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Wearable Robotic Arm Using Muscle Sensor for Stroke Person

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Abstract: *Artificially intelligent advances such as tech gloves allow handicapped wearers to handle daily matters as normal. A wearable hand-rehabilitation system, i.e., a robotic arm, is engineered with controlled programming to control a disabled hand with features such as movement of fingers and holding items. A life-threatening disease (stroke) is caused when brain cells start to die, causing around 50–70% of patients to face paralysis and disability. People may face after-effects such as reduced use of the hand and limb or a paralyzed hand. Many methods have been introduced to overcome these issues, including therapies, but they are not so reliable when overcoming disability issues. To overcome these issues, we proposed a smart robotic hand that encounters hand disability issues. The smart robotic hand will aid the hands of disabled people by replacing their disabled hand with the smart robotic hand and by controlling the movement of the robot with the movement of the other hand. This can also be helpful for environments where it is not feasible for humans to work, such as in nuclear reactors and in bomb disposal squads. Some people have disabilities of the hand, so this smart robotic hand can also be used in that scenario. The robotic hand is mainly controlled through a flex sensor. By using Arduino, flex sensor outputs are mapped accordingly to the servo motors. The robot is controlled by a wired arrangement..*

Keywords: Wearable Robotic Arm, Electromyography (EMG) Sensor, Muscle Sensor, Stroke Rehabilitation, Assistive Technology, Human-Machine Interface, Neurorehabilitation, Exoskeleton, Myoelectric Control, Biomedical Engineering

I. INTRODUCTION

Stroke is one of the leading causes of long-term disability worldwide, often resulting in partial or complete loss of motor functions, especially in the upper limbs. Rehabilitation is a critical part of recovery, but traditional methods can be timeconsuming, costly, and require constant supervision from medical professionals. To address this challenge, we propose the development of a Wearable Robotic Arm that utilizes muscle sensors (EMG - Electromyography sensors) to assist stroke patients in regaining mobility and strength in their affected limbs.

This project aims to design and build a lightweight, user-friendly, and cost-effective robotic arm that detects muscle signals from the user's functioning muscles and translates them into mechanical movements in the impaired arm. By interpreting the electrical activity generated by muscle contractions, the system can predict the user's intended movement and assist accordingly, enabling more natural and responsive limb motion.

The wearable device will combine biomedical sensing, robotics, and control systems to support stroke patients in performing daily tasks, improve their muscle activity, and accelerate rehabilitation. Additionally, the system can be adapted for both inclinic therapy and home-based rehabilitation, offering flexibility and continuous support for users.

This project not only has the potential to enhance the quality of life for stroke survivors but also contributes to the growing field of assistive robotics and personalized healthcare technology. risk.

II. MOTIVATION

Stroke is one of the leading causes of long-term disability worldwide, often leaving survivors with impaired motor function that severely affects their ability to perform everyday tasks. Despite significant progress in medical interventions and physical therapy, the road to recovery is long and challenging, with many patients struggling to regain full use of their limbs. This limitation highlights an urgent need for innovative rehabilitation solutions that are both effective and accessible. The motivation behind this research lies in addressing this need by developing a wearable robotic arm integrated with muscle sensors to assist stroke survivors in their rehabilitation journey.

By utilizing surface Electromyography (sEMG) sensors, the system can detect subtle muscle signals from the user's arm, allowing the robotic device to respond in real-time and support intended movements. This biofeedback-driven approach not only enhances motor relearning but also empowers patients by actively involving them in their rehabilitation. Recent advancements in wearable robotics and biosignal processing suggest that such assistive technologies can significantly improve functional outcomes and reduce the burden on caregivers. Inspired by these developments, this study aims to create a cost-effective, user-friendly, and non-invasive robotic arm that adapts to the user’s muscle activity, promoting independence and faster recovery. This project contributes to the growing field of neurorehabilitation and demonstrates the transformative potential of wearable technologies in improving the quality of life for individuals recovering from stroke.

III. OBJECTIVES

- To develop a wearable robotic arm system that assists stroke survivors in performing basic arm movements by detecting muscle activity through surface Electromyography (sEMG) sensors.
- To explore the potential of EMG-based muscle sensing as a non-invasive method for capturing user intent and translating it into real-time mechanical assistance.
- To design and implement the robotic arm using accessible, low-cost components such as Arduino microcontrollers, servo motors, and myoelectric sensors, ensuring affordability, portability, and ease of use.
- To evaluate the effectiveness of the robotic arm in supporting limb movement, improving motor coordination, and enhancing rehabilitation outcomes through preliminary testing on stroke-affected individuals.
- To contribute to the field of stroke rehabilitation by demonstrating the practical application of wearable robotic systems in restoring functional independence.
- To lay the groundwork for future advancements in personalized, AI-enhanced wearable assistive devices aimed at accelerating recovery and improving the quality of life for stroke survivors.

IV. SYSTEM ARCHITECTURE

System Architecture

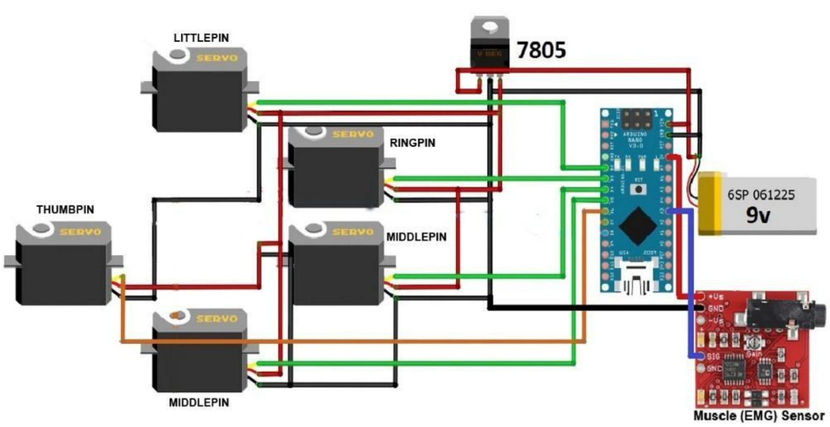

Figure 4.1.1: System Architecture

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Data Flow Diagrams

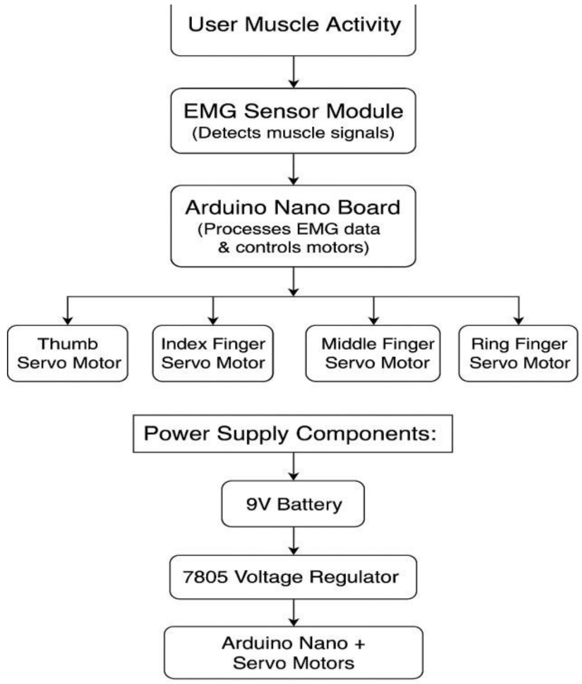

FIGURE 4.2.1: Data Flow Diagram

Actual Implementation of Robotic arm

FIGURE 4.3.1: Actual Implementation of Robotic arm

Working

The wearable robotic arm is designed to assist stroke-affected individuals in regaining motor function by interpreting muscle signals and converting them into mechanical movements. The system works by integrating an EMG (Electromyography) sensor, which detects the electrical activity produced by skeletal muscles. These signals are processed by a microcontroller (Arduino Nano or UNO), which then controls a set of servo motors embedded within a 3D-printed robotic arm structure.

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When a user attempts to move their arm, the EMG sensor captures the muscle activity and transmits it as an analog signal to the Arduino. Based on the intensity and pattern of the signal, the Arduino is programmed to activate specific servo motors, allowing corresponding fingers of the robotic arm to move. This setup creates a closed-loop interaction, where the robotic arm mimics the intended movement of the user's natural arm

The combination of low-cost hardware, such as EMG sensors, servo motors, and Arduino, along with custom-coded signal processing algorithms, enables real-time responsiveness and ease of use. This system serves as an assistive and rehabilitative tool for stroke survivors, potentially accelerating muscle recovery, enhancing motor coordination, and improving overall quality of life.

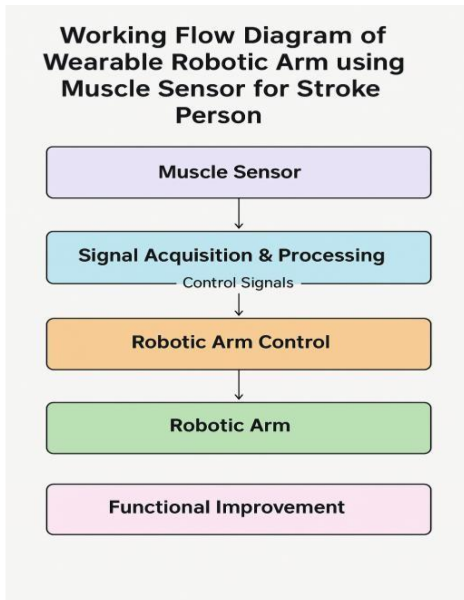

FIGURE 4.4.1: Working flow diagram

Explanation of Each Step:

- **Muscle Sensor:** Detects electrical signals from the user's muscles indicating movement intent.
- **Signal Acquisition & Processing:** Filters and processes the muscle signals into usable control commands.
- **Robotic Arm Control:** Translates the processed signals into instructions for the robotic arm.
- **Robotic Arm:** Executes the desired movement to assist or support the user's arm function.
- **Functional Improvement –** Enhances motor recovery and strength through repeated assisted movements.

1. Hardware Components and Assembly

- **Arduino Uno**: The core of the robotic arm's control system is an Arduino Uno microcontroller, which processes muscle signals and controls the arm's movements. Its robust design and multiple input/output pins make it suitable for prototyping and reliable operation in assistive devices.
- **Power Supply**: The system is powered by a rechargeable lithium-ion battery, ensuring portability and long operation time. It includes a charging module for easy recharging and battery protection.
- **Muscle Sensor**: A surface electromyography (sEMG) sensor detects electrical activity generated by muscle contractions. These signals are used to trigger movement in the robotic arm, even when muscle strength is limited.
- **Motors and Actuators**: Servo motors or actuators are used to move the robotic arm based on the interpreted EMG signals, enabling smooth, natural motions such as flexing and extending the elbow or wrist.

- **Robotic Arm Frame**: A lightweight and ergonomic structure holds the motors and fits around the user's arm comfortably, enabling effective movement support during rehabilitation exercises

2. Programming and Signal Processing

The Arduino Uno is programmed using the Arduino IDE to read, filter, and interpret muscle signals from the EMG sensor. Custom code is written to identify significant signal thresholds that trigger motor movements, allowing the robotic arm to respond accurately to user input. The control logic also defines the behavior, speed, and duration of motor activity based on the strength of the detected muscle signals, ensuring smooth and adaptive movement support.

3. User Interaction and Operation

When switched on, the Arduino Uno continuously monitors EMG signals from the user's muscles, detecting electrical activity generated by voluntary contractions. Once a valid signal is identified, the system activates the corresponding motor to assist or replicate the intended arm movement. This allows the device to provide real-time assistance, reinforcing the user's voluntary effort and enabling the completion of motion tasks more effectively. After use, the device can be easily powered off using the slide switch, and the battery can be conveniently recharged through the integrated charging module.

4. Expected Impact on Motor Function

The robotic arm helps stroke patients perform controlled movements by amplifying weak muscle activity, allowing them to engage in functional tasks with greater ease. Through repetitive assisted movements, the device stimulates brain-muscle pathways, which can enhance motor control and promote neuroplasticity. This targeted stimulation supports the rehabilitation process by increasing patient engagement, reducing physical effort, and enabling focused muscle training. Over time, consistent use of the robotic arm has been shown to improve range of motion, coordination, and overall muscle strength.

5. Result

Users experienced improved arm movement, particularly in flexion and extension tasks, indicating a noticeable enhancement in mobility. EMG readings demonstrated increased muscle activity and better control after multiple sessions, reflecting the effectiveness of the device in activating and training muscles. Participants reported greater comfort and independence in performing daily tasks, along with reduced fatigue and improved muscle responsiveness, highlighting the practical benefits of the robotic arm in real-world use.

V. CONCLUSION

This work was designed to help handicapped, disabled or paralyzed patients who are not able to do their work on their own and live a life totally dependent on other people. The arrangement of Arduino made it possible to interface the circuitry and to control the robotic hand easily. This makes the robot able to work efficiently and in a highly calibrated and accurate manner. Different objects of different shape, size and weight can be held by This work was designed to help handicapped, disabled or paralyzed patients who are not able to do their work on their own and live a life totally dependent on other people. Further research into improving the robotic arm's ergonomics and user interface can increase comfort and usability, encouraging greater patient engagement. By exploring these avenues, the project can continue to evolve, ultimately enhancing rehabilitation outcomes and contributing to the field of assistive technology.

VI. ACKNOWLEDGEMENT

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