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Robotic Arm Control using Eye Blink Detection

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***Abstract*—Computers have always been the key for a better future. It has helped the world develop in various ways and will also continue to do so. In this paper we have made an real-time robot arm controlling using blink signals. Our main aim is to control the robotic arm using blinks for fulfilling basic robot activities like basic motor movement and environmental needs. We have used an simple algorithm for real-time classification and processing of eog signals measured.**

I. INTRODUCTION

Brain-Computer Interface (BCI) as the name suggests acts as a bridge between brain and computer. It provides an interconnection platform that supports the full duplex communication between the brain and an external device. This can be used to solve some complex problems and questions. In this paper, we have created and moved a robotic arm (left or right) based on eye blinks. This is solved by using BCI and deep learning.
Electrical signals are produced in neurons when information is sent through them, these signals can be captured using electrodes. Placement of the electrodes for signal extraction can be done in two different methods namely invasive method and non-invasive method. The invasive methodology is where the electrodes are placed on or within the outer layer of the cerebral cortex. This offers higher values of amplitude, spatial resolution, and also resistance to noise, but these require neurosurgery operations and also they are unsafe and expensive. Non Invasive method uses electrodes placed on the scalp. Non-invasive is safer, has a lower cost of usage when compared to invasive. These advantages show non-invasive as more often used method.
In this paper we have used non-invasive methodology and also 10-20 electrode placement system to fulfil it.

II. HELPFUL HINTS

A. Related Work

BCI or brain computer interface is a booming field in recent times; a technology known as Brain Robot Interaction (BRI) uses the electroencephalogram (EEG) based Brain Computer Interface. This helps provide additional communication channel for robot control via brainwaves. BRI system helps the elderly and disabled people with assistance in daily activities. By decoding brain waves acquired with an EEG device, BRI must identify the human mental activities. [4] Brain computer interface (BCI) has its usages increasing for medical purposes . A wheelchair for paralyzed people is made to navigate the wheelchair from one place to another. This brain actuated wheelchair works based on motor imagery model to control it. [5] Eye blink detection in EEG data can be done using an algorithm known as threshold algorithm[8], The EEG signals captured are smoothed and filtered to differentiate voluntary and involuntary blinks. This algorithm doesn't require a large amount of computation power and time. This algorithm gives an accuracy of 96%, which is lesser than the output accuracy

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achieved in [14].Signals could be precise based on channel selection. So, Binary Harmony Search (BHS), was put forward to optimize the system accuracy by selecting optimal channels [5]

B. Experimental requirements

Open BCI cyton board is used to capture the brain signals. The board has an 8 channel electrode system. This is connected to electrodes to be placed in the head non-invasively. The open BCI kit is shown in figure 1.

Figure 1

The OpenBCI GUI application is used for recording the signals and visualizing them, in real-time. It can change parameters such as filter range, number of channels, and output signal format.
A robotic arm has been made and used for the hardware end. An Arduino acts as a central processing unit for the robot. The communication between the user and the robotic arm is made using a Bluetooth module. As soon as the classifier determines the required movement, the command is passed to the robot for it to move accordingly. The robotic arm and its connections with Bluetooth module and arduino is shown in the figure.

C. The setup

An external sound or disturbance will create noise which results in acquiring of false data; to avoid this specimen is kept in a silent environment to acquire electrical signals. Any electrical device in the environment is also removed so it doesn’t disrupt the signals of brain.

D. Subject Details

To capture the signal, OpenBCI Cyton (This board is discussed in detail in the hardware section) board is used. There are 16 electrodes available which can be placed on certain places on the head excluding GND and REF electrodes. There is no compulsion to use all the 16 electrodes. There are 2 subjects used for the experiment. Both of them are male, one is aged 19 and the other one is aged 18. The subjects were made to sit comfortably and 2 electrodes Fp1 and Fp2 are placed on them excluding GND and REF electrodes. Two electrodes Fp1 and Fp2 above the left and right eyebrows respectively are used for taking signals. The subjects are asked to blink their eyes single time and double time. The signal thus captured from above the eye region is called “Electro ocular Gram (EOG)”. The time window of each signal being taken is 5secs, hence the subject has to blink either once or twice in that time window.

E. Electrode placement

The electrodes are placed according to the 10-20 system (figure 2) to capture the brain signals. Here the terms “10”, “20” describe the percentage of the distance between nasion and inion, left ear and right ear. This system is used to find the distance between electrodes placed. The 10-20 placement system contains 16 electrode placements. These are frontopolar points- fp1,fp2; frontal points – f3,fz,f4; central points – c3,cz,c4;temporal-T8; parietal- cp3,cp4,pz,p4; occipital- O7,Oz,O3;
Electrooculography (EOG) is determined for this project, as we have used eye blink detection. The points near the inion- fp1 (10% left of nasion), fp2 (10% right of nasion) are used. These points capture any muscular movement near the eye (blink) and convert it as a digital signal.
Ground, reference electrodes are placed to find the normal data.

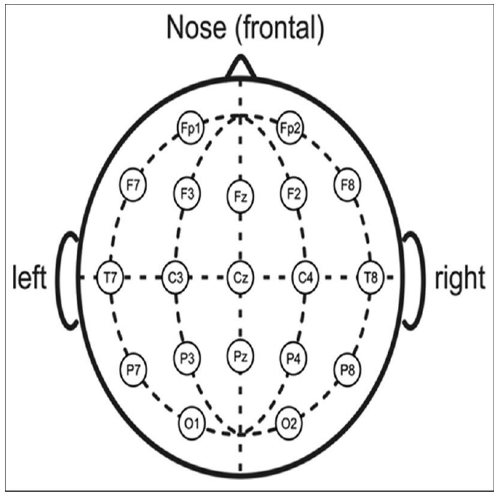

Figure 2

F. Signal acquisition

The OpenBCI Cyton Board is a neural interface to capture brain signals. It uses 32-bit architecture and arduino compatible. This board can be used for recording muscle signals, brain signals and heart signals. The captured signals can be received in a computer using OpenBCI USB RFDuino module. This board has an inbuilt ADC. The board is capable of recording 8-channel data at 250Hz sampling frequency.

The signals can be obtained in two different sampling frequencies 125Hz and 250Hz. The 250Hz sampling frequency is used in this project. A band pass filter of 5-50Hz is applied on the captured signal and sent to the RFDuinoUSB connected in the computer. Through the RFDuino module the computer receives the captured signal in digital format. The received signal will have two arrays for Fp1 and Fp2 respectively.

The EEG signals from the brain are collected using the OpenBCI cyton board using the electrodes fp1 and fp2 to capture blink signals. The signals are sent to the system from the cyton board and received in the system using the Wi-Fi dongle. A 50 Hz notch filter was applied to the signal. The open BCI software helps to store the data as a text file for further processing. Two different types of blinks (single blink, double blink) were captured for this particular project. Blinks are differentiated by the waveforms created during the signal capturing. A single wave can be found during a single blink (figure). A double blink can be found when the signal forms two waves (figure).

1000 samples of 5 seconds each have been recorded for each time of blink. We captured the EEG signals of an 18-year-old female for testing and training the deep learning model. As the blink frequency doesn't change much for each person it is not a person-specific model. The same data and model can be used for any person to control the robotic arm using blinks.

G. Pre Processing

The collected samples are visualized and preprocessed using python. Outliers decrease the accuracy of the model as it is misread data. The data collected is visualized to find any anomalies/ outliers in the collected sample. The outliers are treated before finalizing the dataset.

H. Blink Classification

Muscle movement in general is classified into voluntary and involuntary. In a similar way eye blinks can also be classified. The model must not predict any involuntary movement of eye and classify as a blink (which reduces the accuracy) so unintentional blinks can be neglected by setting the prominence value to 20.

If a single wave form is found above the prominence value, it is classified as single blink. In the case when two wave forms are found above the prominence value it is classified as double blink.

I. Software

Software is developed to stream data between OpenBCI board and Arduino and control the robotic arm manually. The UI has a text field in which the user has to specify the Bluetooth serial port name they want to use. By default the software will use COM8 port. After specifying the COM port name, user can connect to arduino module by clicking the Open COM Port button. Close COM port button is used to close the serial communication.

The Start Live Stream button triggers the following actions on click:

1. The software will start to listen for incoming data from the OpenBCI Cyton board.
2. The data received from the OpenBCI Cyton board will be saved in a Comma Seperated Values (CSV) file.
3. The CSV file will be preprocessed and fed to the blink detection algorithm.

Based on the blink detection algorithm's output the respective command will be sent to the microcontroller through the Bluetooth.

III. Conclusions

This work provides value by showing the proof that the neural signals can be used to automate tasks. The algorithm does not consume much resource and hence makes it ideal for low deploying the software on normal computers and provided satisfactory results.

Future Work

This work uses only the EOG signals which only measure the muscle movement above the eye region. More complex signals like EEG can be used with higher number of channels to automate tasks using thought. These signals can be used not only for automating tasks but for also other potential domains like healthcare and marketing.

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