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Alpha Rhythm Analysis from Frontal Lobe using EEG based BCI

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Abstract: Brain-Computer Interface (BCI) enables users to interact with a computer only through their brain biological signals, without the need to use muscles. BCI could greatly enhance user interactions, improving the user experience by using brain signals as input with immersive environments as output. In this paper we have discussed about the non-invasive method of BCI that is EEG (Electroencephalography). According to international 10-20 system some electrodes are attached over the scalp to detect and measure the electrical activity of brain this is known as Electroencephalogram (EEG). EEG waves contain useful information of brain states; by observing only in time domain directly we cannot extract all of this information. Thus, we have to evaluate these waveforms by signal processing techniques. Five major frequency rhythms in EEG are: Delta (0.5-4 Hz), Theta (4-7.5 Hz), Alpha (8-13Hz), and Beta (14-20Hz). Among EEG rhythms, alpha rhythm is very important, because of its relevance and its dominance during the awareness of person in most of the right hemisphere of brain. Therefore, identification of location of the alpha band over the scalp will be truly advantageous. In this paper we have analysed alpha waves recorded for eye close activity from frontal lobe.

Keywords: BCI, Alpha rhythm, EEG, EEGLAB, Frontal lobe, ICA.

I. INTRODUCTION

The evolution of technology provides significant changes in the way users use interactive systems. With the ever increasing usage of tablets and smart phones, it can be observed that interaction between users and applications will take place through smaller displays and touch screens. With technological advancements different kinds of interaction which use our bodies have emerged, enabling the use of various body parts other than our hands. Brain-computer interface is a research field been studied since middle of 70s in diverse areas of knowledge such as neuroscience, biomedicine, automation and control engineering and computer science. Meanwhile only recently cost and accuracy required for civilian use have been achieved. People with severe motor impairments are main beneficiaries of brain computer interface researches, as persons with locked-in syndrome, i.e. a rare condition characterized by paralysis of voluntary muscles except for the eyes. Nevertheless, we realize that people without any disability are also potential users of solutions which promote interaction between humans and computers through cerebral signals, in the most possible natural way.

II. BRAIN-COMPUTER INTERFACE

Brain-Computer Interface (BCI) is a mode of interaction between human beings and computers which does not use any muscle, since system is controlled through user's mental activity captured with specific equipment. BCI is a communication system with two adaptive components that mutually complement each other. For these authors, at the current technology stage, users should fit into BCI to control the system since it should adapt itself to user's mental signals. Hence, user must understand the system which must adjust itself to user, both required for BCI to succeed.

BCI classification:

- *Active BCI*: An active BCI is a BCI which generates its outputs from brain activity which is directly knowingly controlled by the subject, without help of external events, to control an application.
- *Reactive BCI:* BCI is reactive when it derives its outputs from brain activity which arises in reaction to external stimulation, which is indirectly modulated by the user for controlling an application.
- *Passive BCI*: A BCI which derives its outputs from random brain activity without the purpose of intentional control, for enriching a human computer interaction with implicit information

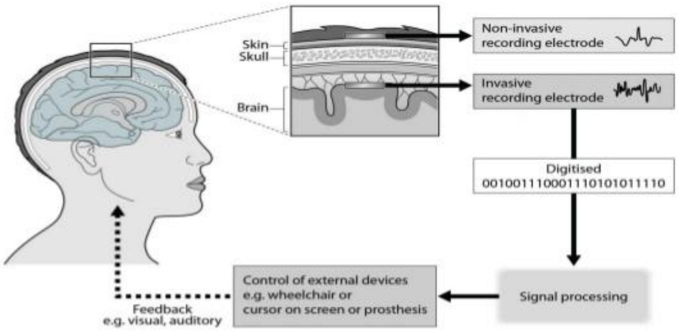

Figure 1: Simple BCI system

III. ELECTROENCEPHALOGRAPHY

Monitoring of brain states in normal as well as abnormal infants, children and adult without any pain can be detected by EEG (the electrical activity of brain). Electrodes which are as small as metal disc with thin wires are placed over the scalp to measure these waves. These signals are sent to a computer for recording and visualizing the results using electrodes. The Electrical activity recorded from brain is arbitrary in nature and may contain useful information about the brain state. They are mostly non-linear and non-stationary in nature. So, it is very difficult to get valuable information from these signals just by observing them directly in the time domain. That is why; advanced signal processing techniques are necessary for investigation and feature extraction of brain states. Some of the signals processing algorithms are linear discriminant classifier, power spectrum density, independent component analysis, principal component analysis, support vector machine etc. EEGLAB is toolbox that work on MATLAB platform and used for processing continuous and event-related EEG, MEG and other electrophysiological data [3]. EEGLAB provides us an interactive graphic user interface (GUI) that allows users to flexibly and interactively process their high-density EEG and other dynamic brain data using independent component analysis (ICA) and/or time/frequency analysis (TFA), as well as standard averaging methods which are freely available.

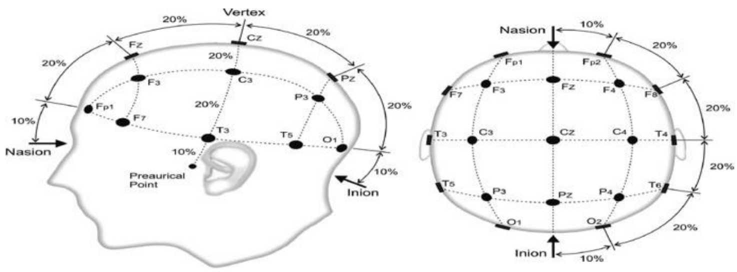

Figure 2: The international 10–20 system: the left image shows the left side of the head, and the right side presents the view from above the head. The nasion is the intersection of the frontal and nasal bones at the bridge of the nose. The inion is a small bulge on the back of the skull just above the neck

a) EEG rhythms:

» *Delta* (0.1 to 3.5 Hz): This rhythm is dominant in infants and during deep sleep of adults and when a person is suffering from serious brain disorder.

» *Theta* (3.5 to 7.5 Hz): This rhythm is found while a person is in sleeping state (or drowsy). It is also found in children when they are awake. Mainly observed at frontal, temporal and parietal region

» *Alpha* (7.5 to 13 Hz): It is dominant when a person is awake performing daily tasks.

» *Beta* (13 to 30 Hz): it appears during intense mental activity or tension in subject.

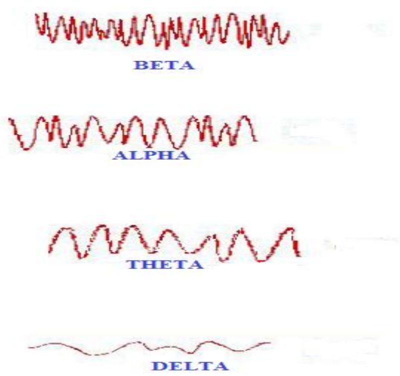

Figure 3: Brain wave samples with dominant frequencies belonging to beta, alpha, theta, and delta band

IV. DATA COLLECTION

The EEG motor Movement /imagery dataset downloads the EEG signal. Different motor task are performed by different subjects. This dataset consists of one or two minutes EEG recordings and this data is in EDF+ format (European Data Format) containing 64 EEG signals, each sampled at 160 samples per second but we are only using occipital and temporal lobe data for our purposes [2].14 experimental runs are performed by each subject. Two one-minute baseline runs (one with eyes open and one with eyes closed which are our purpose), and three two-minutes runs of each of the four tasks with motor movement. For our work eye closed data of five subjects have been take from the data dataset

V. RESULT AND DISCUSSION

For our work we have downloaded only closed eye data of the subject and selected electrode from frontal lobe i.e. F_5, F_3, F_1 of left hemisphere and F_6, F_4, F_2 from right hemisphere. We have only analysed alpha wave having frequency range from 8 to 13 Hz, for all six channels of frontal lobe. On observing alpha wave from figure 4 we found that alpha wave power spectrum shows higher value in left hemisphere i.e for electrodes F_5, F_3, and F_1 and comparatively lower for right hemisphere i.e. F_6, F_4, and F_2

Channel number	**Electrode name**
Channel -1	F_5
Channel-2	F_3
Channel-3	F_1

Table: 1 channel numbers and their respective electrodes in left hemisphere

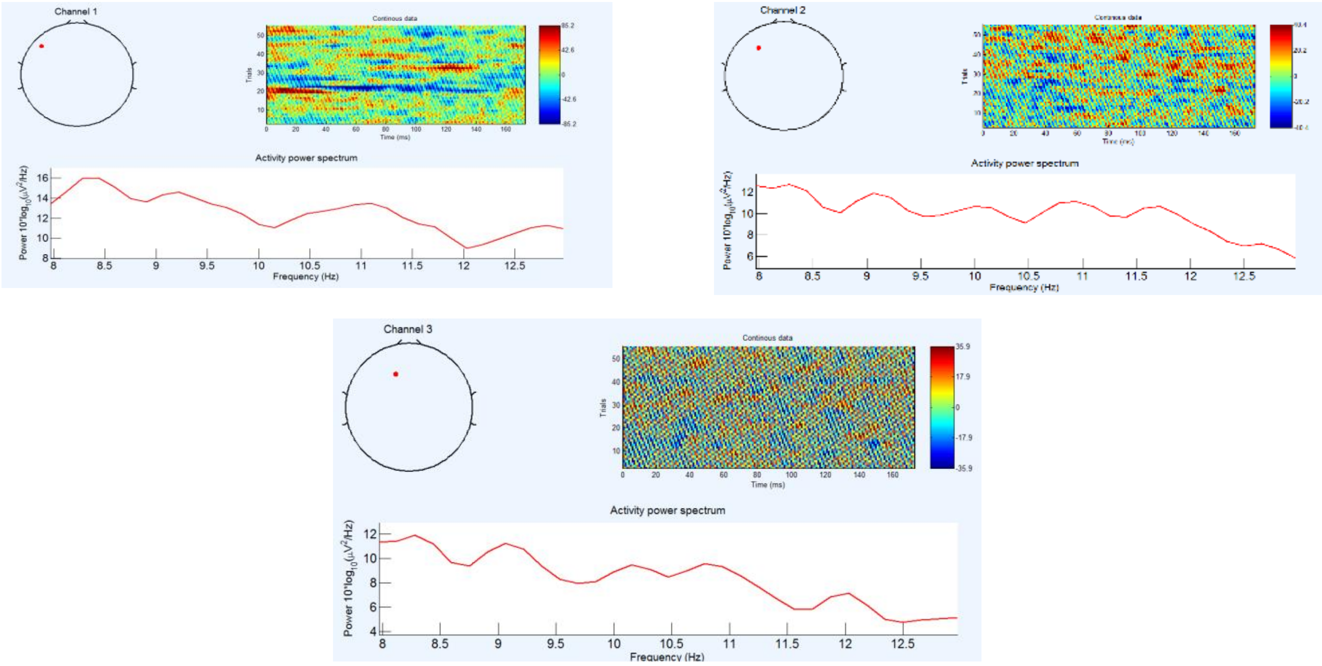

Figure 4: Alpha wave frequency graph of frontal lobe channels left hemisphere of brain [F_5, F_3, and F_1]

Channel number	Electrode name
Channel -1	F_2
Channel-2	F_4
Channel-3	F_6

Table: 2 channel numbers and their respective electrodes in right hemisphere

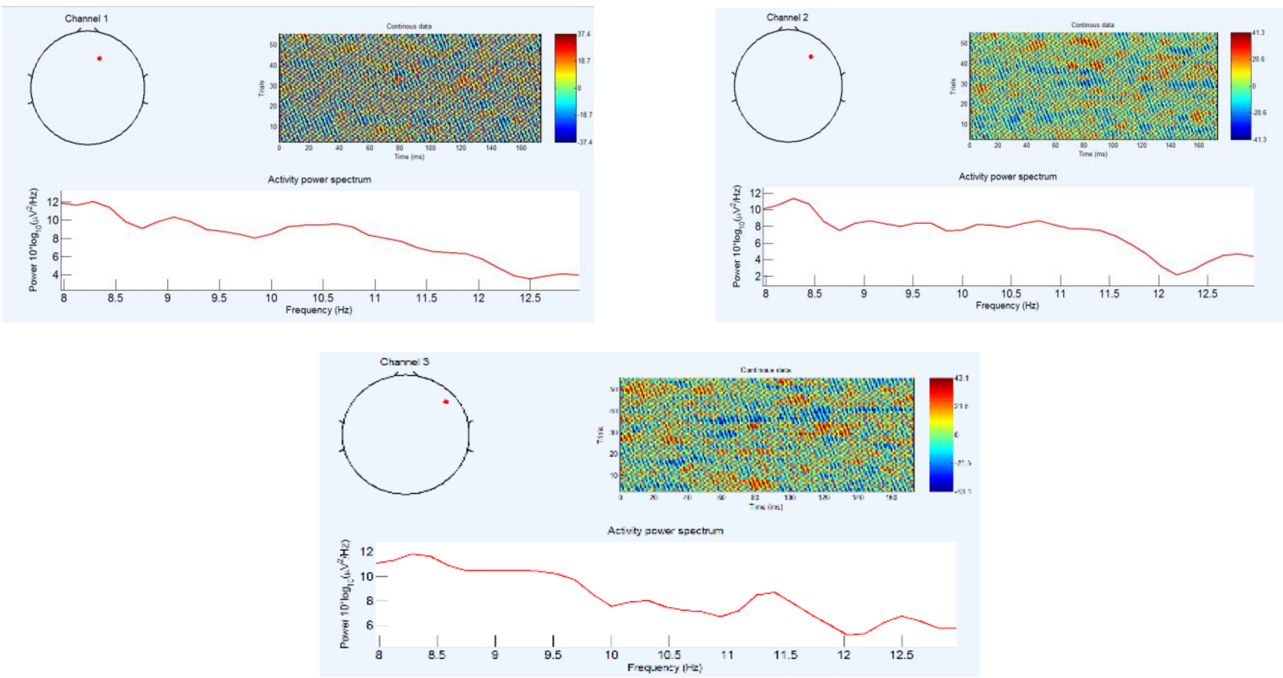

Figure 5: Alpha wave frequency graph of frontal lobe channels right hemisphere of brain [F_2, F_4, and F_6] for subject-1

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Subject no.	Channel	Maximum (in microvolts)	Minimum (in microvolts)
Subject-1	F5,F3,F1	168.84	-159.49
Subject-2	F5,F3,F1	334.45	-317.54
Subject-3	F5,F3,F1	94.33	-128.33
Subject-4	F5,F3,F1	205.33	-152.00
Subject-5	F5,F3,F1	121.66	-133.00

Table 1: Average channel data for five subjects with closed eyes collected from left hemisphere (F_5, F_3, and F_1)

Subject no.	Channel	Maximum(in microvolts)	Minimum (in microvolts)
Subject-1	F6,F4,F2	119.70	-105.628
Subject-2	F6,F4,F2	391.201	-347.779
Subject-3	F6,F4,F2	70	-122
Subject-4	F6,F4,F2	125.66	-111.66
Subject-5	F6,F4,F2	113.66	-110.66

Table 2: Average channel data for five subjects with closed eyes collected from right hemisphere (F_6, F_4, and F_2)

VI. CONCLUSION

Brain computer interface provides a way to communicate without using any muscular activity but using brain signals. A way to record these signal is Electroencephalography which is a non-invasive technique. The brain signal generated include muscles artifacts which are to be identified and removed. Many researchers have found out that eye movement effect all channels of brain and brain is more active or produces more electrical signals while eyes are closed [6]. As frontal lobe is more active when a person is thinking so we have analysed eyes closed effect on frontal lobe and find out that left hemisphere is more effected by eye close than right hemisphere of the brain. Results of five subjects are analysed for six channels ($F_{1,}$ $F_{2,}$ F_3, F_4, F_5, F_6) and as alpha waves are more dominating when person is awake with closed eyes, therefore we have measured power spectrum for alpha wave only (8-13 Hz). We found that maxima of channel data for subjects with eye close is more in left hemisphere than right hemisphere. So we can say that besides channels are effected by eye movements, results from two hemispheres are also different.

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