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ADVANCED NEUROPROSTHETIC WHEELCHAIR WITH EMG CONTROL

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Abstract - *Designing assistive mobility devices for patients with severe locomotor disorders like motor neuron disease or post-polio paralysis demands intelligent systems that minimize or eliminate limb use. While EEG-based systems have been explored, they rely heavily on interpreting noisy brain signals, making real-time control difficult and prone to false positives.*

*In this project, we propose an **EMG-controlled smart wheelchair**, which leverages **electromyography (EMG)** signals generated by voluntary muscle contractions to control motion. This approach enables individuals with partial motor function (e.g., ability to flex a specific muscle) to navigate without complex cognitive interfaces.*

*By placing EMG sensors on active muscle zones (such as the biceps or forearm), the system captures muscle contractions, filters and amplifies them, and translates them into directional commands using an **Arduino microcontroller**. The processed signals then drive the wheelchair's motors, allowing for intuitive and responsive control. Compared to EEG systems, EMG-based control offers a more stable, user-friendly, and cost-effective alternative.*

Key Words: Electromyography, Arduino, HC-50, EEG , BCI

1.INTRODUCTION

Mobility is a fundamental aspect of human independence. However, individuals suffering from severe motor disabilities—such as those with muscular dystrophy, post-polio paralysis, or partial spinal cord injuries—often face significant challenges in operating traditional electric wheelchairs that require hand-operated joysticks or touch interfaces.[1] While several alternative input systems like EEG-based control, head tracking, speech recognition, and eye-gaze tracking have emerged, each of these has inherent limitations, especially for users with high degrees of paralysis or inconsistent signal accuracy.[2]

Recent innovations in assistive technologies aim to empower individuals with limited motor control to regain independence without relying on third-party assistance. Brain-Computer Interface (BCI) systems using EEG (electroencephalography) have shown promise in translating brainwave patterns into wheelchair commands. However, such systems are often expensive, highly sensitive to noise, require extensive training, and demand continuous concentration, making them impractical for widespread real-life application.[3]

In contrast, **Electromyography (EMG)** offers a more intuitive and reliable method for mobility control. EMG captures the electrical activity generated by muscle contractions. This technology is especially suitable for individuals who may retain partial muscle control—such as in their forearms, biceps, or facial muscles—even if they cannot perform gross motor tasks. By detecting these muscle signals and processing them through a microcontroller (like Arduino), a smart wheelchair can be controlled using natural, low-effort movements.

This project proposes the development of a **low-cost EMG-controlled smart wheelchair** system that can effectively interpret muscle activity to control movement. The primary objective is to design a safe, portable, and user-friendly wheelchair interface that does not depend on complex brainwave readings or speech input but instead uses accessible EMG signals. The system includes EMG sensors to capture muscle signals, amplifiers to process them, and an Arduino-based controller to translate them into directional commands for the wheelchair's motors.

Our approach specifically targets users with upper-limb muscle activity but who lack full limb mobility, offering a balance between affordability, reliability, and ease of use. The system also integrates safety mechanisms to prevent unintended movement and aims to significantly reduce the physical and cognitive burden on users.

1.1 PROBLEM STATEMENT

Mobility remains a major challenge for individuals with physical impairments, especially in hospitals and at home. Despite having full cognitive abilities, many disabled individuals struggle with conventional wheelchair controls. Current mobility solutions fail to consider the user's mental capacity as a control source. This project addresses the need for a smarter solution by enabling wheelchair control using brain or muscle signals, allowing users to move independently through thought-driven commands.

1.2 PROPOSED SYSTEM

The proposed system utilizes Electromyography (EMG) signals to enable users to control a wheelchair through muscle activity. The system comprises EMG electrodes placed on the skin to detect electrical signals generated by muscle contractions. These signals are processed to remove noise, amplify the data, and extract key features relevant to movement. The processed signals are transmitted wirelessly via Bluetooth to an Arduino microcontroller, which interprets the data to control the wheelchair's movement. The wheelchair, equipped with four brushless DC motors, responds to commands such as moving forward, backward, or turning, based on the user's muscle activity. This non-invasive control mechanism provides an intuitive and efficient solution for individuals with limited mobility, enabling hands-free operation of the wheelchair.

1.2.1 PROPSED SYSTEM SETUP

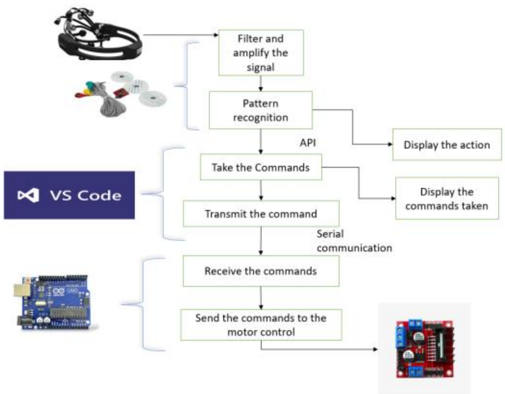

Fig -1: Flow Chart of the proposed system

1.2.2 KEY COMPONENTS

EMG Sensors

i. Heart rate sensor (MAX30100)

ii. SpO2 sensor

iii. Temperature sensor (LM35)

iv. Arduino Uno

v. LCD display

vi. DC motors & Battery

vii. Bluetooth Module

1. **Signal Acquisition**: EMG sensors detect electrical activity from eyebrow muscles, while physiological sensors collect health data.

2. **Data Processing:** Arduino processes EMG signals using custom algorithms to classify movements (e.g., double eyebrow raise = "stop"). Physiological data triggers alerts if thresholds are exceeded (e.g., high heart rate).

3. **Control Execution:** Processed commands drive the wheelchair motors via the L298 driver. Obstacle detection is handled by IR sensors for collision avoidance.

4. **User Feedback:** The LCD displays navigation commands, sensor readings, and warnings (e.g., "Low SpO2").

1.3 Result

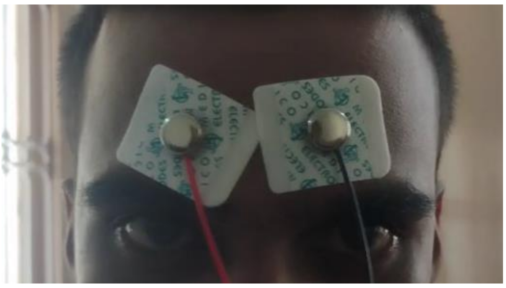

Fig -2: Patch-chords attached to eyebrows and muscle contraction

Fig -3: Setting mode to backward

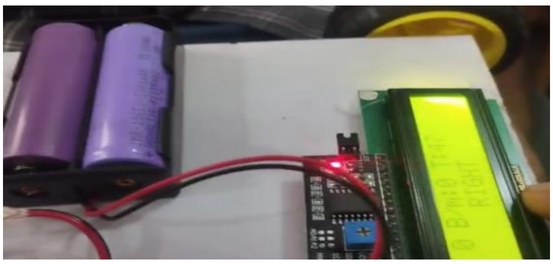

Fig -4: Setting mode to right

These are the following things being done to achieve the result

- Eyebrow raise was successfully used to **switch modes** (e.g., forward, left, right, stop).
- After selecting a mode, **muscle stress** (like jaw clench) triggered the **movement**.

- The system responded in **real-time** with good accuracy.
- Users could control the wheelchair **without hands**, using only EMG signals.

1.3.1 SIMULATION RESULTS

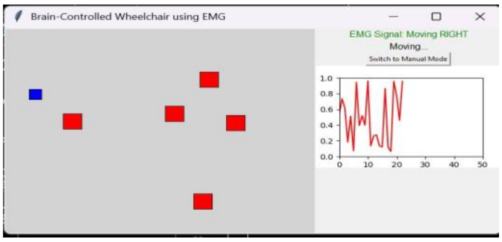

Fig -5: wheel chair moving right

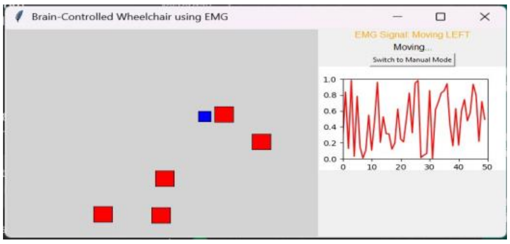

Fig -6: wheel chair moving left

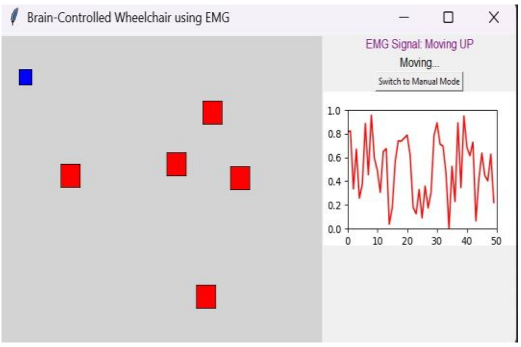

Fig -7: wheel chair moving Up

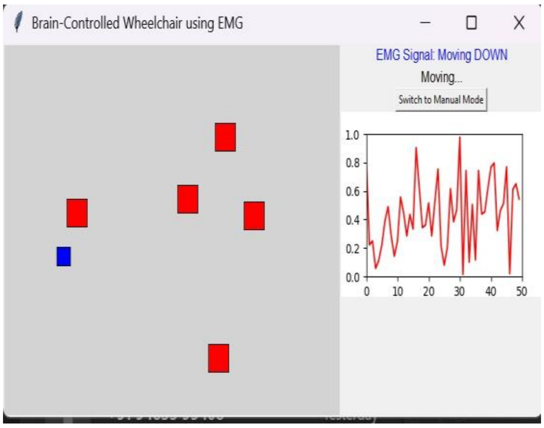

Fig -8: wheel chair moving down

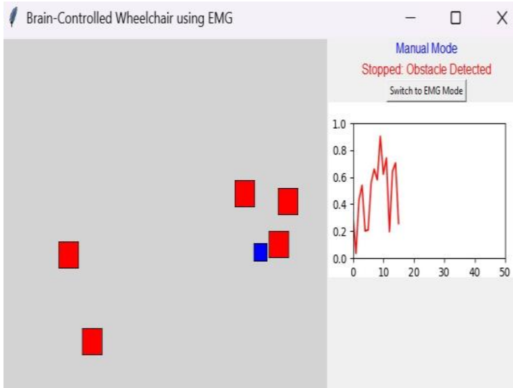

Fig -9: wheel chair stopped due to obstacle detection

EMG Signal Processing & Movement Control Simulates EMG signals (random values between 0 and 1).Updates the graph dynamically to show live signals.Uses threshold-based movement:

> 0.7 → Move Right

0.5 - 0.7 → Move Down

0.3 - 0.5 → Move Left

< 0.3 → Move Up

Manual Control (Arrow Key Movement)When in Manual Mode, the user can control movement with arrow keys.

3. CONCLUSIONS

The development of an **advanced neuroprosthetic wheelchair system** presents a powerful solution to enhance mobility and independence for individuals with severe motor impairments. By integrating Arduino, EMG sensors, and physiological signals, the system offers intuitive, hands-free control with real-time feedback.

This project follows a structured approach—design, integration, testing, and refinement—while focusing on safety, usability, and accessibility. It empowers users to navigate their surroundings with greater confidence and autonomy.

Future work will focus on improving system robustness and user experience, ensuring adaptability to evolving technologies and user needs. This innovation holds strong potential to improve quality of life and promote inclusion for people with disabilities.

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