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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-δ band, 4-8 Hz (theta-θ band), 8-13 Hz (alpha-α band) and 13-30 Hz (beta-β 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-δ band, theta-θ band, alpha-α band and beta-β 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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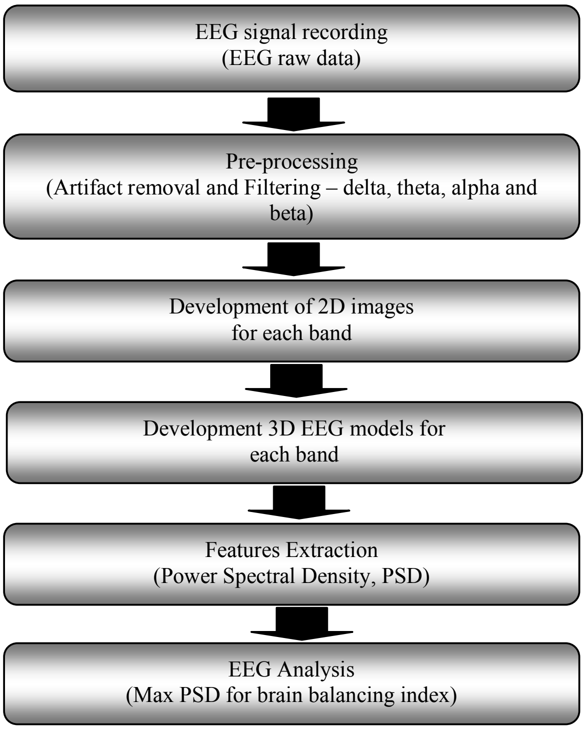

Fig. 1 Flow diagram of methodology

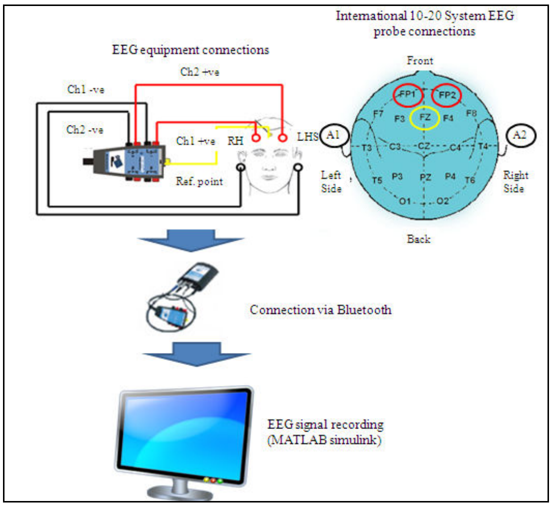

Fig. 2 Experimental setup

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 analize. 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 δ, θ, α and β band , where δ band is 0.5-4 hz, θ band (4-8 hz), α band (8-13 hz) and β (13-3hz). 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 δ, θ, α and β band , where δ band is 0.5-4 hz, θ band (4-8 hz), α band (8-13 hz) and β (13-3hz). 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 δ, θ, α and β band , where δ band is 0.5-4 hz, θ band (4-8 hz), α band (8-13 hz) and β (13-3hz). 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).

$$\text{Percentage of asymmetry} = 2x\frac{\sum left - \sum right}{\sum left + \sum right}x100\% \quad (4)$$

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.

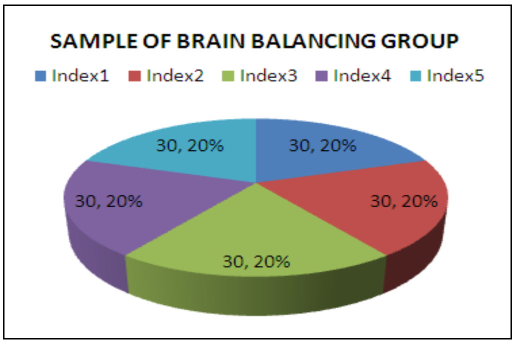

Fig. 3 Number of sample for each index

There are eight (8) 3D EGG 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.

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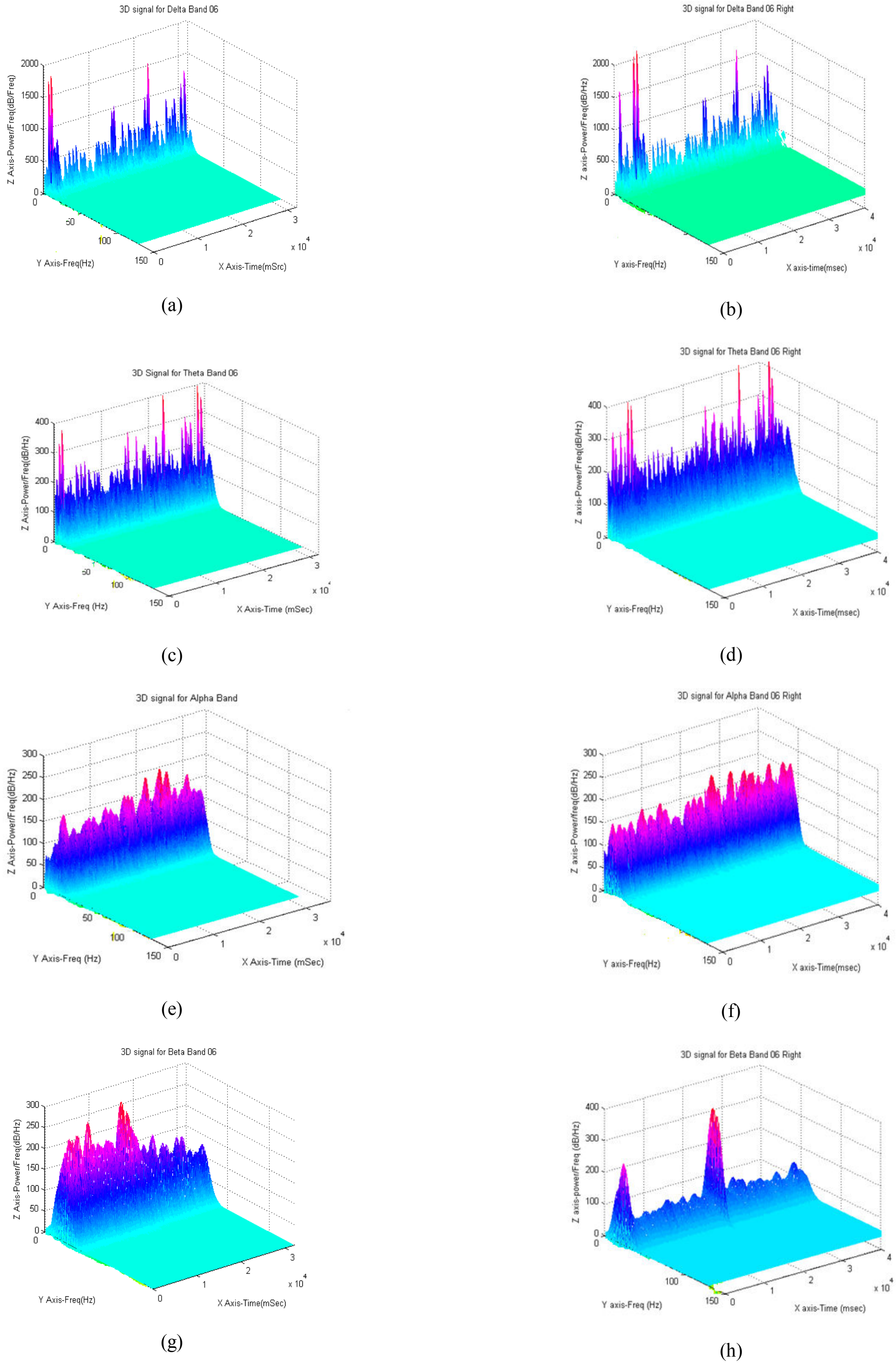
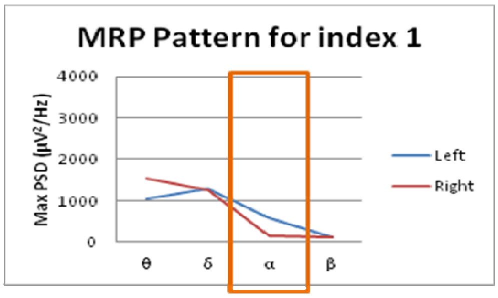
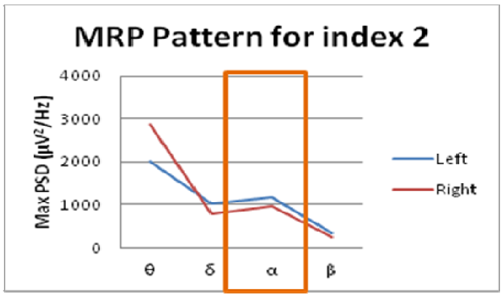


Fig. 4 3D EEG model for (a) Delta band from LF (b) Delta band from RF (c) Theta band from LF (d) Theta band from RF (e) Alpha band from LF (f) Alpha band from RF (g) Beta band from LF (h) Beta band from RF

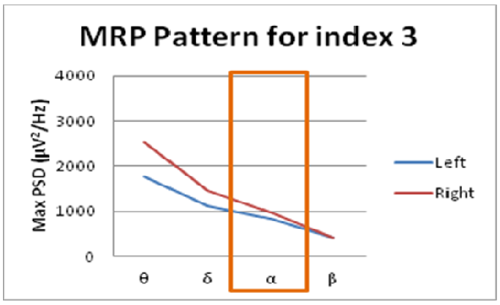
The observation from Figs. 5 (a)-(e) are shown the gap for LF and RF alpha for index 3 (moderately balanced) is bigger compared to index 4 (balanced). However, the gap between LF and RF alpha become smaller and decrease. Because of small difference value between LF and RF alpha for index 5 (highly balanced), 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.



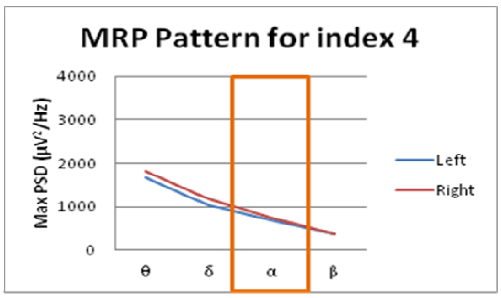
(a)



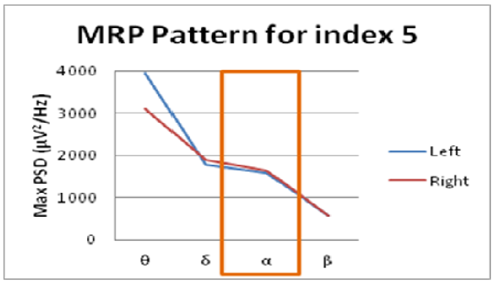
(b)



(c)



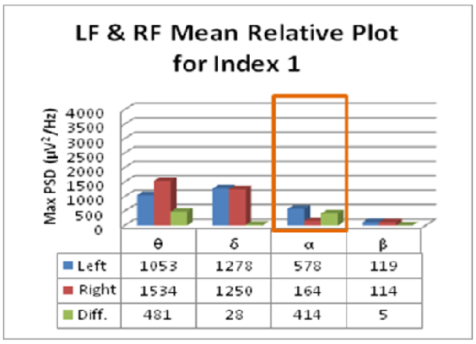
(d)



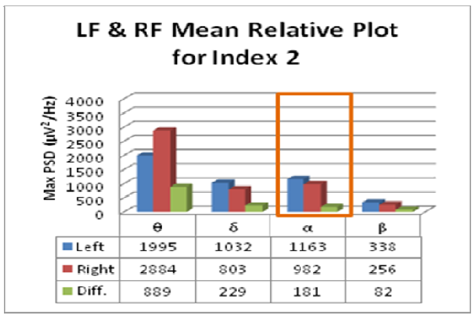
(e)

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)



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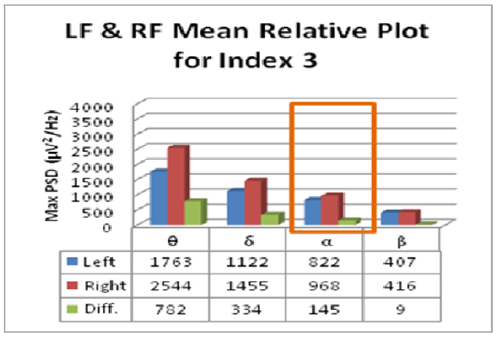
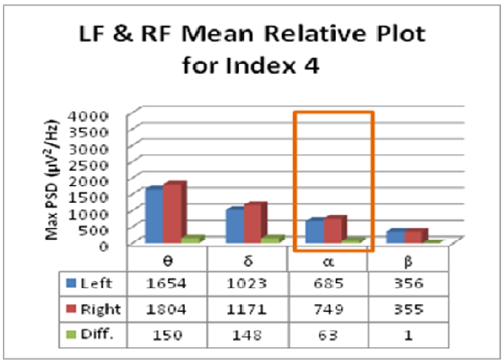


(c)



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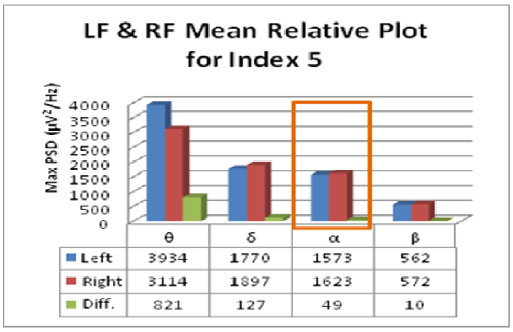

(e)

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.

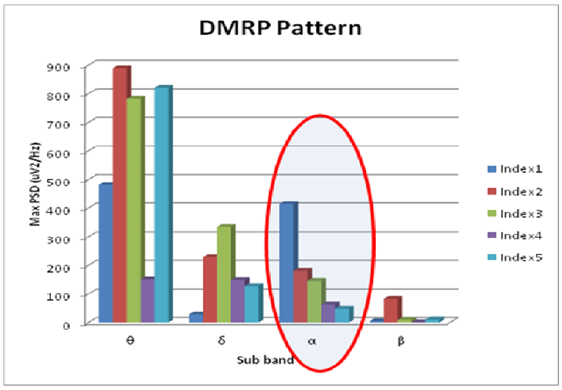

Fig. 7 Difference of mean relative power plot for difference indexes

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.

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References

[1] E. R. Kandel, J. H. Schwartz, T. M. Jessell, *Principles of Neural Science*, Fourth Edition, McGraw-Hill, 2000.

[2] D. Cohen, *The Secret Language of the Mind*, Duncan Baird Publishers, London, 1996.

[3] M. Teplan, Fundamentals of EEG Measurement, *Measurement Science Review, vol. 2*, pp. 1-11, 2002.

[4] E. Hoffmann, Brain Training against Stress: Theory, Methods and Results from an Outcome Study, version 4.2, October 2005.

[5] N.Fuad, M.N.Taib, 'The biological neuron, brainwave and electroencephalograph for human brain balanced: a literature study.' *International Journal of Research In Medical and Health Sciences (IJRMHS),* Vol. 2, No.1, pp 12-18, 2013

[6] R. W. Sperry, Left -Brain, Right Brain, in *Saturday Review: speech upon receiving the twenty-ninth annual Passano Foundation Award*, pp. 30-33, 1975.

[7] J. H. Suresh Kanna, Quantitative EEG Parameters for Monitoring and Biofeedback During Rehabilitation After Stroke, *International Conference on Advanced Intelligent Mechatronics,* pp. 1689-1694, 2009.

[8] Zunairah Haji Murat, Mohd Nasir Taib, Sahrim Lias, Ros Shilawani S.Abdul Kadir, Norizam Sulaiman, and Mahfuzah Mustafa. Establishing the fundamental of brainwave balancing index (BBI) using EEG, *2nd Int. Conf. on Computional Intelligence, Communication Systems and Networks (CICSyN2010)*, Liverpool, United Kingdom, 2010.

[9] Z. Liu, L. Ding, Integration of EEG/MEG with MRI and fMRI in Functional Neuroimaging, *IEEE Eng Med Biological Magazine*, vol. 25, pp. 46-53, 2006.

[10] U. Will and E. Berg, Brain Wave Synchronization and Entrainment to Periodic Acoustic Stimuli, *Neuroscience Letters*, vol. 424, pp. 55-60, 2007.

[11] B.-S. Shim, S.-W. Lee, Implementation of a 3 –Dimensional Game for Developing Balanced Brainwave, *5th International Conference on Software Engineering Research, Management & Applications*, 2007.

[12] Rosihan M. Ali and Liew Kee Kor, Association Between Brain Hemisphericity, Learning Styles and Confidence in Using Graphics Calculator for Mathematics, *Eurasia Journal of Mathematics, Science and Technology Education, vol. 3(2),* pp127 -131, 2007.

[13] Jansen BH, Structural EEG analysis: an explorative study, *Int J Biomed Comput 1988*; 23: 221-37.

[14] L. Sornmo, and P. Laguna, Bioelectrical Signal Processing in Cardiac and Neurological Applications. Burlington, MA: *Elsevier Academic Press*, 2005.

[15] N. Hosaka, J. Tanaka, A. Koyama, K. Magatani, The EEG measurement technique under exercising, *Proceedings of the 28th IEEE EMBS Annual International Conference,* New York City, USA, Sept 2006, pp. 1307-1310.

[16] M. Sharanreddy, P. K. Kulkarni, Can EEG Test Helps in Identifying Brain Tumor?, *International Journal of Medical, Pharmaceutical Science and Engineering Vol:7 No:11*, p.p 230-235, 2013.

[17] Md R. Bashar, Yan Li, and Peng Wen, Study of EEGs from Somatosensory Cortex and Alzheimer 's Disease Sources, *World Academy of Science, Engineering and Technology Vol:57*, p.p 997-1001, 2011.

[18] Seong-wan Baik, Soo-young Ye, Byeong-cheol Choi, Gye-rok Jeon, Comparison of the Parameter using ECG with Bisepctrum Parameter using EEG during General Anesthesia, *World Academy of Science, Engineering and Technology Vol:43*, p.p 530-533, 2010.

[19] Gelareh Mohammadi et., Person Identification by Using AR Model for EEG Signals, *World Academy of Science, Engineering and Technology Vol:11*, p.p 919-913, 2007.

[20] Hiroshi Abe, and Minoru Nakayama, An Investigation into Kanji Character Discrimination Process from EEG Signals, *World Academy of Science, Engineering and Technology Vol:18*, p.p 880-885, 2008.

[21] N. Fuad, M.N.Taib, The Three Dimensional Electroencephalogram Model for Brainwave Sub band of Power Spectral., *International Journal of Scientific Knowledge (IJSK) in Computing and Information Technology*, Vol. 3, No.1, pp 8-18, 2013.

[22] Zunairah Hj. Murat, Mohd Nasir Taib, Sahrim Lias , Ros Shilawani S. Abdul Kadir, Norizam Sulaiman and Zodie Mohd Hanafiah, Development of Brainwave Balancing Index Using EEG, *2011 Third International Conference on Computational Intelligence, Communication Systems and Networks*, pp.374-378, 2011.