Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 42 (2014) 85 – 92

Procedia Computer Science

International Conference on Robot PRIDE 2013-2014 - Medical and Rehabilitation Robotics and Instrumentation, ConfPRIDE 2013-2014

Preliminary Study on Analyzing EEG Alpha Brainwave Signal Activities Based on Visual Stimulation

Iza Sazanita Isa, Balkis Solehah Zainuddin, Zakaria Hussain, Siti Noraini Sulaiman

Universiti Teknologi MARA,Penang Campus, 13500 Pmtg Pauh Pulau PinangMalaysia.

Abstract

A current conceptual studies and researches are focusing on rehabilitation of SCI (Spinal Cord Injury) and stroke sufferer by using FES (Functional Electrical Stimulation) induced. The amount of FES induced is depending on level of injury and the muscle since the electrical stimulate is only in µvolt. To have sufficient amount of FES stimulation, the brain signal that transmit to muscle movement is the main controller of the body. Therefore, this study is conducted to measure brainwave signal of alpha wave electrical activity and observed the effect on visual stimulation of alpha wave on healthy normal brain. The brainwave signals measured from scalp using surface electrodes and EEG (Electroencephalograph) to detect the brain activities based on visual stimulation. From the analyzing results, it indicates that alpha waves during periods of eyes closed are the strongest EEG brain signal. Alpha waves is the most suitable signals to be integrated for FES stimulation as it consistency in producing electrical brainwave signals The findings of this conceptual study can be recommended to be implemented to control amount of FES induced based on physical activities specifically for stroke rehabilitation therapy.

Peer-review under responsibility of the Center for Humanoid Robots and Bio-Sensing (HuRoBs)

Keywords: Alpha wave, brainwaves activities, EEG, FES

1. Introduction

The number of existing neurons in human brain cortex which being activated in synchronize patterns are resulting in certain rhythmic behavior. The potential stimulation produced in brain cortex is recordable with the recommended electrodes position on the skull. The potential patterns occur due to electrical rhythms and transient discharge represents in electroencephalogram (EEG). EEG signals can be classified based on skull positions, frequency ranges, amplitudes, signal waveforms, periods and signal-induced actions. Basically, the EEGs signals are synchronize when the external stimulated has been measured. The EEGs are affected due to different degree of alertness as example the separate sleeping periods result in different EEG characteristics. There are several

Peer-review under responsibility of the Center for Humanoid Robots and Bio-Sensing (HuRoBs)
doi:10.1016/j.procs.2014.11.037

techniques proposed by Do *et al*. [1], Domino *et al*. [2], and Jacobs & Friedman [3], in integration the EEG and FES and the challenging of EEG signals mainly due to its small amplitude. The EEG signal passes through dura, cerebrospinal fluid and skull to scalp will produces peak-to-peak amplitude is only about 1 ~ 100μV with frequency range 0.5 ~ 100 Hz. In addition, the electrode material, contact tightness and electrode paste may even affect the recordings due to some unpredictable noise which interfere with EEG detection.

Brain waves are measured in cycles per second or Hertz (Hz) also known as frequency of brain wave activity. The lower number of frequency indicates that the slower the brain activity or the slower the frequency of the activity. The study from Teplan [8] has been categorized brain waves signal into four basic groups as shown in Table 1.

Nomenclature

β	Beta
α	Alpha
θ	Theta
δ	Delta

Table 1. Brainwaves signals with dominant frequency band

Brainwaves	Frequency ranges
Beta β	>13
Alpha α	8 – 13
Theta θ	4 – 8
Delta δ	0.5 – 4

The objective of this study is to measure an alpha wave electrical activity and observed the effect on visual stimulation of alpha wave for healthy normal brain signal. This is the motivation to conduct this research since the best-known and most extensively studied rhythm of the human brain is the normal alpha rhythm as proposed by Teplan [8]. According to Rahman [7], the normal alpha rhythm is the best-known and most extensively studied rhythm of the human brain because alpha wave can be usually observed better in the posterior and occipital regions with typical amplitude about 50 μV. Previous established research by Klimesch [4] has reviewed and analyzed evidences of alpha and theta oscillations to determine the performance of cognitive and memory based on power contribution. From the reviewed findings, the study proposed that the encoding of new information is reflected by theta oscillations in hippocampo-cortical feedback loops, whereas search and retrieval processes in (semantic) long-term memory are reflected by upper alpha oscillations in thalamo-cortical feedback loops. A study conducted by Jacobs and Friedman [3] analyzed the central nervous system effects of relaxation technique using spectral analysis of alpha and theta EEG activity in all cortical regions. The findings indicate that relaxation technique produced significantly greater increases in theta activity in multiple cortical regions compared to the music condition. A study by Domino *et al*. [2] to determine either tobacco smoking in humans produces localized or widespread neocortical dominant alpha EEG frequency of the brainstem activating system. From the study demonstrates the consistency of tobacco smoking produces widespread bilateral neocortical increases in dominant alpha EEG frequencies.

2. Methodology

2.1. EEG Circuit Design Principles

In the experiment, the electrodes place on the positions of frontal, Occipital and A1 as potential ground. These positions had been chosen since the presences of hair on the scalp make it difficult to place electrodes on the proper region. The isolation concept was incorporated in circuit designing to avoid electrical shock caused by power supply or measuring instrument leakage. Figure 1 shows the block diagram of EEG measurement circuit. The surface electrodes were used to measure the alpha wave that was induced by stimulation the eye with light. Arrhythmic alpha waves were responsive if eye opened or closed. The instrumentation amplifier with gain 50 was used as the preamplifier for picking up the unipolar component of EEG signals. The isolation circuit functions to isolate the signal and line power source. The bandwidth of the band-pass filter is from 1 to 20 Hz and the amplifier with amplification factor of 1000 can magnify the weak signal that passed through the filter. An amplified EEG signals directly sent to oscilloscope for display. Preamplifier circuit is composed of an instrumentation amplifier with gain determination using (1). Figure 2 is showing preamplifier circuit where OP1 is the reference terminal and Z_2 is the compensated potential that can adjust the drift level of output voltage.

$$A_V = \frac{49.4k\Omega}{Z_1} + 1 \qquad (1)$$

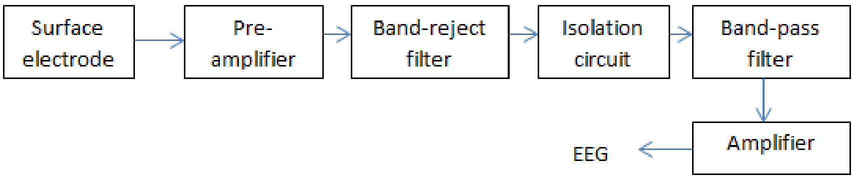

Fig 1 Block diagram of EEG measurement circuit

Band-reject filter composed of RC networks including OP2A where the center frequency can be determined using (2). Figure 3 shows a twin-T band-reject filter.

$$f = \frac{1}{2\pi Z_3 Z_5} \qquad (2)$$

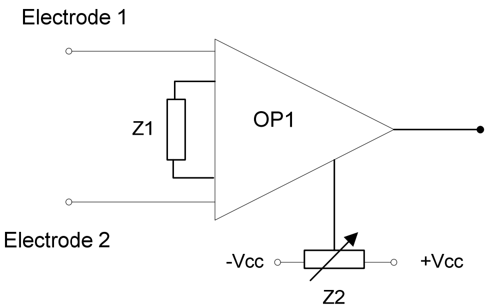

Fig 2 Preamplifier circuit

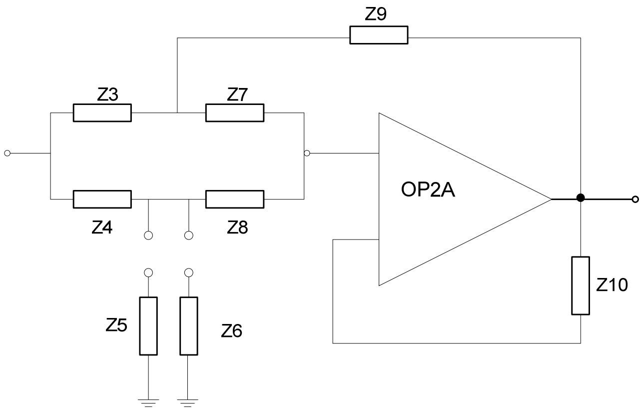

Fig 3 Band-Reject filter circuit

The isolation circuit is constructed by OP3 where the isolation signal is carried out by means of an optical approach. For band-pass filter circuit, the cutoff frequency of the filter is set at 1 Hz for 2nd-order high pass filter meanwhile 20 Hz cutoff frequency is set for 2nd-order low-pass filter as expressed in (3) and (4). Non-inverting amplifier constructed by OP5B where the gain adjustment is expressed in (5).

$$f_L = \frac{1}{2\pi\sqrt{Z_{11}Z_{12}Z_{13}Z_{14}}} \tag{3}$$

$$f_H = \frac{1}{2\pi\sqrt{Z_{19}Z_{20}Z_{21}Z_{22}}} \tag{5}$$

$$A_V = \frac{Z_{17} + Z_{18}}{Z_{187}} \tag{6}$$

2.2. EEG Measurement Technique

Two subject volunteers in this study were selected from a group of healthy students from the Universiti Teknologi MARA, Penang campus, Malaysia. The inclusion criteria were adult, mentally and physically healthy males 21 to 25 years of age. The subjects were installed with EEG electrodes on the scalp and connected to computer to display brain wave signals. Figure 4 shows the measurement procedure during lab session. The subjects were asked to calm and relax with open eye. After a minute, subjects were asked to closed eye for five times and the signals were recorded. The step repeated two or three time to obtain smooth and clear waves. The same procedures were conducted for both subjects.

Fig 4 Experimental conducted at Medical Instrumentation laboratory

3. Results and Discussion

Both EEG recordings even though focusing only on alpha waves, there were no significant differences between both subjects on frontal alpha waves. However the amplitudes during eye closing (blinking eye) are higher compare to eye opening (non-blinking eye). Based on visual analysis, EEG alpha brainwave of subject 2 is showing a consistency on maximum and minimum amplitude as shown in Figure 6 compared to subject 1 as shown in Figure 5. This can explain that Subject 2 is much relaxed and calm compare to Subject 1. The Table 2 tabulates the comparison results in terms of minimum, maximum and standard deviation of alpha wave activities. These results are provides strong evidences that alpha activity is induced by closing the eyes and by relaxation, and abolished by eye opening or alerting by any mechanism (i.e: thinking or calculating) [7]. Figure 7 shows comparison of alpha waves amplitudes during blinking eye and without blinking eye activities. During eye blinking, the amplitudes are highest compared to without eye blinking. Figure 8 is showing the steady state responses on visual stimulation for repeating closed and opened eye. Each completed cycles is stimulated in almost uniform period.

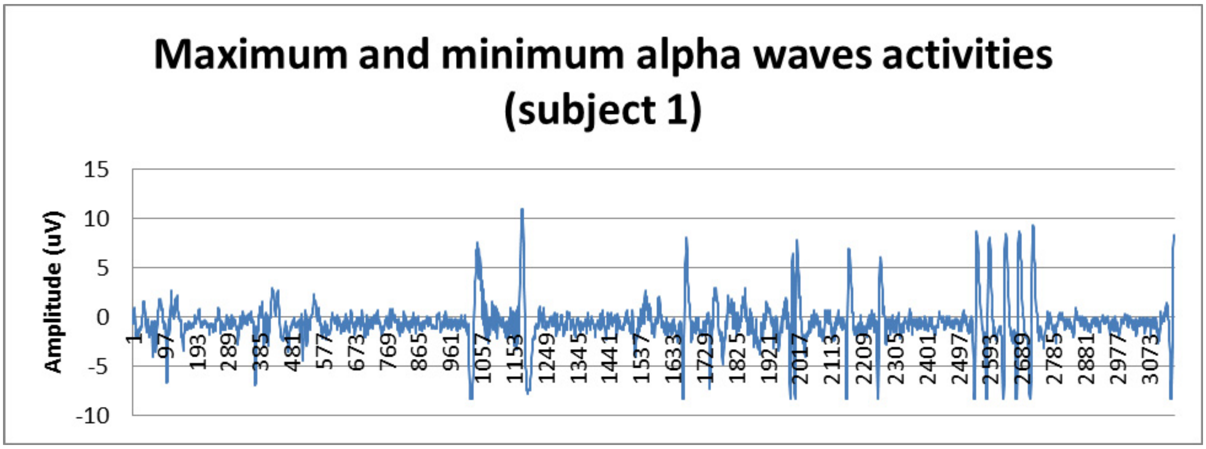

Fig 5 Alpha Waves (subject 1)

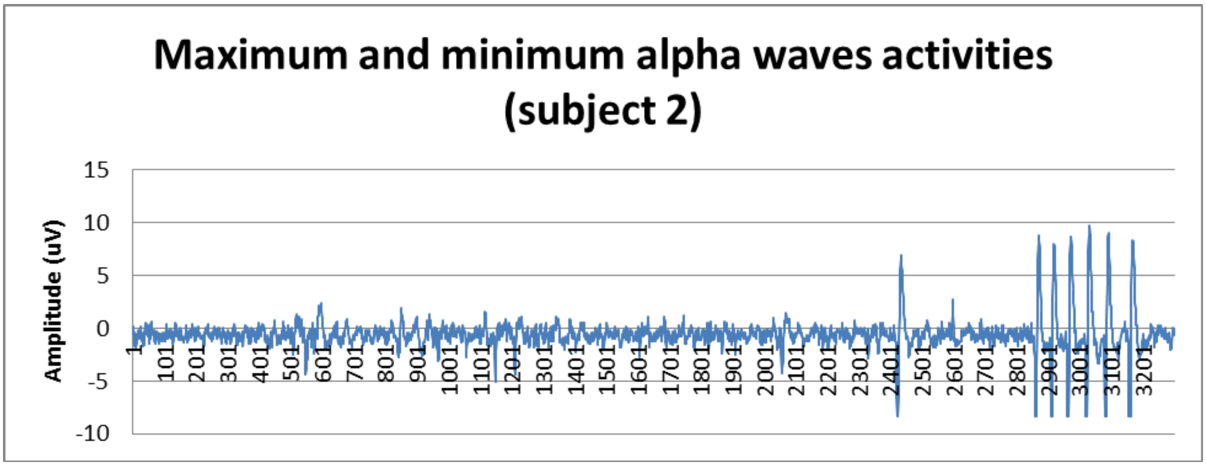

Fig 6 Alpha Waves (subject 2)

Table 2. Maximum and minimum amplitude and standard deviation of alpha wave

	Blinking Eye			Non-Blinking Eye		
	Average Max Value	Average Min Value	Standard Deviation	Average Max Value	Average Min Value	Standard Deviation
Student 1	8.389	- 8.32	0.070	0.210	- 0.799	0.017
Student 2	7.823	- 8.23	0.123	0.378	- 0.959	0.020

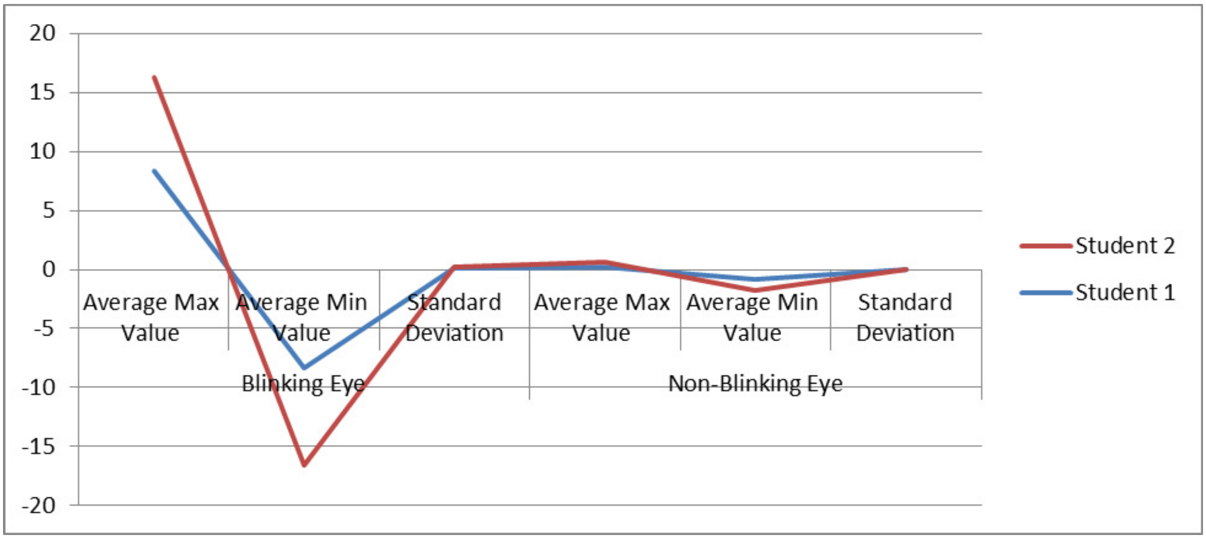

Fig 7 Comparison of Alpha waves activities

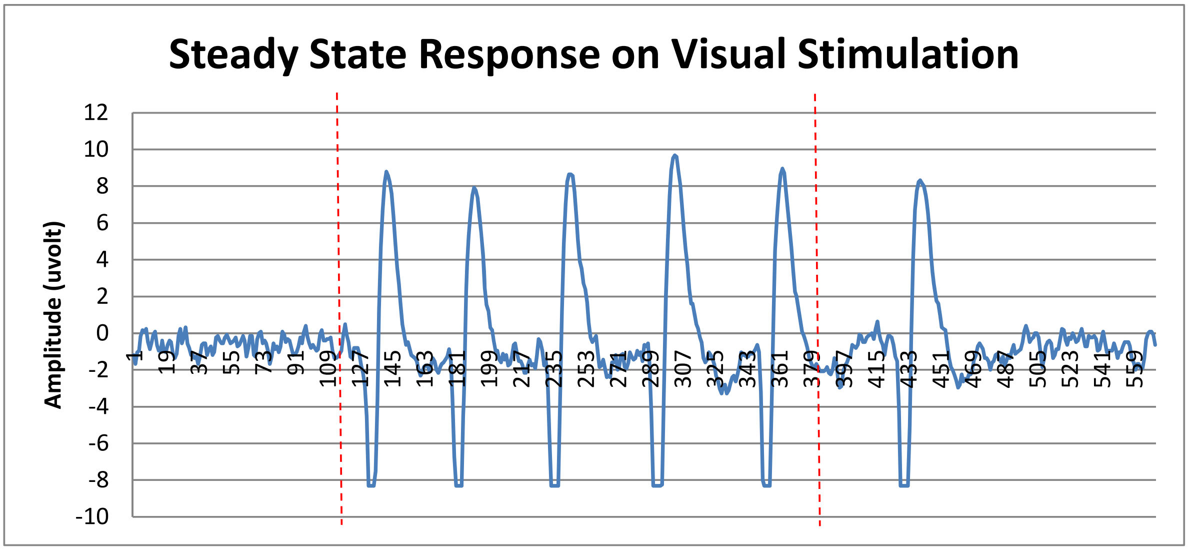

Fig 8 Steady state response on visual stimulation

This paper investigated the activities of alpha wave brain signal on visual stimulating. Alpha waves are reduced with open eyes and during periods of eyes closed are the strongest EEG brain signals. Alpha waves is the most suitable signals to be integrated for FES stimulation as it consistency in producing electrical brainwave signals as recommended by [7] that each action will produce its own signal and this is the easy way to recognize the action done by subject by refer to the brain signal pattern. This fundamental study is further experiment to determine the characteristics of alpha waves during body activities movement.

Acknowledgements

This research is funded and supported by RMU, Universiti Teknologi MARA and Ministry of Higher Education under Fundamental Research Grant Scheme (FRGS 2012) for project 600-RMI/FRGS 5/3 (71/2012).

References

[1] Do, A.H., Wang, P.T., King, C.E., Abiri, A. & Nenadic, Z. 2011. "Brain-computer interface controlled functional electrical stimulation system for ankle movement". Journal of neuroengineering and rehabilitation, 8, 49.

[2] Domino, E.F., Ni, L., Thompson, M., Zhang, H., Shikata, H., Fukai, H., Sakaki, T. & Ohya, I. 2009. "Tobacco smoking produces widespread dominant brain wave alpha frequency increases". International Journal of Psychophysiology, 74, 192-198.

[3] Jacobs, G.D. and Friedman, R. 2004. EEG spectral analysis of relaxation techniques. Applied psychophysiology and biofeedback, 29, 245-254.

[4] Klimesch, W. 1999. EEG alpha and theta oscillations reflect cognitive and memory performance: a review and analysis. Brain research reviews, 29, 169-195.

[5] Moreno, J.C., Del Ama, A.J., De Los Reyes-Guzman, A., Gil-Agudo, A., Ceres, R. and Pons, J.L. 2011. Neurorobotic and hybrid management of lower limb motor disorders: a review. Medical & biological engineering & computing, 49, 1119-1130.

[6] Pfurtscheller, G., Muller-Putz, G.R., Scherer, R. and Neuper, C. 2008. Rehabilitation with brain-computer interface systems. Computer, 41, 58-65.
[7] Rahman, K., Ibrahim, B., Leman, A. & Jamil, M. 2012. "Fundamental study on brain signal for BCI-FES system development", Biomedical Engineering and Sciences (IECBES), 2012 IEEE EMBS Conference on, 2012. IEEE, 195-198.
[8] Teplan, M. 2002. Fundamentals of EEG measurement. Measurement science review, 2, 1-11.