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Mechatronic System Design for the Disabled Using Man-Machine Interface (MMI)

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ABSTRACT: Man-Machine Interface (MMI) has emerged as a significant research area aimed at improving the quality of life for differently-abled individuals. This paper presents the design and development of a mechatronic system that enables disabled users to control assistive devices using Electrooculography (EOG) signals generated through eye blinks. Traditional assistive technologies often lack affordability, usability, and real-time performance in practical environments.

The proposed system utilizes a single-channel EOG-based interface to detect voluntary eye blinks and convert them into control commands. A threshold-based algorithm is implemented for signal processing and command generation. The system is further integrated with a motorized wheelchair, enabling users to navigate independently without the need for muscular movement.

Experimental results demonstrate that the system provides reliable performance with improved accuracy, faster response time, and user-friendly operation. The proposed system offers a cost-effective, robust, and practical solution for assisting disabled and elderly individuals, thereby enhancing independence and mobility.

KEYWORDS: Mechatronics, assistive technology, man-machine interface, human-computer interaction, rehabilitation engineering, adaptive devices, sensor integration, control systems, accessibility, smart assistive systems

I. INTRODUCTION

Disability significantly impacts an individual's ability to perform daily activities, leading to dependency, reduced mobility, and limited participation in society. Globally, millions of people suffer from physical impairments due to aging, accidents, or neurological disorders such as ALS and paralysis.

Traditional assistive technologies often rely on manual control mechanisms, which are not suitable for individuals with severe disabilities. Man-Machine

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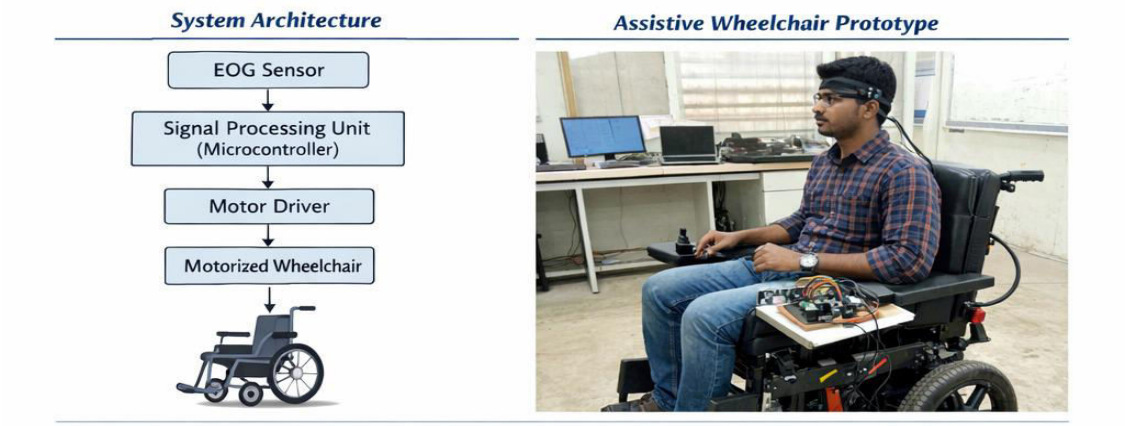

Interface (MMI) systems provide an alternative communication pathway by translating biological signals into control commands.This project focuses on developing a low-cost, user-friendly MMI system based on Electrooculography (EOG). By utilizing eye-blink signals, the system enables users to control assistive devices such as a wheelchair, thereby improving independence and quality of life.

II. SYSTEM ANALYSIS AND PROBLEM IDENTIFICATION

2.1 Existing Systems
Existing assistive systems include:
- EEG-based interfaces
- EMG-based control systems
- Multi-channel EOG systems

Limitations
- High cost and complexity
- Requirement of multiple sensors
- Need for extensive user training
- Dependence on GUI-based control
- Low portability and usability

2.2 Need for Proposed System
- Provide independence to disabled users
- Reduce system complexity and cost
- Enable real-time control
- Improve usability and comfort
- Eliminate dependency on muscular movement

2.3 EOG as a Control Signal

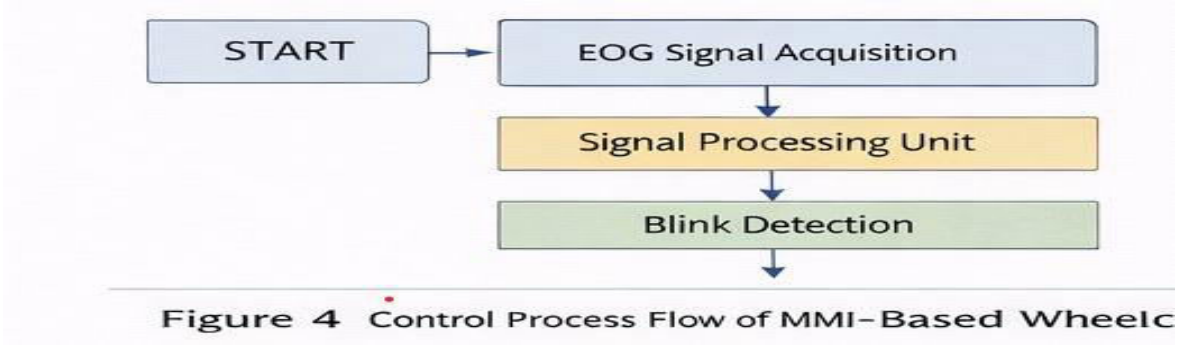

Figure 4 Control Process Flow of MMI-Based Wheelc

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EOG signals are generated due to eye movements and have the following advantages:

- High signal amplitude
- Easy detection and processing
- No need for surgical procedures
- Suitable for paralyzed patients

III. PROPOSED SYSTEM AND METHODOLOGY

3.1 System Overview

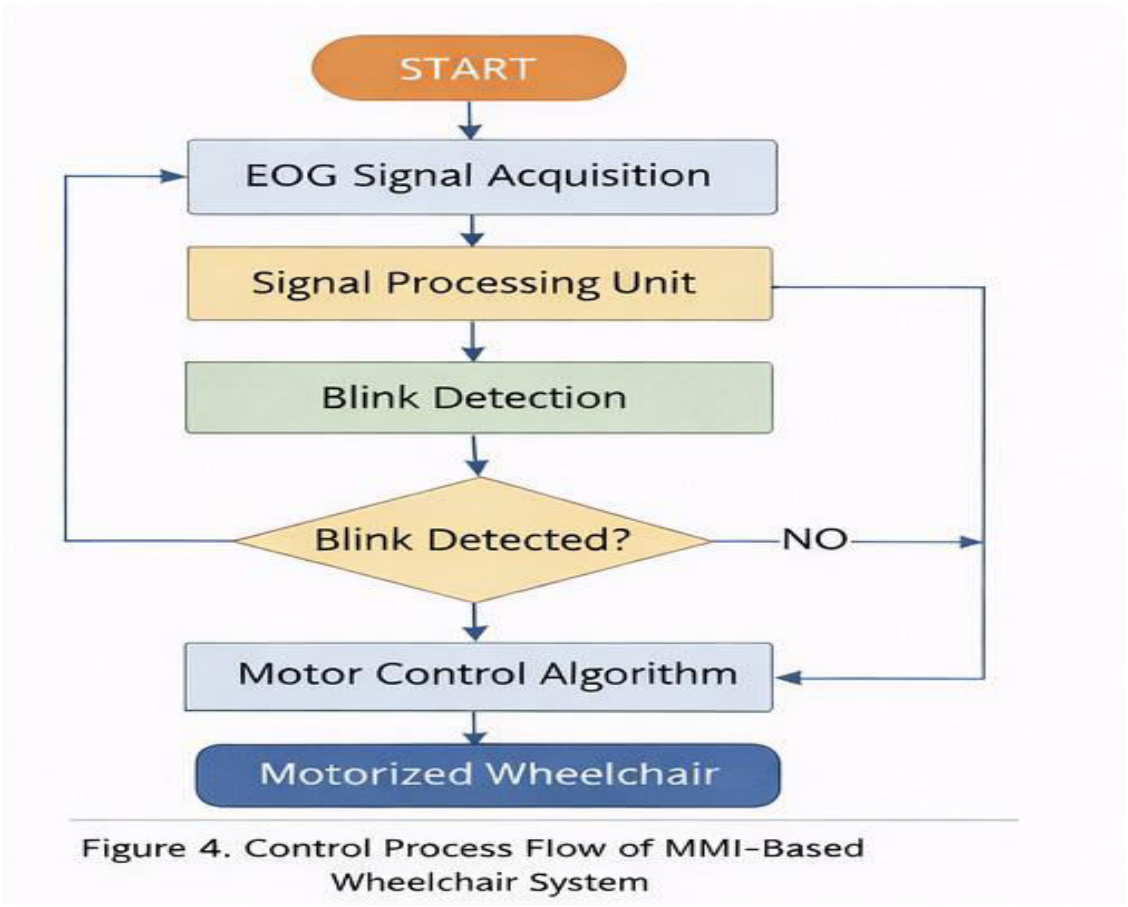

Figure 4. Control Process Flow of MMI-Based Wheelchair System

The proposed system consists of:

- EOG Sensor (single-channel)
- Signal acquisition unit
- Microcontroller
- Motor driver
- Motorized wheelchair

3.2 Working Principle

- Eye blink generates EOG signal
- Sensor captures electrical signal
- Signal is processed using threshold algorithm
- Control commands are generated
- Wheelchair movement is controlled accordingly

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3.3 Hardware Components

The system includes a single-channel EOG sensor for detecting eye-blink signals, which reduces complexity compared to multi-channel systems. A microcontroller is used to process the acquired signals and generate control commands. A motor driver circuit controls the motors of the wheelchair based on these commands. The entire system is powered by a regulated power supply to ensure stable operation

Figure 3. Main Components of the Hardware Setup

3.4 Signal Processing and Control Strategy

A threshold-based algorithm is used to detect different types of eye blinks such as:

- Single blink
- Double blink
- Triple blink

Each blink pattern corresponds to a specific control command such as forward, left, right, and stop. This approach ensures faster response and eliminates the need for graphical interfaces.

IV. EXPERIMENTAL SETUP AND RESULTS

The system was implemented and tested under various conditions to evaluate performance.

4.1 Testing Conditions

- Normal eye blink detection
- Continuous usage scenarios

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- Navigation testing using wheelchair

4.2 Observations
- Accurate detection of voluntary blinks
- Stable signal acquisition using single-channel sensor
- Smooth wheelchair navigation
- Reduced response time compared to traditional systems

4.3 Results
The system achieved:
- High accuracy in blink detection
- Improved Information Transfer Rate (ITR)
- Reliable real-time performance
- Enhanced user comfort and usability

V. CONCLUSION AND FUTURE SCOPE

The developed MMI-based assistive system successfully enables disabled individuals to control a wheelchair using eye-blink signals. The system is cost-effective, easy to use, and provides real-time response with high accuracy.

It eliminates the need for complex multi-channel systems and GUI-based interfaces, making it practical for real-world applications.

Future Scope
- Integration with IoT for remote monitoring
- Implementation of AI/ML for advanced signal classification
- Wireless communication for improved flexibility
- Expansion to control multiple smart devices
- Enhancement of safety features for navigation

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