MIND SWITCH

INTRODUCTION

Human brain is like the central processing system. It is responsible for almost the entire activities, feel and responses of a human. Brain Computer Interface (BCI)[x] is playing a important role in making the lives of severely disabled people better and self-manageable. BCI provides an effective means for communicating or to control or operate several devices, to the physically challenged. During the last decade many BCI enabled devices like Neural prosthesis, robotic platform[x] and general tools for human-machine interaction have been developed in labs.

Electroencephalography is a means for measuring the electrical activity in brain. The EEG signal is measured by placing one to several electrodes on the scalp in various locations based on the kind of response one wants to measure. These electrodes record the electrical activity generated by the brain’s nerve cells. The summed up electrical activity of numerous neurons is transmitted through the electrodes interfaced by a conducting gel and using a data acquisition module, are recorded and stored. This facilitates to explore the functioning of brain and its responses to various real world external stimuli like light, colours, sound, taste and touch. The recorded electrical activity consists of impulses of different frequencies and is processed in particular regions of brain called lobes. Four different lobes corresponding to various tasks are as mentioned below.

Lobe	**Function**
Frontal	behaviour, language and reasoning and long term memory
Parietal	knowledge of numbers and their relations, manipulation of objects and sense of touch
Temporal	emotion, new memories, retention of visual information and processing sensory input
Occipital	visual processing centre and visually stimulated tasks

The electrical activity of brain which occurs very quickly due to which a system with very high time resolution is needed so as to not miss any electrical activity that might occur at an instant. Since EEG is the summed up electrical activity of the brain it’s time resolution is very high. Secondly, it is easy for researchers and safe for the subjects, to record the activity as it does not involve invasive procedure. Finally the portability of the sensors and equipment combined with the low cost when compared to other devices used like fMRI, MRI and CT makes it more preferred method when compared to fMRI, MRI and CT scan. The drawback of spatial resolution in EEG is compensated by more advance techniques that have been evolved in analyzing EEG that helps in better estimation of signal’s source.

The advent of wearable sensors, along with compressed sensing of EEG signals, electroencephalography will facilitate more dynamic study and analysis of brain’s functioning and responses, in a subject’s natural environment. This will give rise to more portable and dynamic BCI applications. From the pre-processed EEG signals segments, set of features can be extracted to represent each of these segments. The features can be either statistical in nature, frequency domain features or entropy based features. With the help of these features and a robust classification algorithm, a good platform for several BCI based application for physically challenged can be developed. Over the last few years many BCI applications were developed using slow cortical potentials, event related potentials, P300 and visually evoked potentials.

EXPERIMENTAL SETUP

The experimental setup consisted of a National Instruments Data Acquisition module, EEG disc electrodes, a rubber cap to hold the electrodes, conducting gel to interface the electrodes to the scalp and a quiet and comfortable room. The experimental setup is as shown in the figure 1.1.

Figure 1.1: DAQ module connected to laptop for acquiring the signals

A. Acquisition

Occipital lobe was chosen to acquire the EEG signals for study and analysis of brain's response to colour stimulus. The reason being the occipital lobe houses the visual cortex that receives visual input from the retina. Thus the electrical signals acquired from that region will contain sufficient information about the responses to various colours and shades. Following the 10-20 international standard for electrode placement, seven silver plated electrodes were placed in a hexagonal arrangement equidistant from each other in the Occipital lobe. The positions of O1 and O2 were fixed based on the 10%-20% international electrode placement, in the occipital region as shown in the figure 1.2(a) and the positions of rest of the electrodes - O3, O4, O5, O6 and O7 were customized based on the subject's head size.

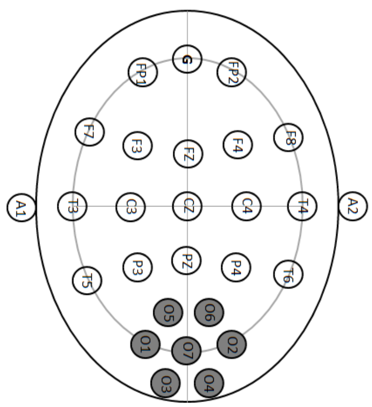

Figure 1.2(a): electrode placement

The figure 1.2(b) shows the electrode placement on the scalp of a subject in the occipital region.

Figure 1.2(b): Electrode placement on scalp of subject in occipital lobe region

The Ag-AgCl disc electrodes were used to along with an electrode gel to tap the electrical stimulus generated by the visual cortex. The electrodes were connected to National Instrument's NI6363 for acquisition purpose in a differential mode. LabView's Signal Xpress was used to record the responses. The recordings were taken in a quiet and poorly lit room free from noise. It was made sure that the subject was free from any medication, prior to the data acquisition. The 26 subjects considered for evaluation and test were both male and female of 22 years of age. The subjects were asked to perform two tasks - one was to observe colors and the next was to visualize colors. The subject observes each color for 5 seconds and then visualizes it for the next 5 seconds and the electrical activity was recorded for both cases.

The colors of RGB that were used for the visual tasks are as shown in figures 1.3.

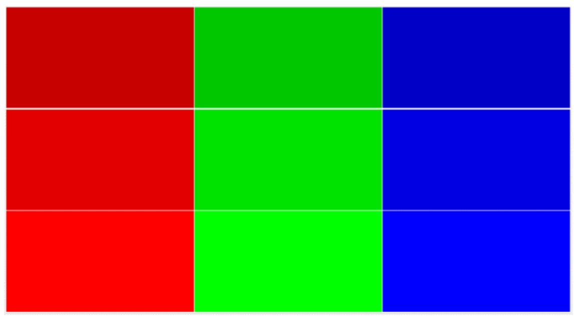

Figure 1.3: 9 sets of shades of RGB

B. Feature Extraction

The EEG recordings were filtered out with a low pass filter of 40 Hz cut-off frequency to eliminate any noise present. This data is passed through Butterworth band pass filters to separate the α, β and θ components. The theta waves have the frequencies from 4 to 8 Hz, alpha waves from 8 to 13 Hz and beta from 14 to 40 Hz. The alpha waves are responsible for the wake period, beta for alert state and theta for drowsy period. Delta which accounts for deep sleep is not taken into consideration. The energy and percentage of energy contained in each band is computed for all the seven electrodes.

C. Current work

Our project has been divided into five sections as shown in figure 1.4. Currently 10 subjects were subjected to visualize the RGB colours and their EEG was acquired using NI6363 and NI *Signal* Xpress. Later the recorded EEG signal was pre-processed and it was separated into respective bands – alpha, beta, theta, delta and gamma. Their energy and percentage energy was calculated, to be used as a feature.

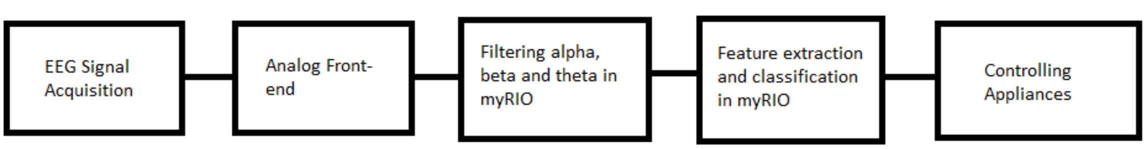

Figure 1.4: Block diagram

Further to come up with a compact device using myRIO we have designed an analog front-end which acquires signal from the electrodes, filters it with a band pass filter of lower cut-off frequency 0.5 Hz and upper cut-off frequency 40 Hz and amplifies in the order of 1000 from micro Volts to a range (0 – 5 V) supported by the analog input pins of myRIO. To differentiate EEG signal into their respective bands, FIR filters were designed and analysed in LabView which will be further implemented in myRIO-FPGA. The filter responses are shown in figure 1.5, 1.6 and 1.7.

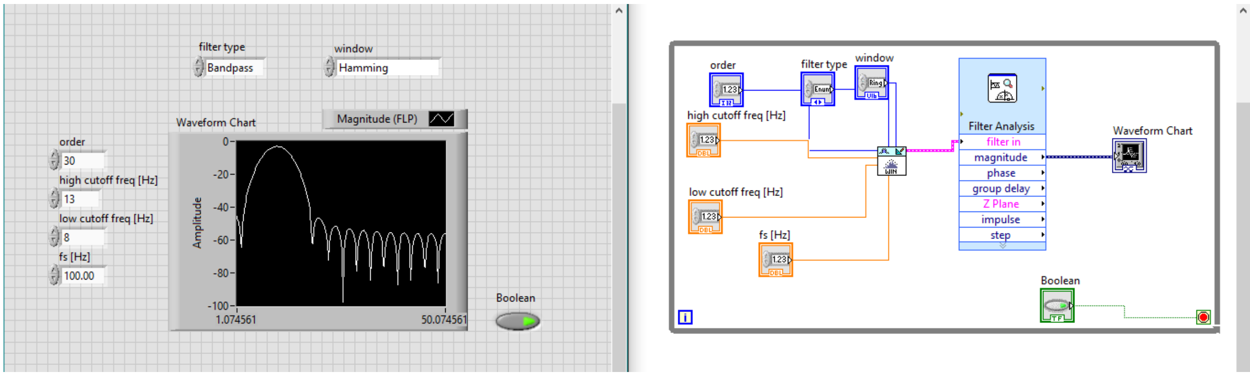

Figure 1.5: Alpha waves (8-13 Hz)

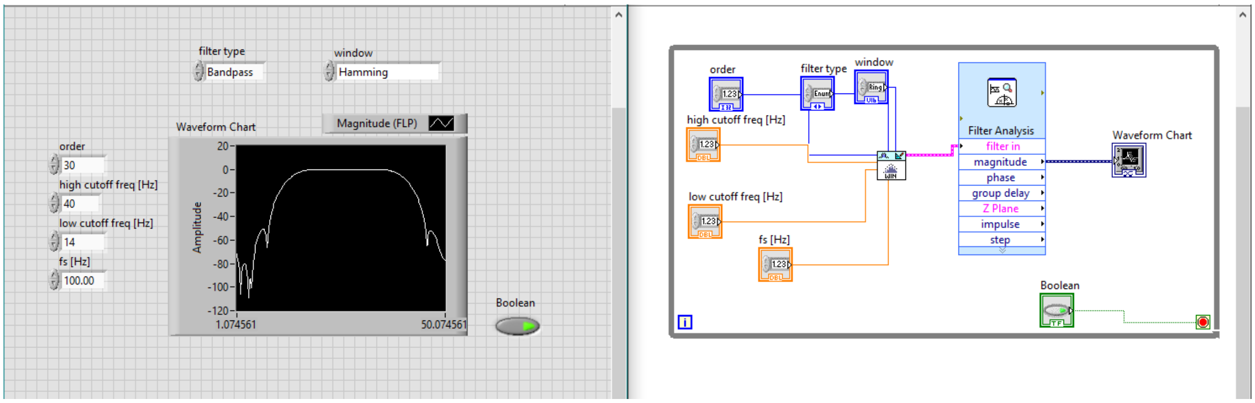

Figure 1.8: Beta waves (14-40 Hz)

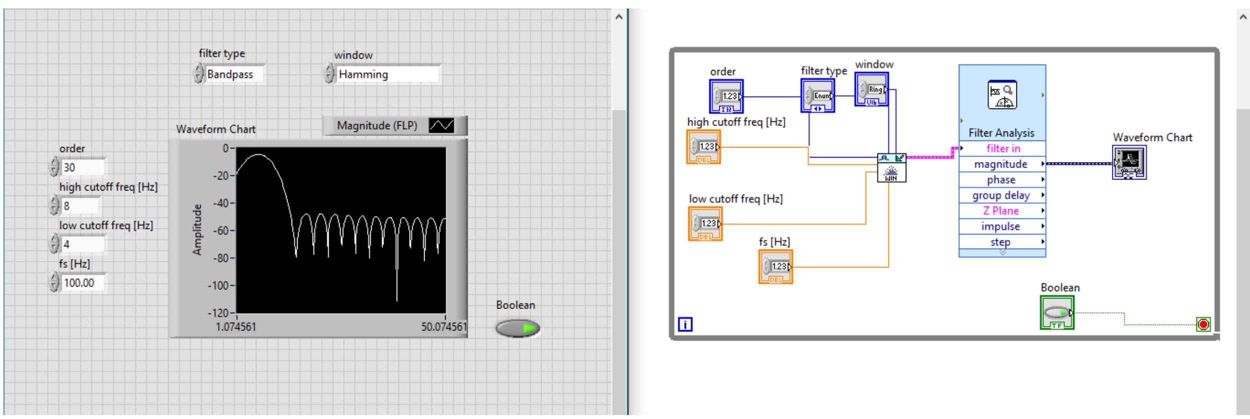

Figure 1.7: Theta waves (4-8 Hz)

D. Future Work

Using the extracted features, using either a suitable clustering or neural network algorithms will be used to cluster or classify, for identification of colour visualized. Once the colour visualized is identified then control signals can be mapped through myRIO to control any appliance. The controlling of devices will be done either via WiFi Access point established on myRIO or via Zigbee modules at both ends.

Timeline

Duration	Task to be completed
12th July to 25th July	Algorithm for identification of visualized color
26th July to 5th August	Getting acquainted with myRio and acquiring data from analog front end
6th August to 20th August	Implementing filters and to be designed algorithm in myRIO
21st August to NI day	Controlling devices and debugging