EEG & EMG Controlled Driving Aid for Electric Wheelchairs: Review

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ABSTRACT

The Brain-computer interface (BCI) is anengaging field which could find applications in numerous fields like industrial, biomedical and engineering. In this paper a BCI based electric wheelchair driving aid design that utilizes mental concentration (EEG signals) and eye blinks (EMG signals) of the user, is presented. The design is a review paper, incorporates a safety controller with peripheral safety sensors that override the user command and stop the wheelchair when it detects an obstacle in its path and it incorporates voice calling facility using Bluetooth communication. The wheelchair driving aid utilizes BCI headset and electronics.

Keywords -**Brain-computer interface (BCI), Bluetooth communication, Electric wheelchair,Safety controller, Voice calling**

I. INTRODUCTION

Control of devices or computer system using human brain signals is a widely-explored area in the field of research. To interact with devices using brain signals, it is necessary to develop the interface between brain and computer. The main purpose of Brain-computer interface (BCI) in the field of bioengineering is to provide the easiest communication channel for people with physical disability. The communication channel can be established by analyzing the brain activity (EEG signals) and facial expressions (EMG signals) with the support of biosensors. Facial expressions can be eye blinks or forehead muscular movements. The brain signals vary from person to person, and picking up small changes and details in a specific brain signal such as the EEG or EMG is a major challenge as they are often contaminated with external noise and other unwanted brain signals. A highly efficient, computationally intensive algorithm is required to synthesize a dependable outcome in the form of control signals.

In this paper, a BCI based electric wheelchair aid which that utilizes mental concentration (EEG signals) and eye blinks (EMG signals) of the user is presented. The design incorporates a safety controller with peripheral safety sensors that override the user command and stop the wheelchair when it detects an obstacle in its path and also it incorporates voice calling facility using Bluetooth communication.

II. RELATED WORK

Thousands of people around the world suffer from mobility disorders like neuromuscular disorders, spinal cord injuries, etc. They usually rely on power wheelchairs for activities of daily living [1]. However, many of them are able to control the wheelchair using the conventionalcontrols such as joysticks due to their physical incapability [1].

In the past, several wheelchair aid designs with alternate interfaces that utilize EMG signals (muscle movements), EEG signals (mental thoughts), and EOG signals (eye lids and eye balls movements) have been presented. In [2], biosensor is used to capture EEG/EMG signals which is then processed by the Think-Gear module in Matlab. In [3], EEG signal captured by multiple electrodes of the Emotive headset are utilized. The analysis of acquired signals is then performed using Support Vector Machine (SVM) and neural networks. The design presented in [4] proposed that the features extracted from the EOG traces can be used to determine whether the eyes are open or closed, and whether the eyes are gazing to the right, center, or left. A smart wheelchair control is implemented by utilizing an android application and Bluetooth protocol communication in [5], [6] and [7].

In general, the wheelchair that operates using different input tools like gesture and voice [8] can be efficiently used only by people with minor disabilities. However, the wheelchair aid design for individuals who have lost movement in their limbs and face muscles as the result of spinal cord injuries and neuro muscular diseases such as ALS, PLS, etc., must rely primarily on brain signals such as EEG, EMG, EOG, etc.

III. PROPOSED METHODOLOGY

A. Brain Computer Interface (BCI)

The design utilizes a commercially BCI headset (Neurosky) that captures the brain signals using integrated biosensors [Fig. 1]. Neurosky BCI headset is a Bluetooth enabled headset, dry, bio-sensor which detects faint brainwave signals (EEG & EMG) safely and passively [9]. The signals acquired from the headset are then analyzed and processed using a customized algorithm in android OS. The android application provides the direct command to control the motion and direction of the electric wheelchair as shown in Fig 2a and 2b.

B. Control System

The android application receives the attention-waves

Figure 2a: Wheelchair driving aid

(EEG) and eye-blinking signals (EMG) from the Neurosky headset biosensors via Bluetooth communication. These received signals are then processed within the android application using an

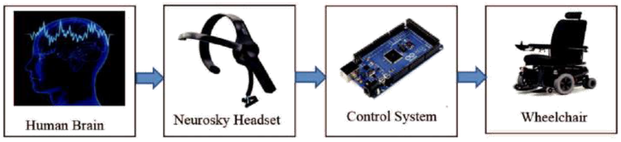


Fig. 1. Brain Controlled Interface for Electric Wheelchairs

Figure.3: Safety sensors

algorithm and are then sent to the control system via Bluetooth module. The control system consists of Arduino microcontroller and Bluetooth module. Command signals received by the Arduino microcontroller controls the wheelchair motion and directions.

C. Safety Sensor Controller and Sensors

One more key aspect of a smart wheelchair [10] [11] is a user's safety. These features are designed to keep the user safe and decrease the collision risk of the wheelchair. The on-board ultrasonic sensors continuously scan and measure the proximity to objects in the environment. This will provide the sense of security and reliability due to the collision avoidance functionality. There could be potential situations where the machine misreads the user's gestures. It could be that the user is not very familiar with the system and makes an incorrect gesture. A wrong command from the user interaction could harm the user and persons nearby due to unwanted navigation of the wheelchair. To safeguard against such dangerous situations, a collision avoidance system that utilizes ultrasonic sensors to measure the distance from oncoming obstacle, was incorporated.

The control system collects the sensor data and processes it to provide the stop command based on the distance to the obstacle. This is an overriding feature and the chair will stop even if the user commands it to go forward. The sensors detect obstacles in all directions and will stop the wheelchair from collisions. The control system utilizes this safety controller, which continuously monitors the inputs from safety sensors, which are mounted on all four sides of the wheelchair. As shown in (Fig. 3), a total of five sensors areattached to the wheelchair (two on the front, one each on rear, left and right side of the wheelchair).

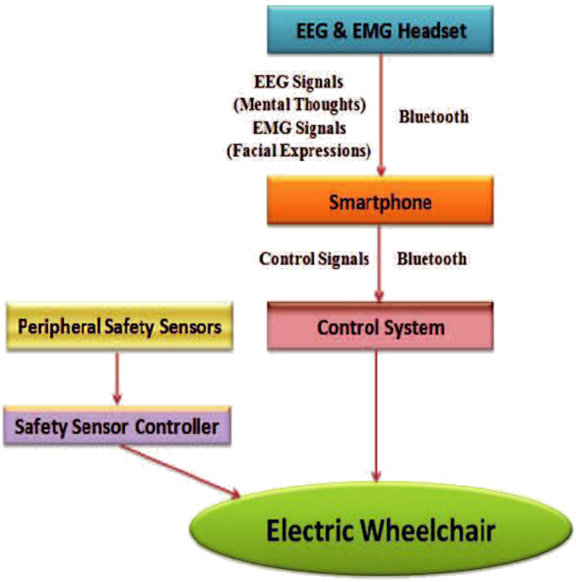
D. Electric Powered Wheelchair

An Arduino microcontroller is connected to the Omni device of the wheelchair that allows for alternate drive controls. This interface is required for any input device other than a standard joystick. The wheelchair driving aid utilizes BCI headset and electronics and it incorporates voice calling facility using Bluetooth communication.

IV. DESIGN FLOW

The design flow of Brain-Controlled Driving Aid for Electric Wheelchairs is shown in (Fig. 4). In order to move the wheelchair, the user would have to concentrate and focus. To change the direction of the wheelchair movement, the user must perform two consecutive blinks. The direction of the wheelchair movement changes as follows: forward, stop, right, stop, forward, stop, reverse, stop, forward, stop, left, stop, and repeats. The stop function is implemented between each movement in order for the user to be able to correctly orient themselves before returning to regular movement. Recording and interpretation of the electro- encephalographic (EEG) signals without dependence mechanical devices. The use of natural interfaces for people with disabilities is a novel application, because with these and with the use of robotic prostheses, the user can perform natural movements executed before losing his limb.

Figure 4: Design Flow



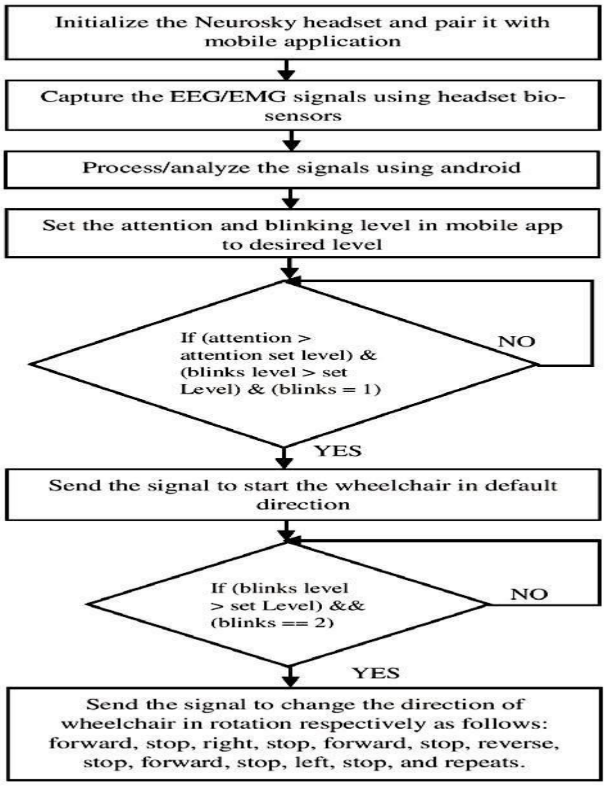
The forward function has also been placed between each other orientation since forward movement is the most common direction of travel when operating a powered wheelchair. The sensitivity thresholds for the movement and directional changes can be customized using the smartphone app.

V. SYSTEM ALGORITHM

The design flow and command decision based on the brain wave signal classification is shown in (Fig. 5). Steps for signal processing and system algorithm:

1.Initialize the Neurosky headset and pair it with the android mobile application.
2.Capture the EEG/EMG signals using headset bio-sensors.
3.Process and analyze the signals in android algorithmic logic.
4.Set the attention and blinking level in mobile app to desired level.
5.If (user attention > attention set level) & (user blinks level > set level) & (number of blinks = = 1) Then the signal command has been sent to initiate the wheelchair in default direction (Forward) Else wheelchair will act as per its last status.
6.If (blinks level > set Level) && (blinks = = 2) Then, the direction of the wheelchair movement respectively changes as follows: forward, stop, right, stop, forward, stop, reverse, stop, forward,
stop, left, stop, and repeats

Fig. 5 System algorithm of mind controlled wheelchair



VI. CONCLUSION

A brain-computer interface based electric wheelchair driving aid that utilizes mental concentration and eye blinks to operate was reviewed. The android application allows user to customize the threshold levels of attention and eye blinking to achieve optimal performance.

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