UNIVERSITI TEKNOLOGI MARA

EEG SUB-BAND FREQUENCY ANALYSIS OF SPECTROGRAM IMAGE FOR BALANCED BRAINWAVE AND IQ APPLICATIONS

MAHFUZAH BINTI MUSTAFA

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CONFIRMATION BY PANEL OF EXAMINERS

I am certify that a panel of examiners has met on 22th May 2014 to conduct the final examination of Mahfuzah Mustafa on her Doctor of Philosophy thesis entitle "EEG Sub-band Frequency Analysis of Spectrogram Image for Balanced Brainwave and IQ Applications" in accordance with Universiti Teknologi MARA Act 1976 (Akta 171). The panel of examiners recommends that the student be awarded the relevant degree. The panel of examiners was as follows:

Mohd Dani Baba, PhD
Professor
Faculty of Electrical Engineering
Universiti Teknologi MARA
(Chairman)

Zakaria Hussain, PhD
Senior Lecturer
Faculty of Electrical Engineering
Universiti Teknologi MARA
(Internal Examiner)

Herlina Abdul Rahim, PhD
Associate Professor
Faculty of Electrical Engineering
Universiti Teknologi Malaysia
(External Examiner)

Riza Muhida, PhD
Associate Professor
Surya Research and Education Center
Surya University
(External Examiner)

SITI HALIJJAH SHARIFF, PhD
Associate Professor
Dean
Institute of Graduate Studies
Universiti Teknologi MARA
Date: 10th October, 2014

ABSTRACT

This thesis introduces new methods in analyzing Electroencephalogram (EEG) signal by utilizing EEG spectrogram image and image processing texture analysis called Gray-level Co-occurrence Matrices (GLCM). The methods attempt to apply in balanced brain and Intelligence Quotient (IQ) applications. The relationship between balanced brain and IQ application also proposed in this thesis. Collection of EEG signals were recorded from 101 volunteers. EEG signals recorded for the balanced brain application contain closed eyes state meanwhile for the IQ application contains closed eyes and opened eyes state. Before processing the information from the EEG signals, signal preprocessing is done to remove artefacts and unwanted signal frequencies. A time-frequency based technique called EEG spectrogram image was used to generate an image from EEG signal. The spectrogram image was produced for each EEG signals sub-band frequency Delta, Theta, Alpha and Beta. The GLCM texture analysis derives features from EEG spectrogram image. Then, Principal Component Analysis (PCA) was applied to reduce the results and selected principal components features were used as inputs to the classifier. Two classifiers involved in this experiment are K-Nearest Neighbor (KNN) and Artificial Neural Network (ANN). The number of training and testing ratio is assessed at 70 to 30 and 80 to 20 to find the best model based on percentage of accuracy, sensitivity, specificity as well as Mean Squared Error (MSE). The relationship pattern of balanced brain and IQ application were observed via histogram and then Scatterplot. The strength and significant of the relationship was evaluated by using Pearson correlation test. The percentage of correctness classification for balanced brain application is 90% and MSE 0.1. The sensitivity and specificity of this application is ranging from 66.67% to 100%. The accuracy for IQ application is 94.44% and MSE 0.0752. Meanwhile, the sensitivity and specificity of this application is ranging from 0% to 100%. The relationship between balanced brain and IQ achieved with positive and strong correlation with r ranging between 0.860 to 1.000 and $p<0.05$ for some cases. The experiments reported in this thesis showed that the proposed technique were highly successful in indexing the balanced brain level and IQ.

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND

Biomedical engineering is a field of study where principles of engineering design and problem solving skills are applied to biological and medical sciences, which consequently have helped improve healthcare diagnosis, monitoring and therapy. There have been numerous studies in the field that have resulted in the fabrication and production of electronics devices that assist medical practitioners in diagnosing the health of their patients. One such device is the Electroencephalogram (EEG) which is used to analyse the human brain. The device captures brainwaves in the form of electric signals which are generated from the activities of neurons in the brain. The brainwaves, usually classified into four frequency bands called Delta, Theta, Alpha and Beta signals, are widely used for diagnosis of epilepsy, tumor and Alzheimer [1-3], while some studies have used brainwaves for determining the levels of balanced brain [4, 5] and Intelligence Quotient (IQ) [6, 7] applications. In this thesis, EEG signals from the brainwaves is used to determine the levels of balanced brain and IQ in a human being. The research on balanced brain is inspired from the studies of brain dominance between the left and right hemispheres of the brain. In a high balanced brain situation, both the left and right hemispheres of the brain are optimally used; on the contrary, in a low balanced brain situation, one uses more of the left hemisphere of the brain, or vice-versa. Additionally, the studies on IQ is focused on areas of Mathematics and logic; high IQ means good knowledge and understanding in Mathematics and logic, and, on the contrary, low IQ means less knowledge and understanding in Mathematics and logic.

The original EEG signal, which is in time-domain, have to be converted into frequency-domain before it can be analysed according to the Delta, Theta, Alpha and Beta frequency bands;the signals that lie outside the range of the four frequency bands is called noise or artefact. In some studies, all four frequency bands are utilised in the analysis, such as in the experiment conducted to analyse the development of the right