Non-Invasive Method to control a wheelchair using BCI

Sriram L, Thirukumaran S, Vijayalakshmi G
UGStudent, UGStudent, Assistant Professor
Department of Electronics and Communication Engineering
Prince Shri Venkateshwara Padmavathy Engineering College, Chennai 127.

Abstract

Physically challenged people have certain difficulties from living a natural life. The main advantage or need for designing a smart wheel chair is mobility. There are products catering to disabled people to satisfy and also assist them to overcome the issues they face in moving from one place to another, in various ways. This is achieved by using a neurosky TGAM module and Arduino over Bluetooth communication. The ultimate outcome is to comfort and cater to a larger population of the physically challenged with a simpler, cheaper yet effective alternative. The system available for brain wave signal processing has a headset of single electrode which works on EEG sensors. The output of the system will monitor at meditation mode, eye blinks and attention mode. Sensor transmits a number of signals at different frequency levels and all the signals are not useful. From that extracting and analysis of useful frequency are more difficult. Each person has a different level of emotion, thoughts and feelings based on behavior of people that brain frequency has been varied. The data for emotion and thought can be gathered from the frontal forehead point. The people should have more concentration while operating a smart wheelchair because contraction of muscles and eye blink will produce electrical signals which will affect the results. The use of electroencephalogram based systems that carry with a several number of electrodes which are high pricey models utilized in the hospitals which is such a tough method. The focus of this method will be based on this non-invasive EEG technique.

Key words—BCI based, EEG waveforms, blink waves, TGAM module, neurosky.

---

1. INTRODUCTION

Invasive BCI research has targeted repairing damaged sight and providing new functionality to paralyzed people. Invasive BCIs are implanted directly into the grey matter of the brain during neurosurgery. Using chips implanted against the brain that have hundreds of pins less than the width of a human hair protruding from them and penetrating the cerebral cortex, scientists are able to read the firings of hundreds of neurons in the brain.

The easiest and least invasive method is a set of electrodes this device known as an electroencephalograph (EEG) attached to the scalp. The electrodes can read brain signals regardless of the location of the electrodes, the basic mechanism is the same: The electrodes measure minute differences in the voltage between neurons. The signal is then amplified and filtered. In current BCI systems, it is then interpreted by a computer program, which displays the signals via pens that automatically write out the patterns on a continuous sheet of paper. Even though the skull blocks a lot of the electrical signal, and it distorts what does get through it is more accepted than the other types because of their respective disadvantages.

Electroencephalography (EEG) is the recording of electrical activity along the scalp produced by the firing of neurons within the brain. How BCI works among the possible choices the scalp recorded electroencephalogram (EEG) appears to be an adequate alternative because of its good time resolution and relative simplicity. Furthermore, there is clear evidence that observable changes in EEG result from performing given mental activities.

The rest of the paper is organized as follows. Chapter 2 explains about the different waveforms and their explanation of each wave under the normative EEG activity. Chapter 3 explains the flowchart and working technique of the proposed system. Chapter 4 gives results obtained by using the waves from the electrodes. Chapter 5 contains the conclusion.

2. NORMATIVE EEG ACTIVITY

The millisecond temporal resolution of EEG allows scientists to investigate not only fluctuations of EEG activity (i.e., increases/decreases) as a function of task demand or subject samples but also to differentiate between functional inhibitory and excitatory activities. As a general rule, low frequencies (e.g., delta and theta) show large synchronized amplitudes, whereas EEG frequencies (e.g. beta and gamma) show small amplitude due to high degree of desynchronization in the underlying neuronal activity. In adults, the amplitude of normative EEG oscillations lies between 10 and 100V. In the following section, a brief review of various EEG bands and their putative functional roles will be presented.

Delta oscillations reflect low-frequency activity (less than 4 Hz) typically associated with sleep in healthy humans and neurological pathology. In adults, delta power has been shown to increase in proximity of brain lesions and tumors, during anesthesia, and during sleep. Moreover, inverse relationships between delta activity and glucose metabolism have been reported in both pathological and normal conditions. An inverse relationship between delta current density and glucose metabolism was found within the subgenual prefrontal cortex. Delta is also the predominant activity in infants during the first two years of life. Ontologically, slow delta and theta activity diminish with increasing age, whereas the faster alpha and beta bands increase almost linearly across the life span.

Theta activity refers to EEG activity within the 4-8 Hz range, prominently seen during sleep. During wakefulness, two different types of theta activity have been described in adults. The first shows a widespread scalp distribution and has been linked to decreased alertness (drowsiness) and impaired information processing. The second, the so-called frontal midline theta activity, is characterized by a frontal midline distribution and has been associated with focused attention, mental effort, and effective stimulus processing. Recent studies have implicated the anterior cingulate cortex (ACC) as a potential generator of frontal midline theta activity.

The alpha rhythm refers to EEG activity within the 8-14 Hz range. In healthy adults, alpha activity typically has amplitude between 10 and 45V, and can be easily recorded during states of relaxed wakefulness, although large individual differences in amplitudes are not uncommon. Topographically, alpha rhythms show their greatest amplitude over posterior regions, particularly posterior occipito-temporal and parietal regions, and can best be seen during resting periods in which the subjects has his/her eyes closed.

Traditionally, lower-voltage oscillations within the 14-31 Hz frequency range have been referred to as beta. In adults, beta activity has amplitudes between 10-20V, presents mainly a symmetrical fronto-central distribution, and typically replaces alpha rhythm during cognitive activity. Consistent with this view, beta rhythm has been shown to increase with attention and vigilance, for example. Collectively, these findings suggest that beta increases generally reflect increased excitatory activity, particularly during diffuse arousal and focused attention.

Gamma oscillations have been associated with attention, arousal, object recognition, top-down modulation of sensory processes, and, in some cases, perceptual binding i.e., the brain's ability to integrate various aspects of a stimulus into a coherent whole. Various findings indicate that gamma activity is directly associated with brain activation.

3. WORKING TECHNIQUE

The brain wave signal processing has a headset of single electrodes which works on EEG sensors. The output of the system will monitor at meditation mode, eye blinks and attention mode. Sensor is transmits a number of signals at different frequency levels and all the signals are not useful. The brain can emit more signals at different frequency levels. From that extracting and analysis of useful frequency are more difficult. Each person has a different level of emotion, thoughts and feelings based on behavior of people that brain frequency has been varied. The data for emotion and thought can be gathered from the frontal forehead point. The issue is eye movement and blink will alter the value of the sensor since it is in the forehead. The people have more concentration while operating a smart wheelchair because contraction of muscles and eye blink will produce electrical signals which will affect the results. Initially the Bluetooth module should be connected and initiated so that the raw signal captured using the electrode transmits to the laptop. Now all the raw data is processed in four different stages by filtering the unwanted waveforms, processing the filtered data at acquisition stage then sends the data in the form of digital value to move the wheels of the chair in the direction when the person blinks at the corresponding time.

The headband which includes the single electrode interfaced with the NeuroSky TGAM(Think Gear ASIC Module) which helps to record all the electrical impulse of brain activity like movement of any face expression blink movement of eye, meditation, concentration, attention level. From this the blink waves are detected for the proposed system and the program is given accordingly. After the detection of this signal it is sent to the Bluetooth module Transmitter which is interfaced with the power supply of 3 AAA batteries in the same headband.Two motors of 60rpm each are used to form a wheelchair prototype. The frame is constructed using aluminium sheets. The control signals from the H-bridge circuit are sent to the motors. Depending on the action performed, the control signals will cause the motor to run in either clockwise, anticlockwise direction or stop.

The Laptop/PC acts as a Bluetooth Receiver where all the data is received and processed in MATLAB software using GUI an application model is created over the screen and the cursor moves at specific time intervals over the directions continuously. This cursor will move continuously till a blink is detected. Whenever a blink is detected, immediately the time of blink will be sent to the program and at that time where the cursor will be pre-stored during this process, so the equivalent direction will be prescribed by the program which sends this to Arduino via the Bluetooth in the wheelchair. For every blink made by the person at the particular time what was the direction in the GUI interface will be performed by the program automatically.

The Figure 3.1 shows the block diagram of the proposed system and Figure 3.2 shows the flowchart of the proposed system.

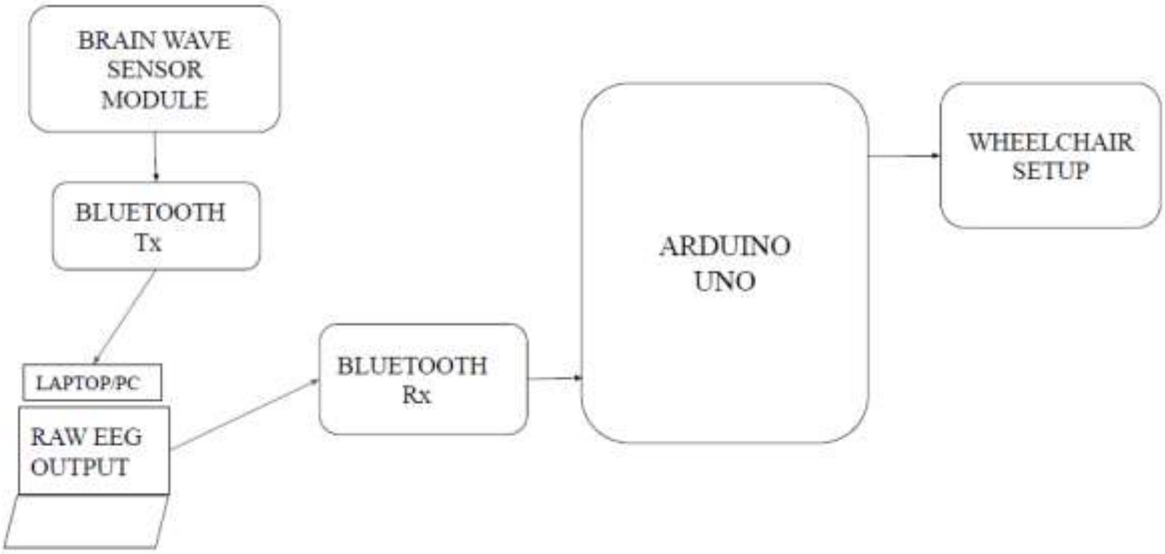

Figure 3.1 Block diagram of Proposed System

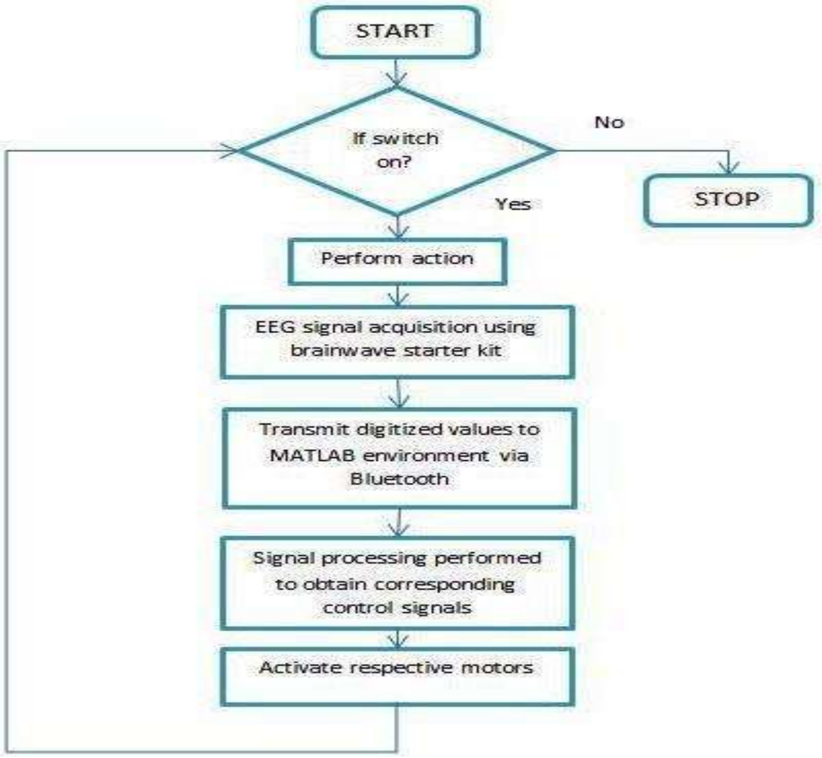

Figure 3.2 Flowchart of the Proposed System

4. RESULTS

The proposed system aims to give navigation by means of reading the EEG waves without any harm to the user who uses it at a minimal cost. So that users who need it can afford it at a nominal price by using this method. Instead of neurosky gadgets this is a simple setup that makes a movement in a single EEG wave which is nothing but the attention and blinking waves. Figure 4.1 shows the ready to capture all blinking EEG raw waves.

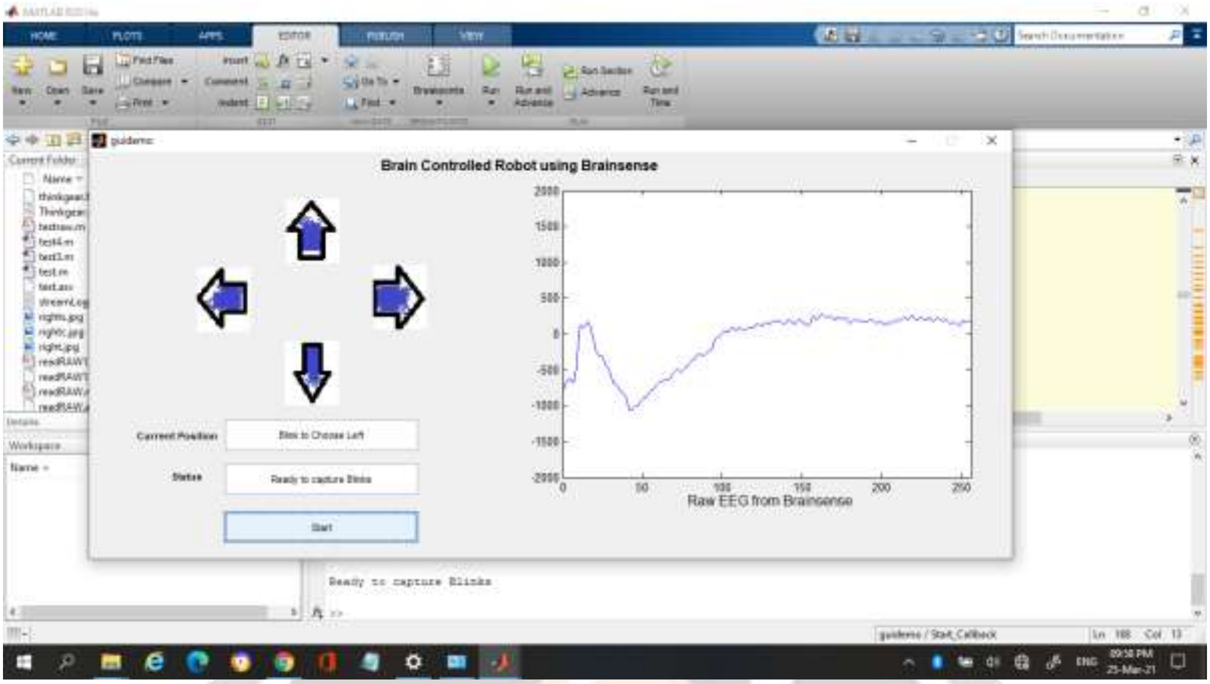

Figure 4.1 All directions are ready to capture stage

The connection of the motor to the wheels are given and the equivalent motor driver relay is also used to control the wheels of the chair in a proper manner and in the correct direction. When the Program is initialized, the Bluetooth of the electrode interfaced headband and the Bluetooth of the Arduino is also connected with the Laptop/PC in the first step. After pairing both the Bluetooth the program is opened. Then the COM PORT of Bluetooth is found from the control panel –Devices and then the properties. When the program is run the each steps are attached one by one with the movement of the corresponding wheels as prescribed in the program. Figure 4.2 shows the blink wave detection and establishment of corresponding direction in wheels.

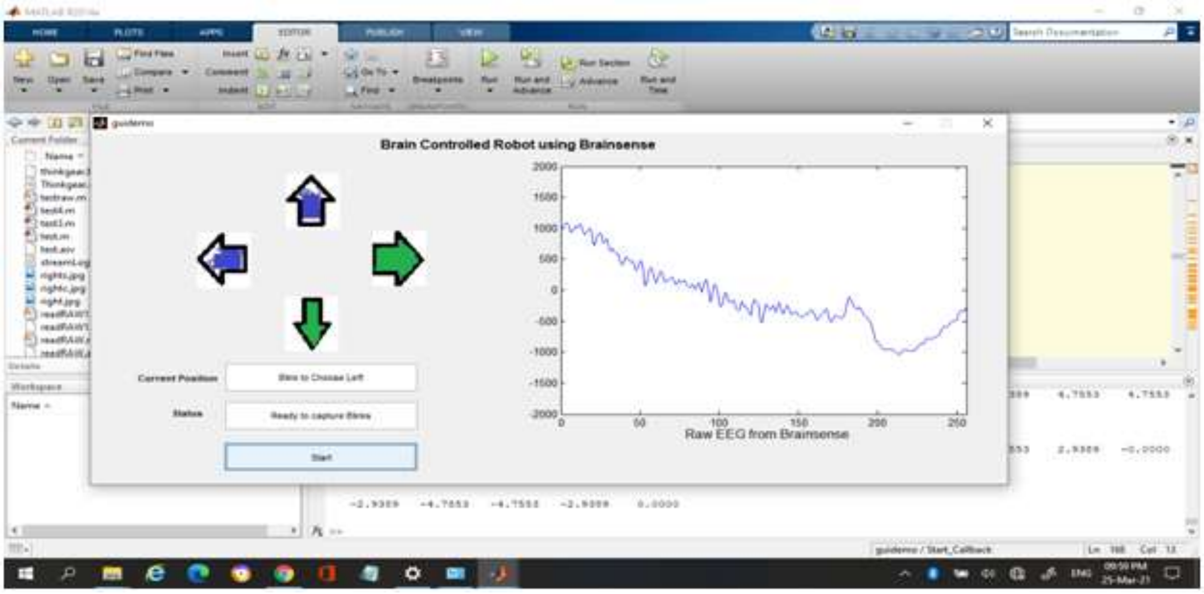

Figure 4.2 Detected and movement established for the corresponding direction

5. CONCLUSION

The proposed system demonstrated the procedures of EEG signal processing in the MATLAB environment without any noise and other waveforms that are noted as disturbances are flattened or nullified. With proper scripting, data can be retrieved from BCI and processed numerically by utilizing modern computing power. Even though we have millions of neurons and brain waves sending out from the brain we can easily take them and compute them with the help of a neurosky module. By this we conclude that movement of the wheelchair in the correct direction is obtained using the blink wave detected with the help of a single electrode. No wrong direction will be performed by the wheel as no predefined values are given. When different subjects performed the same actions, the signal values obtained were within the same range but the delay varied from person to person. It was found that this delay period could be reduced by training the headgear for that person. As it was made of low cost it will be easily accessible by everyone who is in need of that. Accurate control is also obtained from this system. Detecting the raw and movement achieved without maximum delay.

REFERENCES

[1] Abbass H., Guan C., and Tan K., (2016) "Computational Intelligence for Brain Computer Interface", IEEE Computational Intelligence Magazine. Vol.11, No. 1: p. 18.

[2] Li Y., Pan J., Wang F. and Yu Z., (2015) "A Hybrid BCI System Combining P300 and SSVEP and Its Application to Wheelchair Control", In IEEE Transactions on Biomedical Engineering, vol. 60, no.11, pp. 3156–3166.

[3] Mano M., Lécuyer A., BannierE., Perronnet L., Noorzadeh S, and Barillot C, (2017) "How to build a hybrid neurofeed - back platform combining EEG and FMRI" In: Frontiers in Neuroscience 11,p.140.

[4] F. Taher, N. Amor, and M. Jallouli (2015) "A multimodal wheelchair control system based on EEG signals and Eye tracking fusion" International Symposium on Innovations in Intelligent SysTems and Applications (INISTA), IEEE, pp. 1-8.