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# Comparing Alpha Wave Activity of Left and Right Hemisphere of Brain recorded using EEGlab

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***Abstract*— A brain computer interface (BCI), also referred to as a brain machine interface (BMI), is a hardware and software communications system that enables humans to interact with their surroundings, without the involvement of peripheral nerves and muscles, by using control signals generated from electroencephalographic activity. Non-invasive type of brain computer interaction records brain signal by simply placing electrodes on scalp. It does not need any surgery. Electroencephalography (EEG) is one such technique that capture brain signals using an EEG machine consisting electrodes to be placed on scalp using 10-20 international system of electrode placement. Eye movement causes great change in EEG waves (alpha, beta gamma, and theta) produced. For further studies, it is necessary to identify their impact on different parts of the brain. So we have analyzed Alpha EEG wave recorded from various electrodes from brain scalp during open eye and closed eye of subjects. In this paper , we are considering only open eye and results of our work show that alpha wave is dominant in occipital lobe of brain and a variation in readings collected from left and right hemisphere is also analyzed.**

***Index Terms*—BCI, EEG, EEG waves, frontal lobe, left hemisphere, right hemisphere.**

## 1) INTRODUCTION

A BCI is an artificial intelligence system that can recognize a certain set of patterns in brain signals following five consecutive stages: signal acquisition, preprocessing or signal enhancement, feature extraction, classification, and the control interface [1]. The signal acquisition stage captures the brain signals and may also perform noise reduction and artifact processing. The preprocessing stage prepares the signals in a suitable form for further processing. The feature extraction stage identifies discriminative information in the brain signals that have been recorded. Once measured, the signal is mapped onto a vector containing effective and discriminant features from the observed signals. The extraction of this interesting information is a very challenging task. Brain signals are mixed with other signals coming from a finite set of brain activities that overlap in time and space.

Our brain is divided into four lobes [1] which are frontal lobe, parietal lobe, temporal lobe, and Occipital lobe. 64 channel electrodes are placed on these lobes and the brain activity is recorded by EEG machine. This EEG activity is shown in EEG waveform. For different activities different waveforms are generated.

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## 2) LITERATURE SURVEY

First ever EEG machine was given to the world by Hans Berger ('he was a NeuropsychiatristatUniversity of Jena in Germany'), in 1929. To describe graphical map of the brain signals he used the German term "elektrenkephalogramm". He was the first to suggest that- "Depending on the functional status of the brain, brain waves change" such as sleep, awake, thinking, anaesthesia, and epilepsy.

A method based on linear discriminant analysis has been proposed by Denis Delisle et al. [3] to detect events associated to eyes opening and closing, by capturing alpha waves measured from the occipital lobe.

Another method PSD (Power spectral density), helps identify the frequency domain where strength of signal is more or less. PSD can be seen as frequency response of periodic or random signals. The PSD for certain types of random signals is independent of time and hence it is deterministic. PSD is useful for analysis of random signals especially in BCI because brain signals are highly variable. SamanehValipour et al. in their paper [2] have recorded EEG signals only for 10 seconds because these signals are stationary for a time period of less than 12 seconds. MATLAB with EEGLAB has been used for computation of PSD for EEG signals. Authors have observed PSD on three subjects on channels PZ, P3, P4, FZ and CZ with subjects opened and closed eyes.

ICA is a powerful method used to separate independent data mixed linearly using various channels. For instance, when recording electroencephalograms (EEG) on the scalp, ICA can separate out artifacts embedded in the data (since they are usually autonomous of each other). The number of channels directly influence the performance of separation between artifact and pure EEG components. Before applying ICA on EEG data pre-processing is performed i.e. "whitening of data". In this pre-processing step simple linear change is performed over the coordinates of mixed data. Some of the ICA properties are: ICA can only separate the data that are linearly mixed, changing order of data points that are plotted cannot affect the result of ICA algorithm applied, change in position of electrode will also not affect the result of ICA, if data is dependent than also ICA algorithms finds the

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maximum separation between the sources and give the outcome.

While recording data from brain scalp via electrodes the electrical activity of neurons are displayed in waves form on the computers. These waves represent different mental state of the subject. Frequency is best way to represent the varying state of any EEG activity as it is easy to asses it. Brain neurons oscillations are observed in form of waves (defined on basis of their frequency) from a person mind are:

a) **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.
b) **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.
c) **Alpha (7.5 to 13 Hz):** It is dominant when a person is awake performing daily tasks. Mostly found at occipital and parietal lobes of brain and stronger over the right hemisphere. Present when a subject is mentally inactive, alert, with eyes closed. Blocked or weakened by deep sleep, attention, especially visual, and mental effort.
d) **Beta (13 to 30 Hz):** Beta waves, with lower frequencies disappear during mental activity and Beta waves, with higher frequencies appear while a person is in tension and under intense mental activity. Under intense mental activity beta can extend up as far as 50Hz

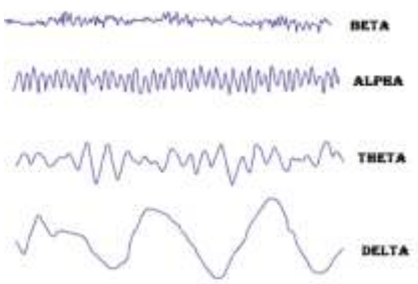


Figure 1: EEG rhythms

## 3) WORKING

EEGLAB: EEGLAB is a tool that collaboratively works with MATLAB toolbox for processing continuous/single and event-related EEG and other electrophysiological data. It includes methods like independent component analysis (ICA), time analysis, frequency analysis and some other artifact removal methods. To process complex EEG data, EEGLAB provides its users an interactive graphical user interface (GUI) which allow easy and interactive processing of EEG data and other available methods. EEGLAB also integrates general tutorial and help windows and a command history function which allow users to easily switch from one mode to another i.e. from GUI-based to script-based. EEGLAB has treasure of methods using those one can visualize and models the event-related brain data. Users who have knowledge of MATLAB for them EEGLAB provides a programming environment, which offers storing, measuring, editing, updating, accessing and visualizing the EEG data. EEGLAB is an open source platform, it allows researchers to create and share their new methods with the world.

## 4) RESULTS

In our paper we have compared and analyzed activity of brain during open eye of subjects.

For our work we have downloaded data, the downloaded dataset was created and contributed to PhysioNet by the developers of the BCI2000 instrumentation system, which they used in making these recordings. The system is described by Goldberger ALet al. in their work [6]. We have collected data for 23 channels from left and 23 channels from right hemisphere of brain. Channel number and their respective electrodes name are shown in table 1. Data was recorded with subjects having open eyes [5].

For analyzing and comparing our results we have selected alpha wave having frequency range from 8 to 13 Hz, for all channels. Channel power and frequency plot using GUI interface of EEGLAB has been performed (Figure 3 and Figure 4). In our paper we have only shown channel plot of electrodes from occipital lobes and other electrodes values have been tabulated (Table 2).

On observing the nature of alpha wave we concluded at two results, first, power values where higher for channel number 21,22 and 23 (Placed on occipital lobe) for maximum subjects and secondly these values were higher in left hemisphere than in right hemisphere. (Comparison is plotted in figure 5).

Table 1. Channel number and their respective electrodes

| Left Hemisphere | | Right Hemisphere | |
|---|---|---|---|
| Channel number | Electrode Name | Channel number | Electrode Name |
| 1 | FC5 | 1 | FC2 |
| 2 | FC3 | 2 | FC4 |
| 3 | FC1 | 3 | FC6 |
| 4 | C5 | 4 | C2 |
| 5 | C3 | 5 | C4 |
| 6 | C1 | 6 | C6 |
| 7 | CP5 | 7 | CP2 |
| 8 | CP3 | 8 | CP4 |
| 9 | CP1 | 9 | CP6 |
| 10 | FP1 | 10 | FP2 |
| 11 | AF1 | 11 | AF4 |
| 12 | AF3 | 12 | AF8 |
| 13 | F7 | 13 | F2 |
| 14 | F5 | 14 | F4 |
| 15 | F3 | 15 | F6 |
| 16 | F1 | 16 | F8 |
| 17 | P7 | 17 | P2 |
| 18 | P5 | 18 | P6 |
| 19 | P3 | 19 | P4 |
| 20 | P1 | 20 | P8 |
| 21 | PO7 | 21 | PO8 |
| 22 | PO3 | 22 | PO4 |
| 23 | O1 | 23 | O2 |

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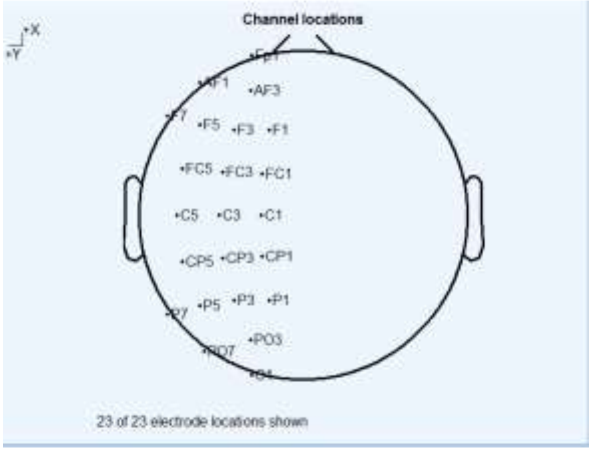
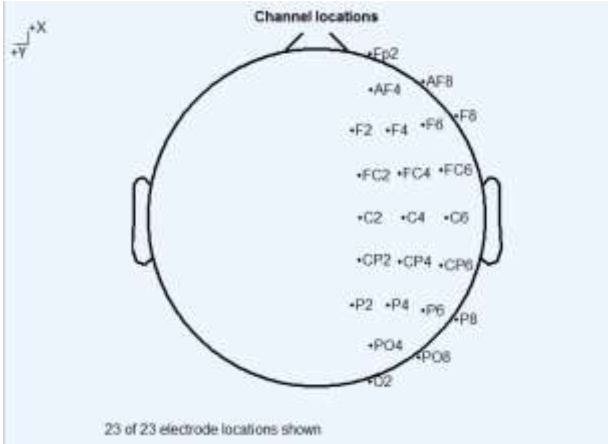


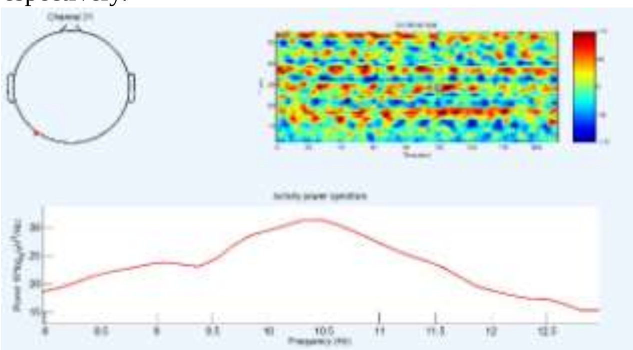

(a)



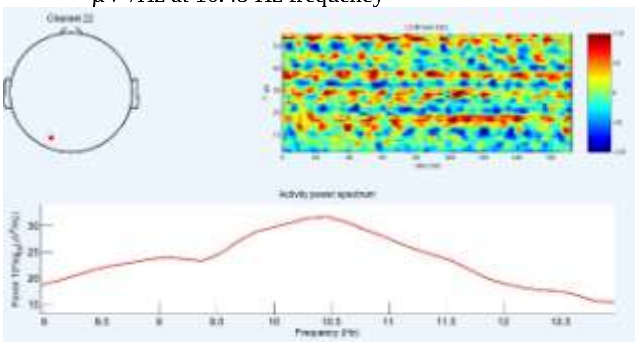

(b)

Figure 2. Electrodes placement in (a) left hemisphere and (b) right hemisphere

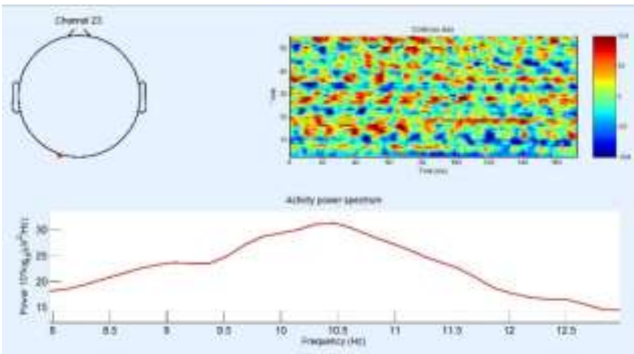
Figure 3 and Figure 4 shows power spectrum values for occipital lobe during eye open from left and right hemisphere respectively.



(a) For channel 21 or electrode PO7 power value reaches 31.4 $\mu V^2/Hz$ at 10.48 Hz frequency

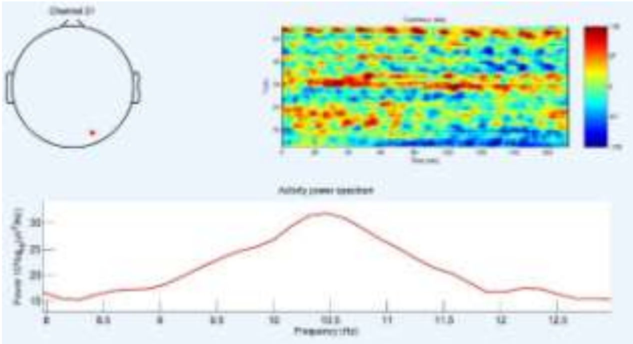


(b) For channel 22 or electrode PO3 power value reaches 31.7 $\mu V^2/Hz$ at 10.48 Hz frequency.

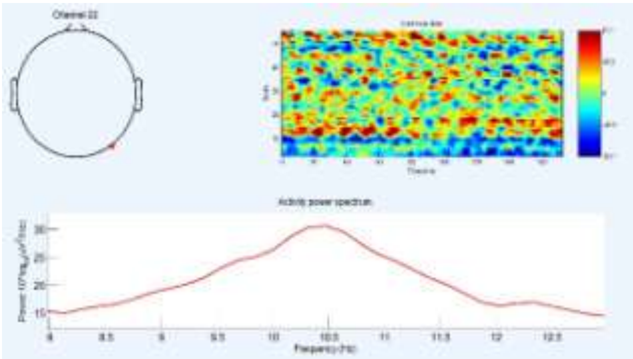


(c) For channel 23 or electrode O1 power value reaches 31.24 $\mu V^2/Hz$ at 10.47 Hz frequency

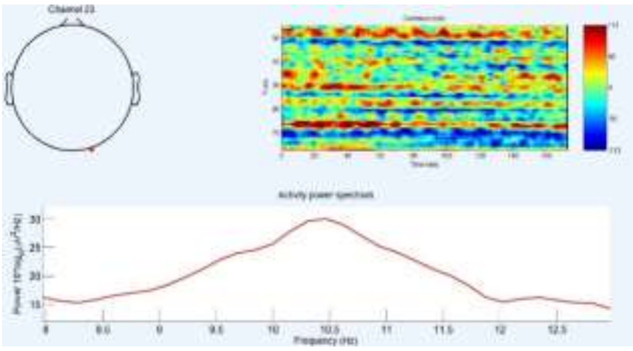
Figure 3: (a) to (c) shows Alpha wave power spectrum for subject 8 recorded from all channels of left hemisphere



(a) For channel 21 or electrode PO4 power value reaches 31.75 $\mu V^2/Hz$ at 10.48 Hz frequency



(b) For channel 22 or electrode PO8 power value reaches 30.5 $\mu V^2/Hz$ at 10.5 Hz frequency



(c) For channel 23 or electrode O2 power value reaches 30.07 $\mu V^2/Hz$ at 10.4 Hz frequency

Figure 4. (a) To (c) Alpha wave power spectrum for subject 8 recorded from all channels of right hemisphere

From table 2 we can see that during eye open electrodes of occipital lobe have higher power values than electrodes of other lobe (Value for occipital lobe is shown in bold ).

Table 2. Power value for subject 8 for left and right hemisphere

| Channel no. | Left hemisphere Power ($\mu V^2/Hz$) | Right hemisphere Power ($\mu V^2/Hz$) |
|---|---|---|
| 1 | 24.1 | 23.37 |
| 2 | 24.7 | 22.62 |
| 3 | 24.2 | 20.77 |
| 4 | 24.5 | 23.6 |
| 5 | 25.7 | 23 |
| 6 | 24.4 | 20.02 |
| 7 | 26.6 | 27.4 |
| 8 | 27.6 | 27.5 |
| 9 | 27.8 | 25.43 |
| 10 | 24.3 | 23.49 |
| 11 | 24.1 | 22.95 |
| 12 | 24.4 | 22.8 |
| 13 | 24.2 | 23.51 |
| 14 | 24.4 | 23.13 |
| 15 | 24.6 | 23.10 |
| 16 | 24.5 | 21.45 |
| 17 | 27.3 | 31.00 |
| 18 | 30.3 | 30.40 |
| 19 | 30.32 | 29.66 |
| 20 | 30.8 | 26.75 |
| *21* | ***31.4*** | ***31.75*** |
| *22* | ***31.7*** | ***30.50*** |
| *23* | ***31.24*** | ***30.07*** |

Mean power value for both hemispheres is:
Mean (LH) = 26.65 µV2/Hz
Mean (RH) = 25.40 µV2/Hz

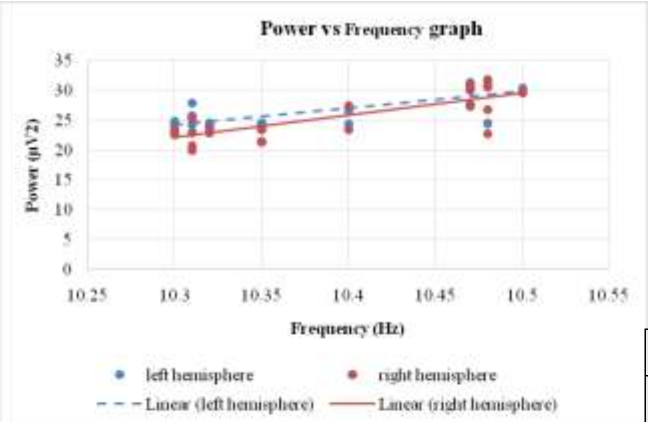



Figure 5: Power vs. frequency plot for left and right hemisphere

Result plotted show that power values of left hemisphere are more than that of right hemisphere for alpha wave, which shows that left part of brain is more active. Standard deviation values have been tabulated and plotted for the same subject.

Table 3. Standard deviation of subject 8 for left and right hemisphere

| | Standard Deviation | |
|---|---|---|
| **Channel number** | **Left Hemisphere** | **Right Hemisphere** |
| 1 | 101.9 | 60.09 |
| 2 | 96.61 | 65.43 |
| 3 | 67.27 | 85.79 |
| 4 | 78.76 | 55.08 |
| 5 | 82.24 | 56.23 |
| 6 | 61.97 | 53.13 |
| 7 | 88.17 | 58.54 |
| 8 | 68.5 | 60.35 |
| 9 | 67.09 | 78.49 |
| 10 | 110 | 97.26 |
| 11 | 148.9 | 86.46 |
| 12 | 96.15 | 117.9 |
| 13 | 138.6 | 68.06 |
| 14 | 103.9 | 65.67 |
| 15 | 90.26 | 95.29 |
| 16 | 82.03 | 121.8 |
| 17 | 82.59 | 60.57 |
| 18 | 101.1 | 74.35 |
| 19 | 87.15 | 48.26 |
| 20 | 66.96 | 42.47 |
| 21 | 73.43 | 82.5 |
| 22 | 75.63 | 57.83 |
| 23 | 72.63 | 80.92 |

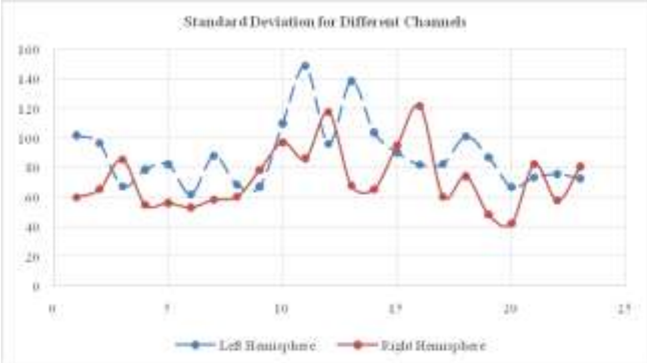



Figure 6: Plot of Standard Deviation

Root mean square value for each channel from both hemisphere is also calculated which is shown in table 3 for all the channels. Let, '$V_n$', be the peak voltage, '$V_{rms}$' be the rms voltage and 'n' be the channel number, than the value of $V_{rms}$ can be calculated as:

$$Vrms = \frac{1}{\sqrt{2}}.Vn; \forall n = 1 \text{ to } 23$$

Table 4: Showing average min and max RMS value of all 23 channels for all 11 subjects

| | **Left hemisphere** | | **Right Hemisphere** | |
|---|---|---|---|---|
| Subject no. | Maximum (RMS in microvolt) | Minimum (RMS in microvolt) | Maximum (RMS in microvolt) | Maximum (RMS in microvolt) |
| Subject-1 | 133.26 | -127.94 | 125.78 | -131.39 |
| Subject-2 | 269.69 | -269.91 | 319.13 | -316.34 |
| Subject-3 | 94 | -108.95 | 86 | -11.04 |
| Subject-4 | 166.13 | -153.21 | 122 | -122.34 |
| Subject-5 | 121.30 | -121.82 | 107 | -112.39 |
| Subject-6 | 327.39 | -319.34 | 270.39 | -278.73 |
| Subject-7 | 182.95 | -221.86 | 159.73 | 218.47 |
| Subject-8 | 333.04 | -292.73 | 269.21 | -251.08 |
| Subject-9 | 171.39 | -164.95 | 159.78 | -159.34 |
| Subject-10 | 311.17 | -292.82 | 310.52 | -296 |
| Subject-11 | 147.47 | -143.08 | 122.30 | -139.65 |

## 5) Conclusion

EEG measures electric brain activity caused by the flow of electric currents during synaptic excitations of the dendrites in the neurons and is extremely sensitive to the effects of secondary currents . Though EEG signals can be recorded in a non-invasive manner through electrodes placed on the scalp, making them by far the most widespread recording modality. However, it provides very poor quality signals as the signals have to cross the scalp, skull, and many other layers. This means that EEG signals in the electrodes are weak, hard to acquire and of poor quality. This technique is moreover severely affected by background noise generated either inside the brain or externally over the scalp.

In our paper, we have analyzed and studied 23channels, from left and right hemisphere of brain each and found out the alpha wave nature on these electrodes i.e. 8-13 Hz. It was observed that open eye have higher value of alpha wave on occipital lobe compared to any other. Occipital lobe seems to be more active when subject is with eye open and from values we can observe that Left hemisphere is more active than right hemisphere.

In future researchers can analyse individually if for right handed people left hemisphere is equally active as right hemisphere for left hander. Then we can minimize the number of electrodes and instead of using 64channel electrode placement we can also use half of the channels in future.

## References

1) B.D. Chaurasia (2004, volume 3), "Human Anatomy" fourth edition page no. 345-365
2) SamanehValipour , A.D. Shaligram, G.R.Kulkarni, Detection of an alpha rhythm of EEG signal based on EEGLAB, Department of Electronic Science, Pune University, Pune, 411 007, Maharashtra,IndiaDepartment of Physics, Pune University, Pune, 411 007,Maharashtra,India.
3) Denis Delisle-Rodriguez, Javier F. Castillo-Garcia, TeodianoBastos-Filho, AnselmoFrizera-Neto, Alberto Lopez-Delis, "Using Linear Discriminant Function to Detect Eyes Closing Activities through Alpha Wave "
4) Motoki Sakai, Daming Wei, Wanzeng Kong, Guojun Dai, and Hua Hu," Detection of Change in Alpha Wave following Eye Closure Based on KM2O-Langevin Equation",International Journal of BioelectromagnetismVol. 12, No. 2, pp. 89 -93, 2010
5) [http://www.bci2000.org/]
6) Goldberger AL, Amaral LAN, Glass L, Hausdorff JM, IvanovPCh, Mark RG, MietusJE,Moody GB, Peng CK,Stanley HE. PhysioBank, PhysioToolkit, and PhysioNet: Components of a New Research Resource for Complex Physiologic Signals. Circulation101(23):e215e22 [Circulation Electronic Pages;[http://circ.ahajournals.org/cgi/content/full/101/23/e215] ]; 2000 (June 13).
7) Oner, M.; Gongzhu Hu, "Analyzing One-Channel EEG Signals for Detection of Close and Open Eyes Activities," in Advanced Applied Informatics (IIAIAAI), 2013 IIAI International Conference on , vol., no., pp.318-323, Aug. 31 2013-Sept. 4 2013
8) Vargic, R.; Kacur, J., "Detection of Closed and Open eyes via brain control interface," in ELMAR (ELMAR), 2014 56th International Symposium , vol., no., pp.1-4, 10-12 Sept. 2014
9) Aziz, F.; Rahman, M.M.; Ahmad, T.; Jahan, M.S.; Tosrif, T.M.; Huq, M.M.; Reza, C.M.F.S.; Ahmed, A.U.; Day, P.; Badsha, S.; Al Mamoon, A.; Hasan, S.M.M., "Discrimination analysis of EEG signals at eye open and eye close condition for ECS switching system," in Electrical Information and Communication Technology (EICT), 2013 International Conference on , vol., no., pp.1-4, 13-15 Feb. 2014
10) Nishifuji, S.; Sugita, Y.; Hirano, H., "Event-related modulation of steady-state visual evoked potentials for eyes-closed brain computer interface," in Engineering in Medicine and Biology Society (EMBC), 2015 37th Annual International Conference of the IEEE , vol., no., pp.1918-1921, 25-29 Aug. 2015
11) Sosa, O.A.P.; Quijano, Y.; Doniz, M.; Quero, J.E.C., "Development of an EEG signal processing program based on EEGLAB," in Health Care Exchanges (PAHCE), 2011 Pan American , vol., no., pp.199-202, March 28 2011-April 1 2011
12) Ching-Chang Kuo; Lin, W.S.; Dressel, C.A.; Chiu, A.W.L., "Classification of intended motor movement using surface EEG ensemble empirical mode decomposition," in Engineering in Medicine and Biology Society, EMBC, 2011 Annual International Conference of the IEEE , vol., no., pp.6281-6284, Aug. 30 2011-Sept. 3 2011
13) Farina, D.; Jensen, W.; Akay, M., "Methods for Noninvasive Electroencephalogram Detection," in Introduction to Neural Engineering for Motor Rehabilitation , 1, Wiley-IEEE Press, 2013, pp.600