BCI for Comparing Eyes Activities Measured from Temporal and Occipital Lobes

Sachin Kumar Agrawal, Annushree Bablani and Prakriti Trivedi

Abstract Brain–computer interface (BCI) is a system which communicates between user and machine. It provides a communication channel without using muscular activity. BCI uses brain rhythms as input of BCI system which are recorded by invasive or non-invasive BCI. Brain rhythms are always generated by brain when we are thinking, sleeping, deep sleeping, working and non-working states. In this paper, analysis of data recorded from electrodes placed at occipital and temporal lobes and comparison between both lobes using open and close eyes data.

Keywords EEG · Brain–computer interface · EEGLAB · Temporal lobe · Occipital lobe

1 Introduction

Brain–computer interface (BCI) is a system. As we know that a system is a middleware of two or more objects, as operating system communicates between user and computer hardware similarly BCI system communicates between user and machine through brain signals and these brain signals are called brain rhythms. BCI uses two types of communication: invasive and non-invasive BCI. Electroencephalography (EEG) is a non-invasive technique to record brain signals. Today non-invasive

S.K. Agrawal (✉) · Annushree Bablani · Prakriti Trivedi
Department of Computer Science and Engineering,
Government Engineering College Ajmer, Ajmer, Rajasthan, India
e-mail: sachinkumar.aggarwal@gmail.com

Annushree Bablani
e-mail: annushree.bablani@gmail.com

Prakriti Trivedi
e-mail: prakrititrivedi@rediffmail.com

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technique is popular because it does not physically harm the subject, but signal quality is poor than invasive technique. BCI is useful for people, who are not able to control their body organs, but the mental capacity is normal. Every living being is doing some task like thinking, sleeping, working, etc. so brain generates many events when these tasks are performed. An event is triggered at specific time. For example when we open eyes and close eyes, our brain generates many events. In our work we have detected feature eyes open and eyes close effects on occipital and temporal lobes and compared the results retrieved from both lobes with open and close eyes.

2 Classifications of BCI

BCI can be classified in either of following three ways.

2.1 Input Types

BCI takes input in various ways, such as invasive and non-invasive techniques. In invasive, BCI signals are recorded with surgery of user or subject. This surgery can break the brain skin but it does not damage any neurons. Invasive BCI captures good quality signals, has very good spatial resolution and high frequency range, but can physically harm the subject. In non-invasive BCI, signals are recorded without surgery and do not physically harm the subject. Electroencephalography (EEG) is a way of recording electrical activity from the scalp using electrodes. This method is used for client and research purpose. Non-invasive BCI is very popular today but to only limitation is weak signal quality, more noise data and less frequency range.

2.2 Processing Types

BCI provides various types of methods for processing, and these methods use different purpose for different application area. BCI processing methods are synchronous, asynchronous, dependent and independent BCI.

In Synchronous BCI, Events are executed step by step: first step completes then the other step starts and as the other step completes the next step starts. It has to be done till the last step, if any of steps is not complete or fails then whole process fails. For example if I make my left hand up and then right hand up then machine starts. If I am not doing same as above then machine will not start. Synchronous BCI is a queue with specific order; queue contains set of subtask.

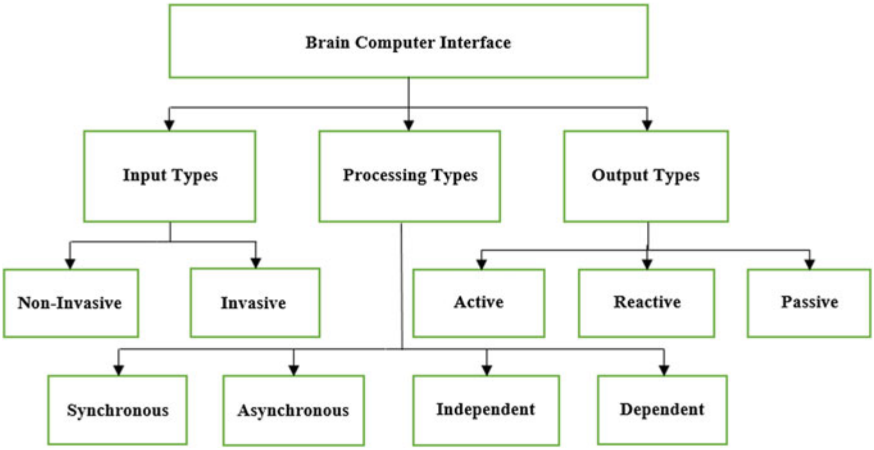

Fig. 1 Classification of BCI

When all subtasks have been completed (empty of queue) then only whole task is completed. Asynchronous BCI is not a queue-based processing. It does not any contain subtask; it is a set of tasks. Each task is run by single event. For example when I wake up then machine is started and when I sleep machine turns off (shut-down). Asynchronous BCI is more useful than synchronous BCI because it does not use queue whose event has to occur to complete task.

A dependent BCI does not use the brain's normal output pathway to carry the message, but activity in these pathways is needed to generate the brain activity that does carry it. EEG machine uses dependent BCI. For example when we open or close eyes then brain generates the muscular signal and via scalp these signals are recorded. Independent BCI does not depend on muscular activity. The user only thinks about the muscular action that user wants to perform and machine performs that action. It provides absolutely a new channel for communication. For example when we add two numbers our brain generates events, and these events are captured by device and perform task (Fig. 1).

2.3 Output Types

BCI can otherwise be classified as active, reactive and passive. Active BCI generates its output directly from brain activity, i.e. machine is controlled by thoughts of one's mind. It does not depend on external muscular events to trigger the generation of output. On the other hand, reactive BCI uses some command to be sent by focusing on some stimuli provided by the BCI system that will generate event which we want to perceive. Passive BCI gives output of arbitrarily generated brain signals that are not under voluntary control.

3 Working

EEGLAB is an open-source toolkit which is run on MATLAB. EEGLAB is very flexible and easy to use because it provides graphical user interface (GUI) for new users. EEGLAB also provides tutorial, help windows and command history so that user can easily build a new script for own purposes. It provides various methods (independent component analysis, time/frequency analysis and artefact rejection) which helps user to analyse data.

3.1 Independent Component Analysis (ICA)

Independent component analysis algorithm can be applied to isolate artifactual and neurally generated EEG source. It maximises entropy of each component (independent of each other component) and it also decomposes speech and noise data. In EEGLAB, ICA works by default through runica() function. EEGLAB provides other functions that are similar to runica().

Figure 2 shows the continuous data and activity power spectrum. We can easily see that when frequency increases power decreases.

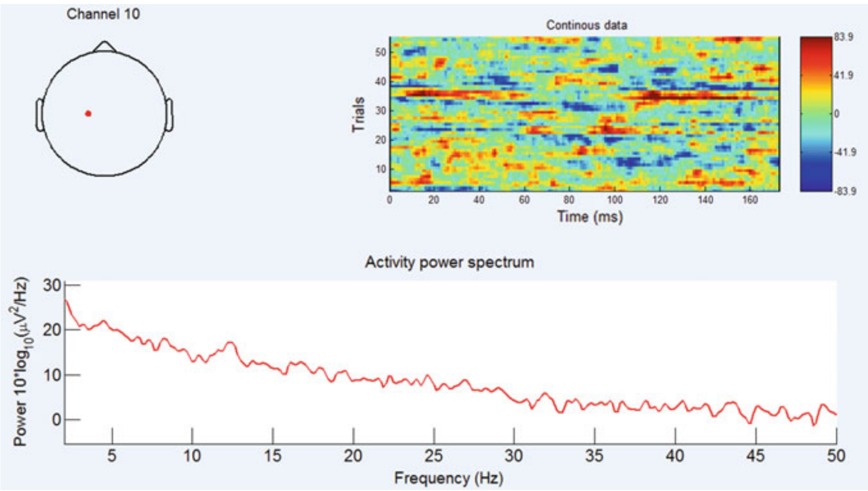

Fig. 2 Channel C1 (10) continuous data with activity power spectrum

3.2 Time and Frequency Decomposition

Its primary measures are event-related spectral perturbation (ERSP), inter-trial coherence (ITC) and event-related cross-coherence (ERCOH). ERSP measures mean event-related change in power spectrum at component or channel data. ITC measures magnitude and phase change in the power spectrum at a single channel or component data. ERCOH measures magnitude and phase change in the power spectrum at between two channels or component data. Normally, for n trials, if $f_k(f,t)$ is the spectral estimate of trial k at frequency f and time t then,

ERSP defined by

$$\text{ERSP}\ (f,t) = \frac{1}{n}\sum_{k=1}^{n} |f_k(f,t)|^2 \tag{1}$$

Inter-trial phase coherence is defined by

$$\text{ITPC}\ (f,t) = \frac{1}{n}\sum_{k=1}^{n} \frac{f_k(f,t)}{|f_k(f,t)|} \tag{2}$$

And inter-trial linear coherence defined by

$$\text{ITLC}\ (f,t) = \frac{\sum_{i=1}^{n} f_k(f,t)}{\sqrt{n\sum_{k=1}^{n} |f_k(f,t)|^2}} \tag{3}$$

To compute $F_k(f, t)$ EEGLAB uses the short-time Fourier transform, a sinusoidal wavelet transform decomposition that provides a specified time and frequency resolution.

3.3 Rejecting Artefacts

EEGLAB provides user to remove non-neural artefacts of channel, epoch and component data by GUI interface. EEGLAB provides reading data, events information, rejecting data and channel location file in different formats (Binary, Matlab, ASCII, Neuroscan, EGI, European Standard BDF, EDF, EDF+, etc.).

4 Result and Discussion

We have used EEG data for our research (experiment) which have been downloaded from PhysioNet. This dataset consists of 1 or 2 min EEG recordings and this data is in EDF+ format (European Data Format) containing 64 EEG electrodes as per the international 10-10 system, each sampled at 160 samples per second. We are choosing eyes open and close effect on temporal lobe and occipital lobe. We have selected six electrodes T7, T8, T9, T10, TP7 and TP8 for temporal lobe and three electrodes O1, Oz and O2 for occipital lobe.

Table 1 Subject max and min values of opened and closed eyes with respective electrodes (all value in rms microvolt)

Electrodes name	Open eyes		Close eyes	
	Max	Min	Max	Min
T7	104.000	−80.000	169.000	−201.000
T8	79.000	−59.000	166.000	−124.000
T9	62.000	−48.000	154.000	−88.000
T10	118.000	−94.000	111.000	−131.000
TP7	78.000	−84.000	147.000	−121.000
TP8	81.000	−109.000	142.000	−97.000
O1	65.000	−58.000	105.000	−74.000
Oz	71.000	−58.000	97.000	−69.000
O2	66.000	−78.000	100.000	−86.000

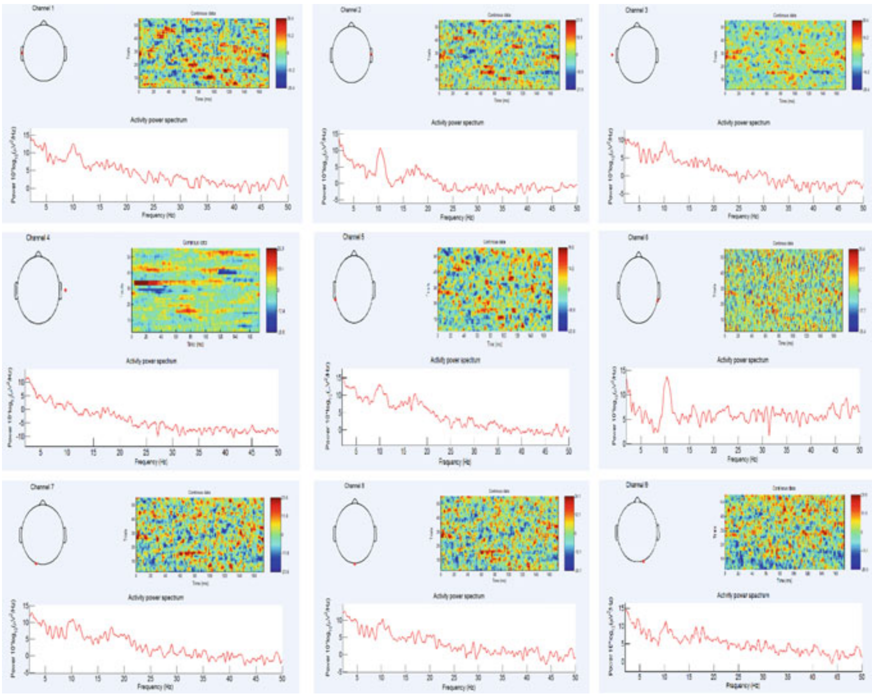

Fig. 3 Channel 1–9 continuous data and activity power spectrum of opened eyes

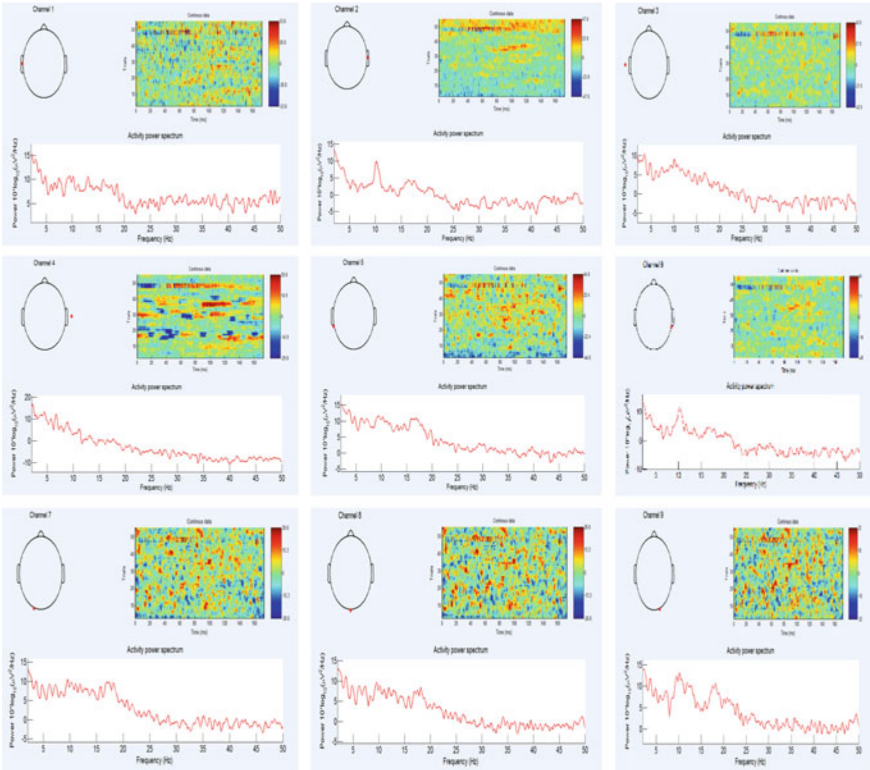

Fig. 4 Channel 1–9 continuous data and activity power spectrum of closed eyes

5 Conclusion

EEG is the best non-invasive BCI technique to record what is going on one's mind and to analyse these data we have EEGLAB, an interactive tool. For our work we have downloaded data recorded by EEG machine and investigated that data using EEGLAB toolbox. From our work it can be easily shown that occipital lobe is always more active when (eyes are closed) from the Table 1 data. Occipital lobe and temporal lobe both are more active at alpha wave (8–13 Hz) from Figs. 3 and 4. If max and min values of closed eyes are greater than min and max values of opened eyes, then we can say that occipital and temporal lobes become more active when eyes are closed and subject is in relax state and does not hear any sound.

Further Reading

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