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EMG Controlled Bionic Arm

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Abstract: *Advanced prosthetic hand development faces the challenge of replicating the human hand's complexity, particularly in achieving intuitive, multi-degree-of-freedom control via EMG signals. To address this, a novel approach focuses on leveraging the deterministic structure of initial muscle contractions, using feature extraction and artificial neural networks for enhanced pattern classification. This method aims to increase controllable functions without added user effort. Simultaneously, improvements in energy efficiency, weight reduction, and miniaturization are pursued through low-power microcontrollers, optimized motor control, lightweight materials, and efficient power supplies. The overarching goal is to create prosthetic hands that offer increased functionality, reduced user burden, and a more natural control experience, bridging the gap between current technology and the capabilities of the biological hand.*

Keywords: prosthetic hand development

I. INTRODUCTION

The motto of new era in medical sciences is *"Repair it if you can. Replace it if you can't"*. The myoelectric arm works under the influence of Electromyography signals extracted from skin surface. These Electromyographic signals are utilized to run various motors which enable the user (patient) to grip and move limbs in a much more effective manner.

A. Electromyography - EMG

Electromyography (EMG) is a medical technique for measuring muscle response to nervous stimulation. EMG is performed using an instrument called an electromyograph, to produce a record called an electromyogram. An electromyograph detects the electrical potential generated by muscle cells when these cells contract.

B. Phantom Limb

P Patients who have lost limb still "Feel" its presence. Due to this whenever the person wants to realize an action using the lost limb (he feels he still has), electric impulses are passed on to the nerve endings from brain. Therefore, myoelectric signals are still being produced which can be tapped into.

With present technology, it is impractical to assume that any of the standard hand's parameters and output requirements may be replicated in a handmade unit. The human hand can be a fine instrument in many respects. This represents the various degrees of freedom and can work in an interconnected way. With existing technologies, it is impractical to assume that any of the standard hand's parameters and output requirements may be replicated in a handmade unit. With these perfect parameters, consensus can be made and a practical prosthetic hand can be built. The main aim of this section is to examine the natural hand's functional capacity and evaluate the most common grasping patterns of the hand from an unlimited range of patterns.

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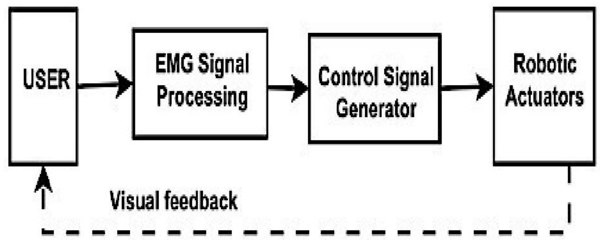
BLOCK REPRESENTATION

I.



Standard Control Method for Myoelectric Arm

II. METHODOLOGY

Start: The process begins with the user intending to move the robotic hand.

Electrode Placement and Acquisition of EMG Signals from Muscles:

- Surface electrodes are placed on the user's forearm muscles.
- When the user contracts their muscles, the electrodes detect the electrical signals (EMG signals) produced.
- These signals are then acquired and sent to the next stage..

EMG Processing:

- The raw EMG signals are often noisy and need to be processed to extract meaningful information.
- This step involves filtering, amplifying, and sometimes rectifying the signals to make them easier to analyze.

Feature Extraction:

- In this stage, relevant features are extracted from the processed EMG signals.
- Features might include the amplitude, frequency, or specific patterns of the signals.
- These features will be used to classify the user's intended movements.

Motion Classification:

- The extracted features are fed into a classifier, which is typically a machine learning algorithm.
- The classifier identifies the specific motion the user intended based on the patterns in the EMG signals.
- This step translates the user's muscle signals into commands for the robotic hand.

Control Command:

- Based on the motion classification, the system generates control commands.
- These commands are signals that will instruct the robotic hand to perform the desired movement.

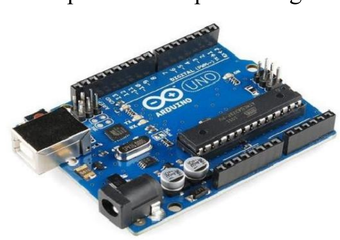
Robotic Hand Activation:

- The control commands are sent to the robotic hand's actuators (motors).
- The actuators convert these electrical signals into mechanical motion, causing the hand to move.

End: The robotic hand performs the intended movement, completing the process.

III. HARDWARE REQUIREMENTS

01. Arduino UNO: The microcontroller board responsible for processing sensor data and controlling other components.



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02.EMG sensor: Captures electrical signals generated by muscle movements. Detects muscle activation and outputs a signal that the Arduino can process. These sensors usually have electrodes that attach to the skin.

03.Servo Motors (for Arm Movement): Purpose: Actuators that control the movement of the bionic arm's joints (e.g., fingers, wrist, elbow). Common Choices: SG90 (for smaller models), MG996R, or larger servos depending on the required torque. Functionality: Each motor receives PWM signals from the Arduino, allowing for control of movement angles in the arm.

04.Power Supply: Purpose: Provides power to the servos and Arduino. Options: 7.4V LiPo batteries, AA battery packs, or USB power banks. Importance: Servos can require significant current, so a separate power supply for servos is recommended to avoid overloading the Arduino.

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05.Wires and Connectors: Purpose: Used to connect the EMG sensor, servo motors, and Arduino. Options: Jumper wires, breadboard, or soldered connections for more stable setups.

IV. SOFTWARE TOOL

The following software tools and libraries are required for the development and operation of the SafeDrive system:

Arduino IDE:

- Purpose: The primary software for programming the Arduino UNO. It provides an integrated development environment to write, compile, and upload the code to the microcontroller.
- Link: Arduino IDE

Arduino Libraries:

- Purpose: Libraries are used to interface with the hardware components like the eye blink sensor, relays, and buzzer. These libraries simplify the coding process by providing predefined functions for hardware control. Some commonly used libraries are:
- Servo Library: For controlling servo motors (if applicable in the project).
- Relay Module Library (if using a specialized relay module): To control relays easily.

Sensor Libraries:

- Purpose: If the eye blink sensor is based on a specific type of sensor (e.g., infrared sensor, camera-based module, or any specialized blink sensor), corresponding sensor libraries will be needed to process the data and detect blink patterns. Examples include:
- Ada fruit Sensor Library (for certain sensors).
- TCS3200 or similar library (if using a color sensor or optical sensor for detecting eye blinks).

Serial Monitor (Arduino IDE Tool):

- Purpose: Used for debugging the system by displaying real-time sensor readings and system status messages during development.

V. ADVANTAGES

- **Improved functionality**: The bionic arm can be controlled with more precision and dexterity than traditional prosthetics, allowing for a wider range of movements and tasks.
- **Increased independence**: The user may be able to perform everyday tasks more easily, leading to greater independence and quality of life. This can include tasks such as dressing, eating, and bathing..
- **Enhanced sensory feedback**: The bionic arm can provide sensory feedback to the user, such as touch and pressure, making it feel more natural and intuitive to control.
- **Reduced phantom limb pain**: Some users may experience a reduction in phantom limb pain, a common problem for amputees. The bionic arm can help to provide a sense of proprioception, which is the awareness of the position and movement of one's body. This can help to reduce phantom limb pain.
- **Improved quality of life**: The bionic arm can help to improve the user's overall quality of life by increasing their independence, functionality, and self-esteem.

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VI. DISADVANTAGES

- High cost: The bionic arm may be more expensive than traditional prosthetics. This is due to the complex technology involved in the device.
- Technical complexity: The bionic arm is a complex device that requires specialized training to use and maintain. This can be a barrier for some users
- Limited availability: The bionic arm may not be readily available in all areas. This is due to the limited number of manufacturers and distributors of the device.
- Potential for malfunction: Like any electronic device, the bionic arm could malfunction or break down. This could leave the user without a functioning prosthetic.
- Cosmetic concerns: Some users may be self-conscious about wearing a bionic arm, as it may look different from a natural limb. However, advances in 3D printing have made it possible to create bionic arms that are more cosmetically appealing

VII. FUTURE SCOPE

- **Advanced Control Algorithms**: Implementing machine learning and AI to enable more intuitive and adaptive control of the prosthetic arm, allowing it to learn and respond to the user's unique patterns and intentions.
- **Enhanced Sensory Feedback**: Integrating advanced sensors to provide the user with a sense of touch, temperature, and proprioception, making the prosthetic arm feel more like a natural limb
- **Miniaturization and Power Efficiency**: Developing smaller, lighter, and more energy-efficient components to improve the comfort and wearability of the prosthetic arm, while also extending its battery life.
- **Biocompatible Materials**: Exploring the use of biocompatible materials to create a more seamless and natural interface between the prosthetic arm and the user's body, reducing the risk of rejection and improving comfort.
- **Customization and Personalization**: Utilizing 3D printing and other advanced manufacturing techniques to create highly customized prosthetic arms that are tailored to the individual user's anatomy, needs, and preferences..
- **Expanding Functionality**: Developing specialized attachments and tools that can be easily integrated with the prosthetic arm, allowing users to perform a wider range of tasks and activities, such as playing musical instruments, participating in sports, or engaging in specific hobbies
- **Improved Aesthetics**: Focusing on the design and aesthetics of the prosthetic arm to make it look and feel more like a natural limb, reducing the stigma associated with prosthetics and improving the user's self-confidence.
- **Accessibility and Affordability**: Working to make EMG-controlled bionic arms more accessible and affordable for people in developing countries and underserved communities, ensuring that this life-changing technology is available to those who need it most.

VIII. CONCLUSION

Technical Achievements

- Successful development of a functional bionic arm controlled by EMG signals.
- Effective implementation of signal processing algorithms to translate muscle signals into precise arm movements.
- Design and integration of a robust control system enabling a variety of grip patterns and movements.
- 3D printing can be a cost-effective method for producing customized prosthetics.
- The project successfully demonstrates the feasibility of using EMG signals to control a bionic arm.
- This technology has the potential to significantly improve the lives of amputees by restoring lost functionality and independence.
- The results of this project can be used to further research and develop even more advanced and intuitive bionic prosthetics.

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Clinical and User-Centric Impact

- The bionic arm has the potential to significantly improve the quality of life for amputees.
- User testing demonstrates the arm's functionality and ease of control.
- The project highlights the importance of user-centered design in developing effective prosthetics.
- Further research should focus on long-term reliability, durability, and comfort.
- Future work should explore incorporating sensory feedback to enhance the user experience.
- The project contributes to the growing field of myoelectric prosthetics and its potential to transform assistive technology.

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