

# Characterization of 3D-MRP for Analyzing of Brain Balancing Index (BBI) Pattern

N. Fuad, M. N. Taib, R. Jailani, M. E. Marwan

**Abstract**—This paper discusses on power spectral density (PSD) characteristics which are extracted from three-dimensional (3D) electroencephalogram (EEG) models. The EEG signal recording was conducted on 150 healthy subjects. Development of 3D EEG models involves pre-processing of raw EEG signals and construction of spectrogram images. Then, the values of maximum PSD were extracted as features from the model. These features are analyzed using mean relative power (MRP) and different mean relative power (DMRP) technique to observe the pattern among different brain balancing indexes. The results showed that by implementing these techniques, the pattern of brain balancing indexes can be clearly observed. Some patterns are indicates between index 1 to index 5 for left frontal (LF) and right frontal (RF).

**Keywords**—Power spectral density, 3D EEG model, brain balancing, mean relative power, different mean relative power.

## I. INTRODUCTION

THE information signal generated by human brain is in electrical wave [1]-[3]. The neuron is an organ that transmits these signals between different parts of the body to control the various bodily activities [4]. However, human brain is consisted left hemisphere and right hemisphere. The language, arithmetic, analysis and speech are performed in the left hemisphere and the right hemisphere is dominant in the cognitive tasks [5]-[8]. The brain hemispheres are not exactly symmetrical, but the degree of asymmetry between the two hemispheres is insignificant [7].

However, many researchers have been carried out the methods for balancing of the brain [9]-[11] such as auditory and visual methods [10]-[12]. There are other methods to perform the test namely Transcranial Magnetic or Electric Stimulation. Nowadays, there is no evidence to prove brain balancing index using electroencephalogram (EEG). Also, there are some techniques or devices to help human felling calm and balance emotion.

The EEG is a device to collect brainwave data [13]. The EEG raw data is produced in spectral pattern. The power for each spectral power has the frequency bands: 0.5-4 Hz is delta- $\delta$  band, 4-8 Hz (theta- $\theta$  band), 8-13 Hz (alpha- $\alpha$  band) and 13-30 Hz (beta- $\beta$  band) [14]. These components are

utilized and hypothesized to produce the variation of neuronal assemblies [1], [15]. There were some EEG applications in various fields especially in medical field. The EEG patterns were used to recognize the human brain tumor [16], Alzheimer's disease [17] and anesthesia [18]. Besides that, the EEG also was used for person identification [19] and Kanji Character [20]. Therefore, Table I shows the type of brainwave and human condition in different frequencies band.

TABLE I  
TYPES OF BRAINWAVE

Frequency band	Frequency range	Voltage range	Human condition
Beta	12-30 Hz	10 -20 uV	Activity, thinking
Alpha	8-12 Hz	50 uV	Relax, Closed Eye
Theta	3- 8 Hz	10 uV	Light sleep, emotional stress
Delta	0.2- 3 Hz	10 mV	Profound sleep

Hence, this paper shows the results of 3D model for EEG. The features namely PSD is extracted from 3D EEG model. Then the features extraction patterns of maximum PSD are analyzed by mean relative power (MRP) and difference of mean relative power (DMRP) technique. MRP and DMRP is proven can implemented to recognize difference index of brain balancing.

## II. METHODOLOGY

The flow diagram of methodology has been shown in Fig. 1. Initially, EEG signals were collected from 150 volunteers. Then, the EEG signals were pre-processed to produce clean signals and filtering into four band frequencies delta- $\delta$  band, theta- $\theta$  band, alpha- $\alpha$  band and beta- $\beta$  band. Next, the 2D image called spectrogram was produced from clean EEG signals and 3D EEG model have been developed from EEG spectrogram using image processing techniques.

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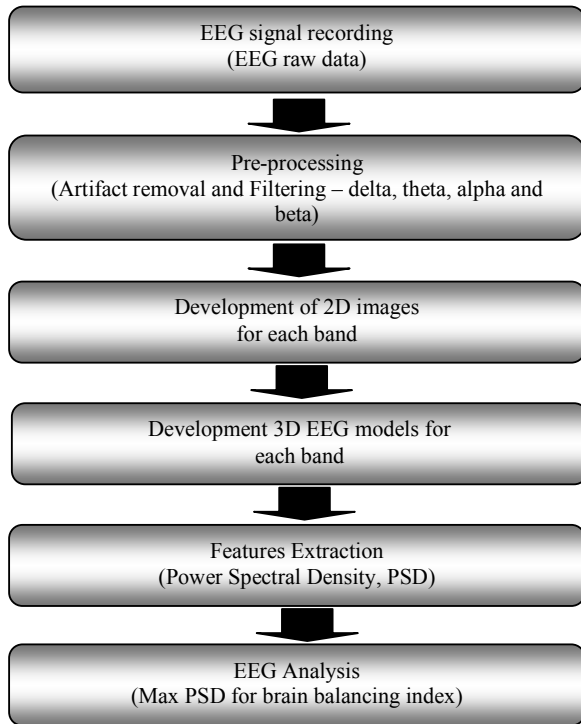


Fig. 1 Flow diagram of methodology

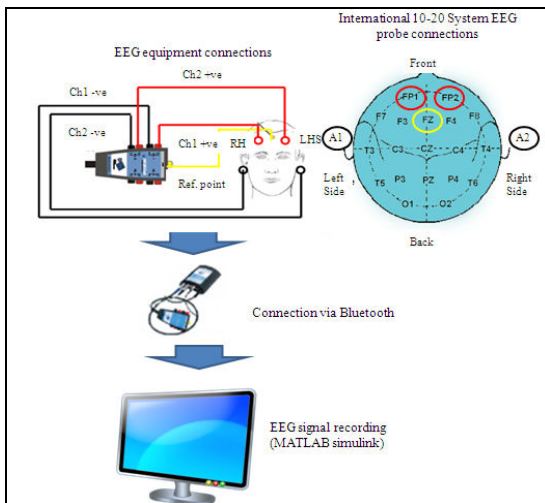


Fig. 2 Experimental setup

The experimental setup as Fig. 2, EEG signal recording and development of 3D EEG model has been explained previously [21]. The 3D EEG model produces spectral of PSD, then the maximum PSD is chosen as features to analyze. Equations (1) and (2) are implemented for mean relative power (MRP) technique for sub bands between left frontal (LF) and right frontal (RF).

$$LF \ k \ MRP = \frac{\sum LF \ k \ power}{N} \quad (1)$$

$k$  corresponded to  $\delta$ ,  $\theta$ ,  $\alpha$  and  $\beta$  band, where  $\delta$  band is 0.5-4 Hz,  $\theta$  band (4-8 Hz),  $\alpha$  band (8-13 Hz) and  $\beta$  (13-30 Hz).  $N$  is the number of the sample for left frontal (LF).

$$RF \ k \ MRP = \frac{\sum RF \ k \ power}{N} \quad (2)$$

$k$  corresponded to  $\delta$ ,  $\theta$ ,  $\alpha$  and  $\beta$  band, where  $\delta$  band is 0.5-4 Hz,  $\theta$  band (4-8 Hz),  $\alpha$  band (8-13 Hz) and  $\beta$  (13-30 Hz).  $N$  is the number of the sample for right frontal (RF).

However, (3) is implemented for different mean relative power (DMRP) technique for sub bands between left frontal (LF) and right frontal (RF).

$$k \ DMRP = \sum LF \ k \ MRP - \sum RF \ k \ MRP \quad (3)$$

$k$  corresponded to  $\delta$ ,  $\theta$ ,  $\alpha$  and  $\beta$  band, where  $\delta$  band is 0.5-4 Hz,  $\theta$  band (4-8 Hz),  $\alpha$  band (8-13 Hz) and  $\beta$  (13-30 Hz). The calculations for all equations are using Statistical Analysis Microsoft Excel 2010.

The brain balancing index was analyzed offline from previous work [22]. The percentage difference between left and right brainwaves was calculated from PSD values of EEG signals using the asymmetry formula as shown by (4).

$$\text{Percentage of asymmetry} = 2 \times \frac{\sum \text{left} - \sum \text{right}}{\sum \text{left} + \sum \text{right}} \times 100\% \quad (4)$$

### III. RESULT AND DISCUSSION

The respective index and number of sample for each index are shown in Fig. 3. There were five (5) groups; index 1 (highly unbalanced), index 2 (unbalanced), index 3 (moderately balanced), index 4 (balanced) and index 5 (highly balanced). There were 150 samples for the analysis.

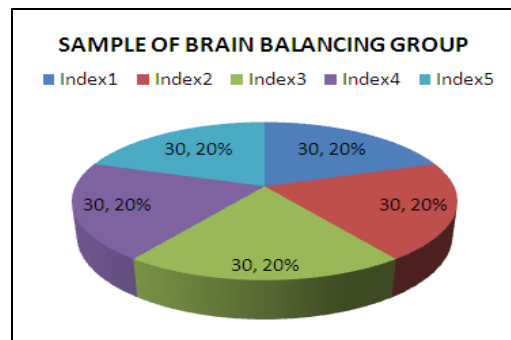
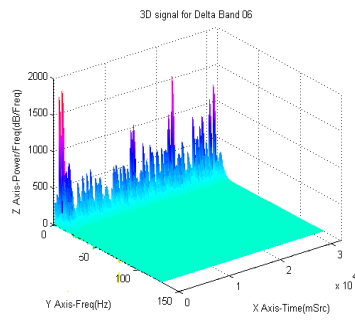
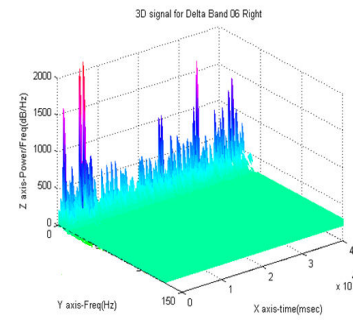


Fig. 3 Number of sample for each index

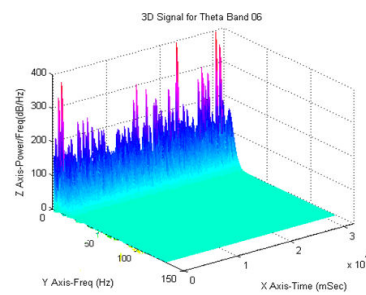
There are eight (8) 3D EEG models shown in Fig. 4 (a)-(h). The results depicted as delta band from LF and RF, theta band from LF and RF, alpha band from LF and RF and beta band from LF and RF. These models were produced using optimization; gradient and mesh algorithms.



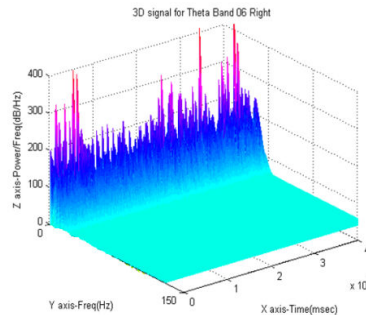
(a)



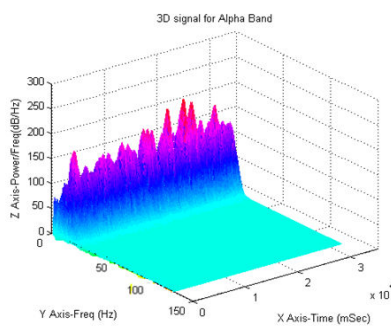
(b)



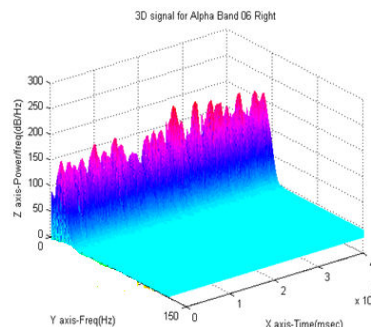
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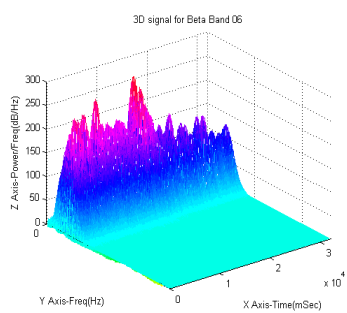
(d)



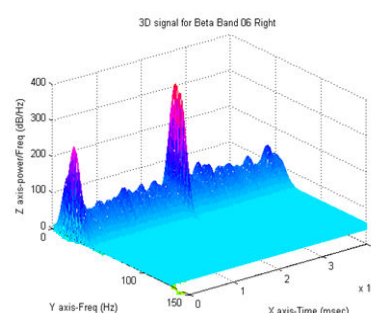
(e)



(f)



(g)



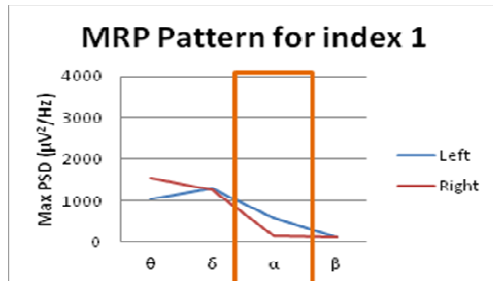
(h)

Fig. 4 3D EEG model for (a) Delta band from LF (b) Delta band from RF (c) Theta band from LF (d) Theta band from RF (e) Alpha band from LF (f) Alpha band from RF (g) Beta band from LF (h) Beta band from RF

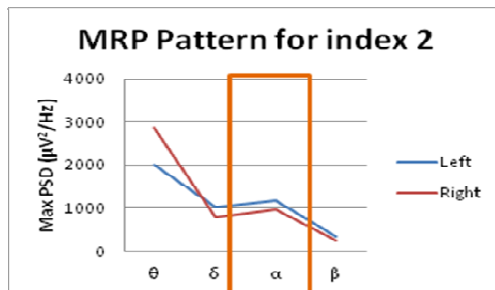
The observation from Figs. 5 (a)-(e) are shown the gap for LF and RF alpha for index 3 (moderately balanced) is bigger

compared to index 4 (balanced). However, the gap between LF and RF alpha become smaller and decrease. Because of

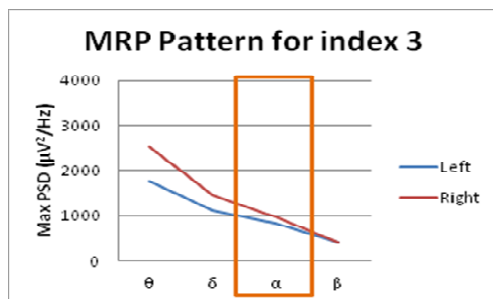
small difference value between LF and RF alpha for index 5 (highly balanced), the curves are overlapped each other. Based on the results, there is evidence that the gap between LF and RF alpha decrease when the number of index become high. The gap among LF and RF for theta, alpha and beta become smaller when the number of index becomes high.



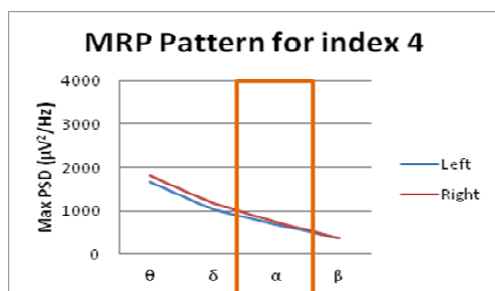
(a)



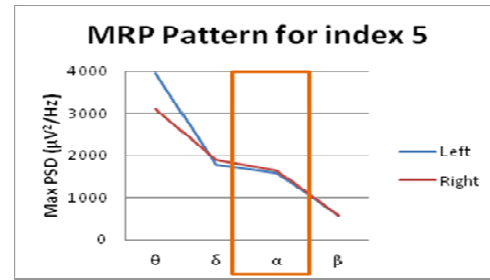
(b)



(c)



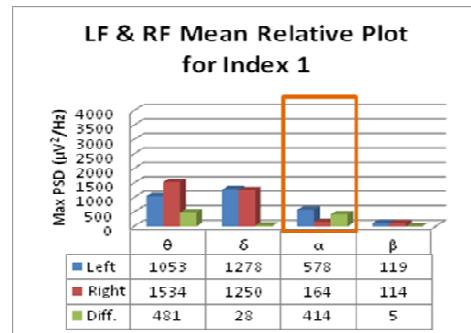
(d)



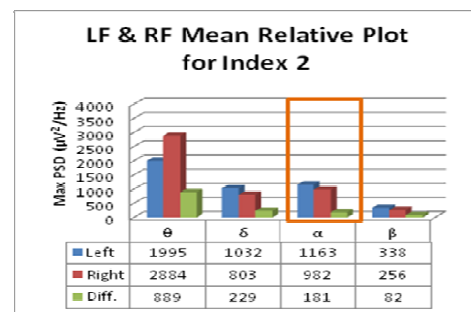
(e)

Fig. 5 The gap pattern between LF and RF for mean relative power (a) Index 1 (b) Index 2 (c) Index 3 (d) Index 4 (e) Index 5

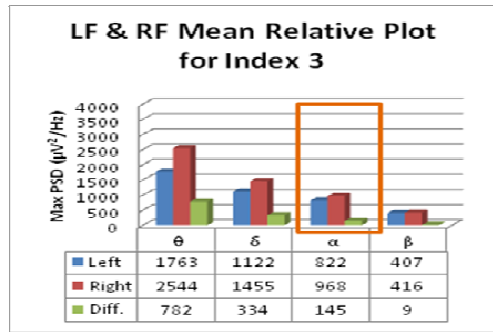
Some patterns can be observed from Figs. 6 (a)-(e). The mean relative for maximum PSD in LF group shows lower value compared to RF group because the samples were calmness and not stress or tension. The theta-alpha in LF and RF group show the same pattern for three indexes. In contrast, beta signal in the same group shows opposite pattern caused of the samples were in relax (alpha band) or deep relax (theta band). The mean relative value for LF and RF for alpha is higher than LF and RF beta showed that the samples were relax, not sleep and not in thinking mode when EEG data recording. The difference of mean relative between LF and RF for alpha decrease when the number of index become high means that the signal for LF and RF alpha became more balance in index 5 compared index 3.



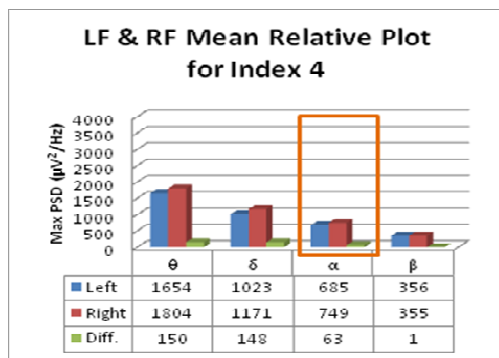
(a)



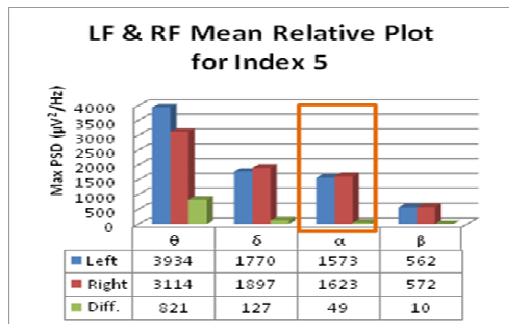
(b)



(c)



(d)



(e)

Fig. 6 Mean Relative plot for LF and RF and Difference Mean Relative (a) Index 1 (b) Index 2 (c) Index 3 (d) Index 4 (e) Index 5

Fig. 7 shows the DMRP results for difference indexes. The result between LF and RF is showed that for alpha band decreases when the number of index becomes high. It's mean the signal LF and RF for alpha becomes more balanced from index 1 (unbalanced) to index 5 (highly balanced). The condition of samples are relax, not sleep and thinking mode. This pattern has been proved from previous observation for difference index.

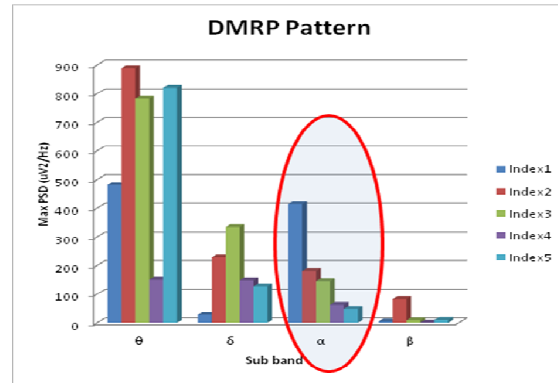


Fig. 7 Difference of mean relative power plot for difference indexes

#### IV. CONCLUSION

Experimental results revealed that maximum PSD from 3D EEG model can be used as a characteristic to recognize the pattern of brain balancing groups. The statistical analysis for sub bands right and left side shows that the data is significant. The index 5 is highly balance compared to index 1, meaning the signal for LF and RF must equally same. The gap pattern becomes decrease when the number of index is high. It is mean the signal for LF and RF become more balance for index 5 compared to index 1. Theta and alpha band showed the same pattern that RF signal is higher than LF signal but beta signal in the same group shows opposite pattern.

#### ACKNOWLEDGMENT

N. Fuad would like to thank the members of Biomedical Research Laboratory for Human Potential, FKE, UiTM for their cooperation and kindness and Advanced Signal Processing Research Group (ASPRG) for their supportive.

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