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Analysis of Brain Computer Interface Based Robot Wheel Chair Control

P.Priyan[1], M.Uma[2], S.Prabhu[3],
[1] PG Student, Robotics, Department of Mechanical engineering, SRM University, Chennai 603 203
[2]Assistant Professor (Sr.G), Department of Software Engineering, SRM University, Chennai 603 203
[3]Professor, Department of Mechanical Engineering, SRM University, Chennai 603 203, India
E-mail: prabhume@yahoo.co.in[3]
[3]Corresponding author

Abstract

Eye blink and concentration are prominent in EEG signal which are recorded by placing electrodes in the frontal region of the brain. This paper presents the development of a robotic wheelchair that can be controlled by the users by map the Eye double blink and concentration from EEG data. MATLAB based flexible graphical user interface with some possible choices such that letters or image are flashes in 3s of time period to the users for choosing their movement to travel. NeuroSky's mind wave mobil ebio-sensor head set is a device with portable EEG sensors is used for reading the brain frequencies in real time. Ultrasonic sensor based obstacle avoiding system provide the safe navigation of the wheelchair and it speed up the control system by disabling unavailable directions. The system is provided with very high accuracy, an easy access of target and the graphical user interface is allow the users to choose commands to be sent to the robotic wheelchair for its actuation and which required only little mental effort to select the destination.

Keywords: Brain Computer Interface, Robot wheel chair, Graphical User Interface

Introduction

BCI is a combination different fields such as of neuroscience, psychology, computer engineering, Human Computer Interaction and Robotics. The people who suffering from neurological diseases can be highly paralyzed and enable of any motor functions but they still have some cognitive abilities. The only way to communicate with their environment is by using their brain activities. There are two type of BCI technique are available invasive and noninvasive methods for monitoring brain activity [3], here considered noninvasive type electroencephalography (EEG) techniques and P300 potential. Electroencephalography (EEG) is the measuring of electrical activity around the scalp. These electrical signals are generated from the current flow between the two neurons. NeuroSky's Mind wave mobile is a device is used to detect neural activities, it also record the electrical activities generated due to the muscles movement called Electromyogram (EMG) and Electrooculogram (EOG) signals related to eye ball movement. The signals generated due to the eye movement are detected from the frontal area of the scalp.

The P300-based online BCI which reaches very competitive performance in terms of information transfer rates. An online optimization method help to improve the information transfer rates and/or accuracies [2]. The performance of the method is evaluated using simulated and real data of P300 responses measured using auditory stimuli. The multichannel approach is shown to give realistic and comparable information about the amplitude differences of the P300 peak between different channels is introduced by Ranta-aho [1]. Classification and detection of the presence of a P300 in the electroencephalogram (EEG) (brain activity), Electroocculogram (EOG) (eye movement) are done by using Neural network is presented by Hubert [4]. Many experimental data's are recorded from the subjects executing a visual P300 speller-like discrimination tasks. The disadvantage of the P300 was low communication speed. Improved the communication speed with keep a good classification accuracy by using Bayesian approach with certain threshold for take adaptive decision about input signal [5,6]. Ioana introduced a statistical Active Appearance Model (AAM) to track and detect eye blinking [7]. The source for EOG signal is cornea-retinal potential (CRP) and is generated due to the movements of eyeballs within the conductive environment of the skull. While recording the EOG signal, it will be contaminated by electromyography (EMG) signal. As the EOG is a non-stationary signal, the multi resolution analysis using wavelet decomposition offers the best solution to de noise and feature extraction of EOG signals [10]. The model had designed to be robust to variations of head pose or gaze. Analyze and determine the model parameters which encode the variations caused by blinking. Machine learning approach to detect eye movements and blinks from EEG data and map them as intents to control external devices like a wheel chair [8].Controlling the direction (left or right) of the electric wheelchair by using a recursive training algorithm to generate recognition patterns from EEG signals [11, 12]. Jinyi developed a cursor control on a monitor screen. To move the cursor to a target on the monitor screen the target selection or rejection functionality is implemented using a hybrid feature from motor imagery and the P300 potential. To select the target of interest, the user must focus his or her attention on a flashing button to evoke the P300 potential [9].

In this paper, brain signals are recorded in real time by using a NeuroSky's Mind wave mobile is a device with portable EEG sensors is used for reading the brain frequencies in real time. Matlab based graphical user interface has been implemented for present letters or images to the user to select their required actuation commands send to the robotic wheelchair. Ultrasonic sensors are used for obstacle avoidance and remove the unavailable movement from the flash queue. In this system improved the speed and accuracy of the wheelchair control and Neural network based classification algorithm are used to differentiate the targets and non-targets. The results show that the NeuroSky's Mind wave mobile preserves the amplitude information of the peaks of the estimated potential remarkably better than other conventional systems.

System Design

The design of the system involves 6 main levels as shown in Fig.1. EEG signal acquisition, preprocessing, feature extraction, classification and environmental feedback and Graphical User Interface (GUI).

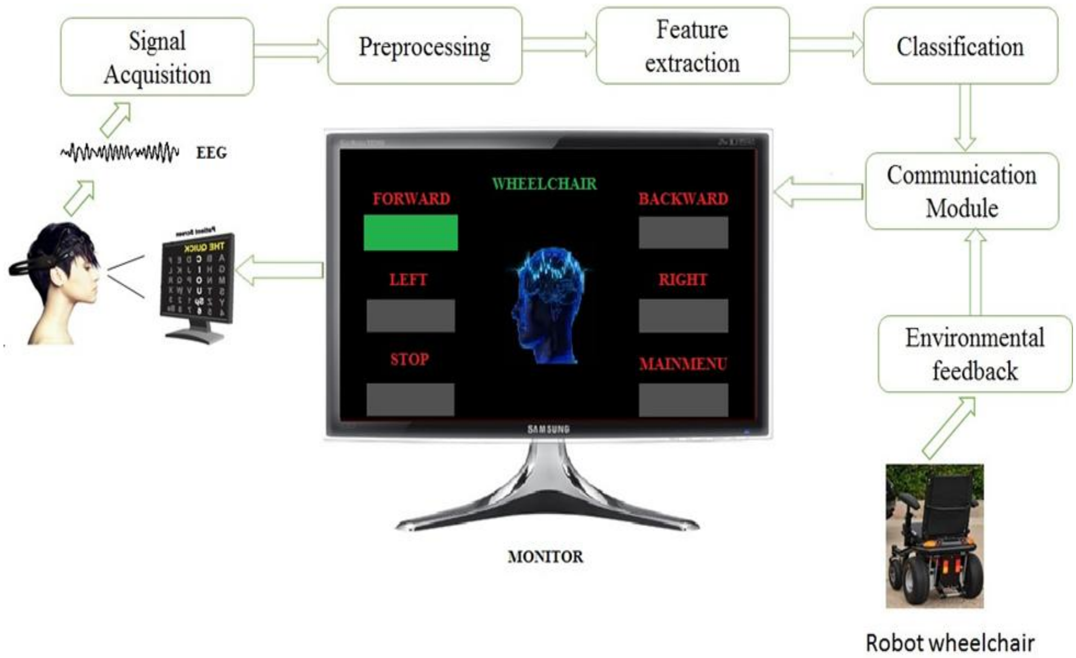

Figure 1: System Architecture

Signal Acquisition and Preprocessing of EEG

NeuroSky's Mind wave mobile bio-sensor headset is a device with portable EEG sensors is used for reading the brain frequencies in real time. The headset is an easy to use, non-invasive single dry sensor that reads brainwave impulses allowing to interact with Apps and it digitizes brainwave signals from the forehead FP1 provides a high degree of freedom; NeuroSky devices can measure multiple mental states simultaneously. Part of NeuroSky's IP involves noise cancellation. Signal amplification makes the raw brainwave signal stronger. Filtering protocols eliminate known noise frequencies such as muscle, pulse and electrical devices. The headset has frequency ranges from 3-100 Hz. All signal ware acquired at a sampling rate 512 Hz as shown in Fig.2. A notch filter is applied at 50-60 Hz to remove interference from supply lines. The acquired EEG signals are transferred wirelessly to PC by using Bluetooth interface.

Mind Rec is the research tool which is used to filter out eye blink signals from the EEG data. Raw EEG signal is allowed to pass through a 6th order Butterworth band pass filter with lower cut-off frequency 0.01Hz and higher cut-off frequency 3Hz with ripple of 1dB as shown in Fig.3.

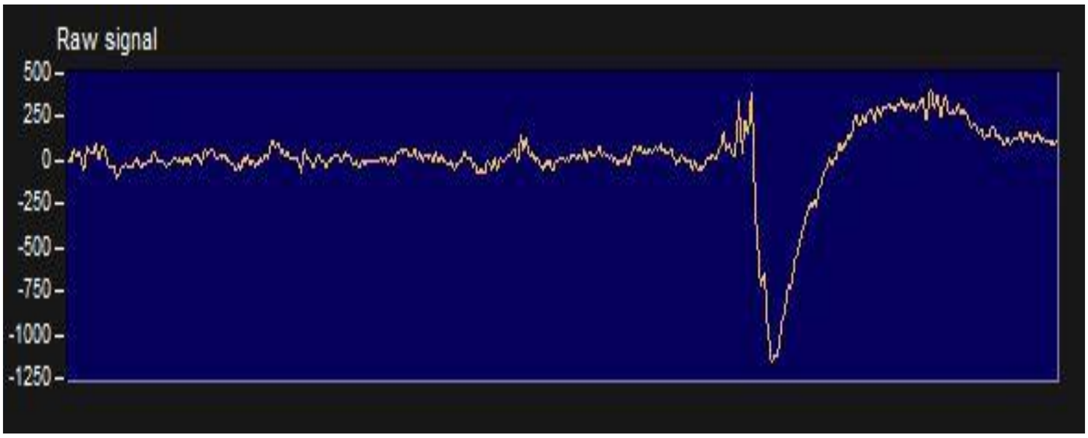

Figure 2: Raw Eeg Signal At Sampling Rate 512hz

Figure 3: Eye Blink Detected After Passed Through Butter Worth Band Pass Filter with cut-off 0.01Hz-3Hz

Feature Extraction

Recorded EEG patterns are investigated and extract the relevant information's such Eye blink and high concentration. Feature extraction is used to reduce the complexity of recorded raw data from various trails and grouped according to the type of their feature. Classification algorithms are used to classify the target and non-targets in the stimuli. Neural network with 2N hidden layers are used for train the system for classify the target and non-targets. The input of the classification algorithm is the output of the feature vector.

The operational flow chart of GUI explains the working of wheelchair and the interface of Neuro sky head set with MATLAB as shown in Fig.4. Initially load the Think Gear native library to the MATLAB for the utilization of Unity's plug-in functionality. The Think Gear wrapper essentially imports all of the Think Gear functions exposed in the library as static ThinkGear class methods. By virtue of being in the Plug ins directory, Unity makes this class available at runtime. The incoming real time brain signals are examined for finding the Eye double blink and High concentration. When any one of these executed by the user, the current time flash will take as the required movement otherwise it keep on change the flash.

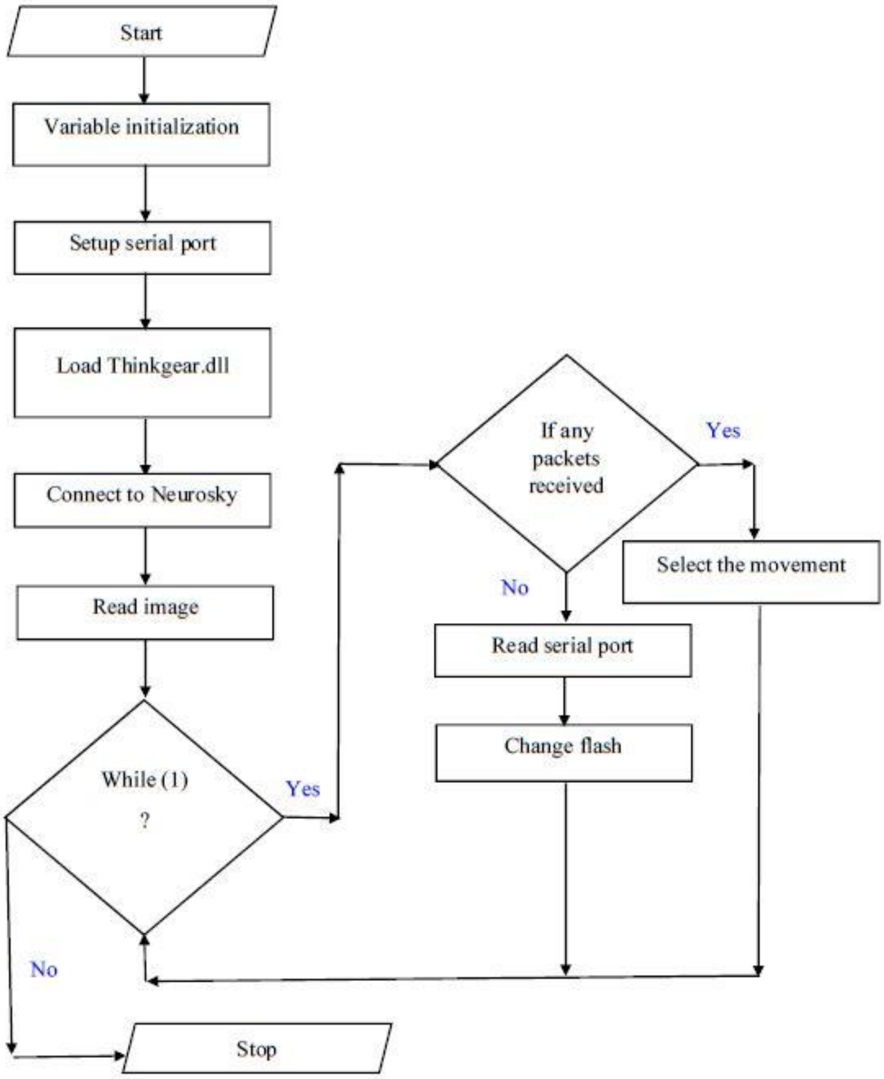

Figure 4: Operational flowchart of GUI

Environmental Feedback

Ultrasonic sensor based feedback system is used to avoid the obstacles and provide the safe navigation to the wheelchair. When the obstacle is very near to the wheelchair that particular direction of movement is remove from the flash queue and it reduce the wait time for the required flash of the movement. Arduino atmega2560 is used to monitor the four ultrasonic sensors in the four directions such as left, right, forward and backward. Feedback signals are wirelessly send to the Arduino by using Zig bee wireless module.

Results and Discussion

Hardware Development

The circuit design contains power supply unit with LM7805 and LM7812 voltage regulator IC's to provide 5V and 12V supply to the entire system. The Arduino Mega 2560 is a microcontroller board based on the ATmega 2560 is used to control the wheelchair movement and also reading obstacle distance measurement from the ultrasonic sensors. Arduino is communicated to the MATLAB through Zig-bee wireless communication and it sending next available flash in every 3s time interval. EAGLE is a powerful graphics editor for designing PC-board schematics and layout. The schematics and layout of the wheelchair control system is show in Fig.5-6. Relay switch is used to provide the needed running voltage to the wheelchair motor and the relay switch is controlled by On-OFF of a BC547 transistor controlled by Arduino.

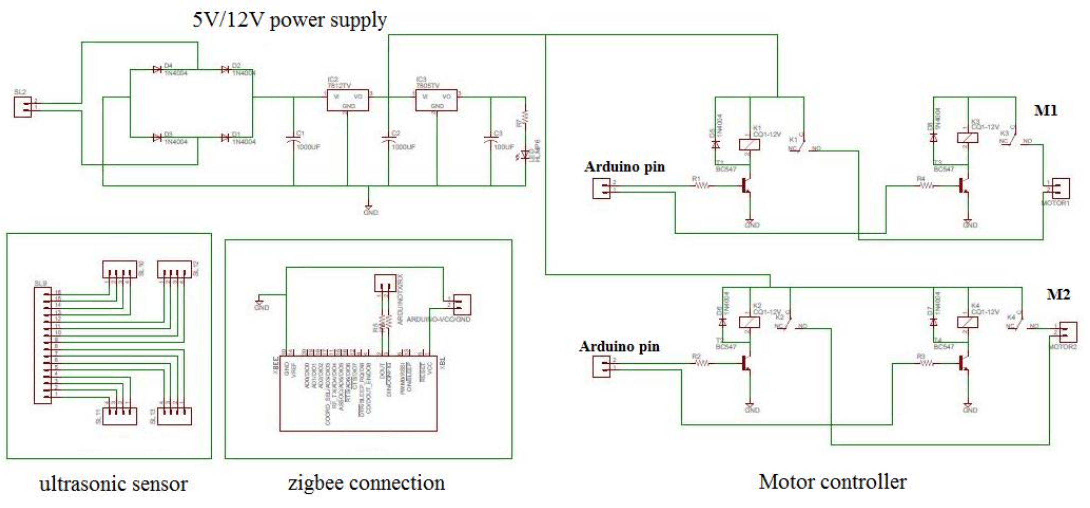

Figure 5: Schematic of Wheelchair Control

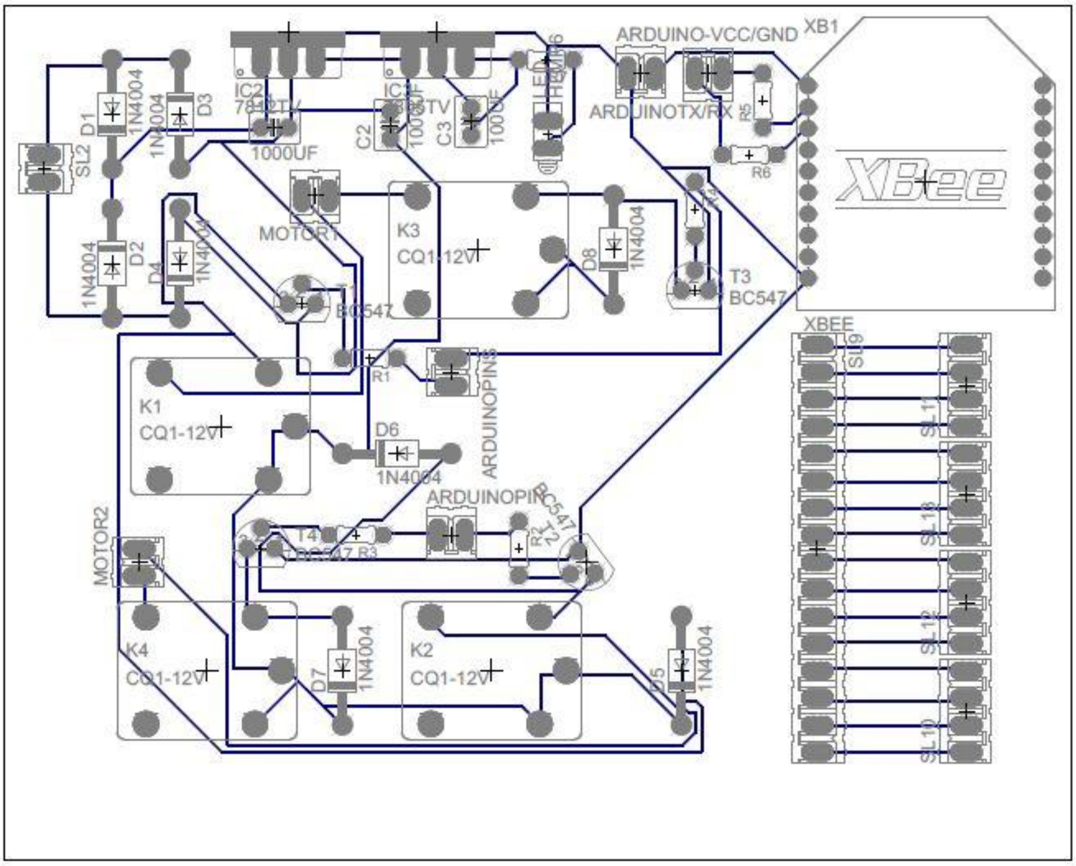

Figure 6: Layout Design of Wheelchair Control

Graphical User Interface (GUI) output

MATLAB based flexible graphical user interface with some possible choices such that letters or image are flashes in 3s of time period to the users for choosing their movement to travel. Examples given that all the flash boxes below the each commands are in red color. When it turns to blue the user can select the particular direction by Eye double blink or concentrate the required movement if the option is selected by user the flash box become green color and the related motion command is wirelessly send to the wheelchair control system. For reducing the wait time groped all options into two. Each group contains 3 options. When one task performs similar time we can select other available option as shown in Fig.7.

Figure 7: Working of Graphical user interface of Wheel chair

Conclusions

This paper present a mechanism to control the wheelchair movement by using eye double blink or concentration from EEG signals recorded from brain by using NeuroSky’s mind wave mobile is EEG device. The developed system have capability to control the wheelchair movement in the familiar environments, used a reliable interface for destination selection and motion control. The newly developed GUI helps the user easy access of their required movement. NeuroSky’s Mind wave mobile is the device is used to send the real time brain signal to the MATLAB based GUI system for extracting the Eye double blink and concentration for the selection of target. The results obtained with allow the healthy subjects to control the wheelchair in the familiar environment safely, efficiently, with limited effort and in a good time. With this BCW the user needs about 6s time to select one of six movement option with almost 100% confidence using a P300 BCI. The selected movement will stop after each 5s time interval or any obstacle come in the way. If he missed one option he need to wait 12s time to catch the correct option. By comparing the movement time and selection time of target to move the required destination, newly developed GUI model gives the better performance which required only little mental effort to select the destination than the other existing systems.

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