feedback Calculation - Implement algorithms for touch feedback calculations, enhancing the user's awareness and control over the prosthetic hand.
  - Calibration Software - Develop calibration software to fine-tune and customize the prosthetic hand's responsiveness based on individual user needs.

## VI. METHODOLOGY

Below is the block diagram of the Bionic Arm which provides comprehensive understanding of the working of the project:




This project aims to deploy a deep neural network on the micro-controller for real-time bionic arm control. We use a 2D Convolutional Neural Network (CNN) as our EMG pattern recognition algorithm, which has been fine-tuned and compressed before deploying to microcontroller. Our EMG data collection is based on Myo Armband.

This project has 4 major parts:

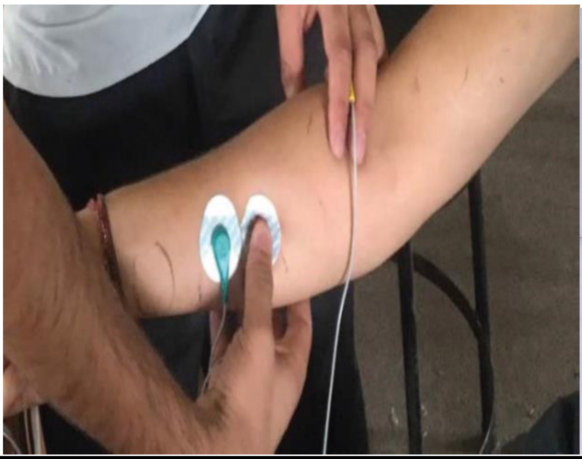
- EMG signals collection
- Preprocessing Offline CNN model training
- Finetuning On-device CNN model deployment
- Inference Real-time bionic arm control

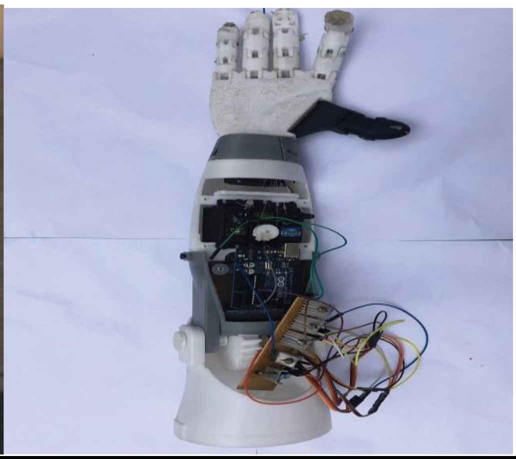
## VII. WORKING

A bionic arm controlled by muscle sensors operates through a process known as electromyography (EMG). EMG involves detecting the electrical activity generated by muscle cells when they contract.

Here is a simplified breakdown of how it works:

1. **Muscle Sensors**: These sensors are placed on the user's residual limb, typically where muscles still exist and can generate electrical signals.
2. **Electrodes**: These sensors consist of electrodes that detect the electrical signals produced by muscle contractions.
3. **Signal Processing**: The electrical signals picked up by the electrodes are amplified and processed by a control unit.
4. **Pattern Recognition**: Advanced algorithms analyse the patterns of muscle activity to determine the user's intended movements. This could involve recognizing specific muscle activation patterns corresponding to different hand or arm movements.
5. **Bionic Arm Control**: The processed signals are then used to control the bionic arm's motors or actuators, enabling the user to perform various tasks by simply thinking about them or making specific muscle movements.
6. **Feedback Loop**: Some advanced bionic arms also provide sensory feedback to the user, allowing them to perceive sensations such as pressure, temperature, or texture through the prosthesis.





## VIII. Future Scope

The future scope of bionic arms is incredibly promising. Researchers and engineers are working on developing more lightweight and compact designs that are more comfortable for users to wear.

They are also focusing on improving the dexterity and precision of bionic arms, allowing users to perform delicate tasks with greater ease. Additionally, advancements in sensory feedback technology aim to provide users with a more natural and intuitive experience. There's also ongoing research into integrating bionic arms with the user's nervous system for even more seamless control. With continued innovation and advancements, the future of bionic arms looks bright.

## IX. Conclusion

In conclusion, bionic arms are incredible pieces of technology that have the potential to greatly improve the lives of individuals with limb loss or impairment. While there are still some limitations and challenges to overcome, ongoing research and advancements are paving the way for more accessible, comfortable, and functional bionic arms in the future. With continued advancements, we can expect more accessible, comfortable, and functional bionic arms in the future. The potential for enhancing mobility, independence, and overall well-being is truly exciting.

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