DETECTION OF ENTROPY CHANGES IN BRAIN FUNCTION USING ELECTROENCEPHALOGRAM

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PROJEK SARJANA MUDA II

Tajuk Projek : **DETECTION OF ENTROPY CHANGES IN BRAIN FUNCTION USING ELECTROENCEPHALOGRAM**

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To my beloved parents and sisters

ACKNOWLEDGEMENT

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ABSTRACT

Electroencephalography (EEG) is used to measure human brain electrical activity and analyzing is done mainly by visual inspection and years of training. However, the constraint of the traditional method brought on by the subjective nature of brain signal. Therefore, in this project, a recommendation on the better approach in quantifying the degree of order in a signal is hoped to be produced. Two approaches (The Fourier spectral entropy and the wavelet entropy) will be studied in quantifying the degree of order in a signal. Performance of each method will be justified and summarized. A recommendation on the better approach between the two methods in quantifying the degree of order in a signal is expected to be produced. Difference in results using the two methods to quantify the degree of order in a signal can be determined.

ABSTRAK

Electroencephalography (EEG) digunakan untuk mengukur aktiviti elektrik dalm otak manusia dan penganalisasian dilakukan dengan kaedah permerhatian and pengalaman. Walau bagaimanapun, sifat subjektif isyarat otak menjadi halangan kepada penggunaan kaedah tradisional. Oleh itu, dalam projek ini, satu cadangan kepada pendekatan yang lebih baik dalam mengukur tahap susunan dalam isyarat diharap dapat dihasilkan. Dua pendekatan (Fourier spektrum entropi dan wavelet entropi) akan dikaji untuk mengukur tahap susunan dalam isyarat. Prestasi setiap kaedah akan dijelaskan dan diringkaskan. Pendekatan yang lebih baik antara kedua-dua kaedah dalam mengukur tahap susunan dalam isyarat dijangka akan dihasilkan. Perbezaan dalam keputusan menggunakan kedua-dua kaedah untuk mengukur tahap susunan isyarat boleh ditentukan.

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List of Abbreviation

EEG	-	Electroencephalogram
ERP	-	Event Related Potential
FFT	-	Fast Fourier Transform
PSD	-	Power Spectral Density
CWT	-	Continuous Wavelet Transform
SE	-	Shannon Entropy

CHAPTER 1

INTRODUCTION

This chapter contains the basic introduction to the project together with the problem statement. Objectives, scope, and simple explanation on methodology will be stated in this chapter.

1.1 Introduction

Human brain electrical activity can be measured from the scalp, in a non-invasive way, by means of electroencephalography (EEG). Recently, oscillatory EEG activity has been discussed in relation with functional neuronal mechanisms. In this regard, it is of major interest to investigate how brain electric oscillations get synchronized in pathological or physiological brain states (e.g., epileptic seizures, sleep–wake stages, etc.), or by external and internal stimulation (event related potentials (ERP) or evoked potentials (EP)). This issue can be addressed by applying methods of system's analysis to the EEG signals, because changes in EEG activity occur in temporal relation to triggering events, and could be thought of as transitions from disordered to ordered states (or vice versa).

1.2 Objectives

(a) To analyse the EEG signal by the two entropy measures (The Fourier spectral entropy and the wavelet entropy)

(b) To recommend a better approach between the two entropy measures in quantifying the degree of order in a signal

1.3 Problem Statement

The traditional way of analyzing brain electrical activity, on the basis of Electroencephalography (EEG) records, relies mainly on visual inspection and years of training. Although it is quite useful, one has to acknowledge its subjective nature that hardly allows for a systematic protocol.

1.4 Scope

Two approaches (The Fourier spectral entropy and the wavelet entropy) will be studied in quantifying the degree of order in a signal. Performance of each method will be justified and summarized.

1.5 Brief Methodology

Matlab analysis will be done to the brain signal by using the two entropy measures. The better approach will be recommended and will be justified.

1.6 Report Structure

The five chapters in this report are the Introduction, Literature Review, Methodology, Result and Discussion, Conclusion and Future Work. Literature review will be on the reading and studies in the project whereas Methodology will be on the process and steps to achieve the project's objectives. Project results will be presented and analyse in Result and Discussion. Project overall conclusion and suggested improvement will be presented in Conclusion and Future Work.

CHAPTER 2

LITERATURE REVIEW

This chapter contains some of the reading that consists mainly of Internet journal. Books and online website are also parts of the reading but are not stated in this report.

Rosso, Martin, and Plastino [1] found that the wavelet entropy, being independent of the amplitude or the energy of the signal, yields new information about EEG signals in comparison with that obtained by using frequency analysis (Fourier analysis). The wavelet entropy has the advantages of in contrast to the spectral entropy; the total wavelet entropy is capable of detecting changes in a non-stationary signal due to the localization characteristics of the wavelet transform.

In the thesis presented by Basar [2], the abstract method for analysis of brain signal is as follow:

(a) Methods to analyse brain states

(i) Power Spectral Density

(ii) Cross Correlation

(iii)Cross Spectrum

(iv)Coherence

(b) Methods to analyse evoked brain activity

(i) Transient Response Analysis

(ii) Frequency Analysis

(iii)Response Adaptive filtering

(iv)Combined EEG-EP Analysis

(v) Evoked Coherence

(c) New emerging methods to analyse event related oscillations

(i) Wavelet Analysis

(ii) Wavelet Entropy

(iii)Single Sweep Wave Identification

(iv)Event Related Oscillations

(v) Study of nonlinearities and chaos approach

The work from thesis [3] describes the use of quantitative parameters derived from the orthogonal discrete wavelet transform as applied to the analysis of brain electrical signals. The relative wavelet energy provides information about the relative energy associated with different frequency bands present in the EEG and enables one to ascertain their corresponding degree of importance. The normalized total wavelet entropy carries information about the degree of order/disorder associated with a multi-frequency signal response. In addition, the time evolution of these quantifiers gives information about the dynamics associated with the EEG records.

According to Quiroga, Ross, Basar, Schurmann [4], the information obtain with the wavelet entropy proved to be not trivially related to the energy and consequently the amplitude of the signal. In particular, the wavelet entropy gives a quantitative characterization of EEGs, its physiological interpretation being very rich due to its relation to order, frequency synchronization and tuning.

This study of [5] demonstrates that wavelet entropy is physiologically meaningful since it differentiated specific physiological brain states under spontaneous or stimulus-related conditions. Significant decrease in the wavelet entropy was observed in the post-stimulus epoch, indicating a more rhythmic and ordered behavior of the EEG signal compatible with a dynamic process of synchronization in the brain activity. In addition, time evolution parameters derived from wavelet entropy can identify the time localizations of dynamic processes in the post-stimulus epochs.

CHAPTER 3

METHODOLOGY

This chapter contains the steps and process to achieve the project objectives.

3.1 Data acquisition

Five subjects are involved in this part. Three 1 minute duration of brain signal for three different situations is acquired from every subject. The situations are:

(a) Subject is not introduced to any simulation. Data from this situation is used as baseline reference.
(b) Subject is introduced with an audio. Subject is required to push button when upon hearing a certain audio playback.
(c) Subject is introduced with the same audio as in (b). Subject is not required to do anything.

Mean value of the acquired data from all subject for all situation is obtained.

3.2 Fast Fourier Transform

Fast Fourier Transform (FFT) is performed on each mean data to transform the data into frequency domain to compute Power Spectral Density.

3.3 Power Spectral Density

The computed data from FFT is to be computed for its Power Spectral Density (PSD) to see how the power of signal is distributed over the frequency component.

3.4 Continuous Wavelet Transform

Continuous Wavelet Transform (CWT) is second approach to the mean data. This step is done to divide the data time function into wavelets.

3.5 Shannon Entropy

Shannon Entropy (SE) is performed to the outcome of PSD AND CWT to determine the uncertainty of the result from the two approach.

3.6 Comparison between the two approaches

After analyzing the signal by the two methods, comparison of the two results after performing SE will be done.

3.7 Recommend the better approach

The better method between the two entropy measures to analyze human brain signal will be recommended. Justification will be given to the recommendation.

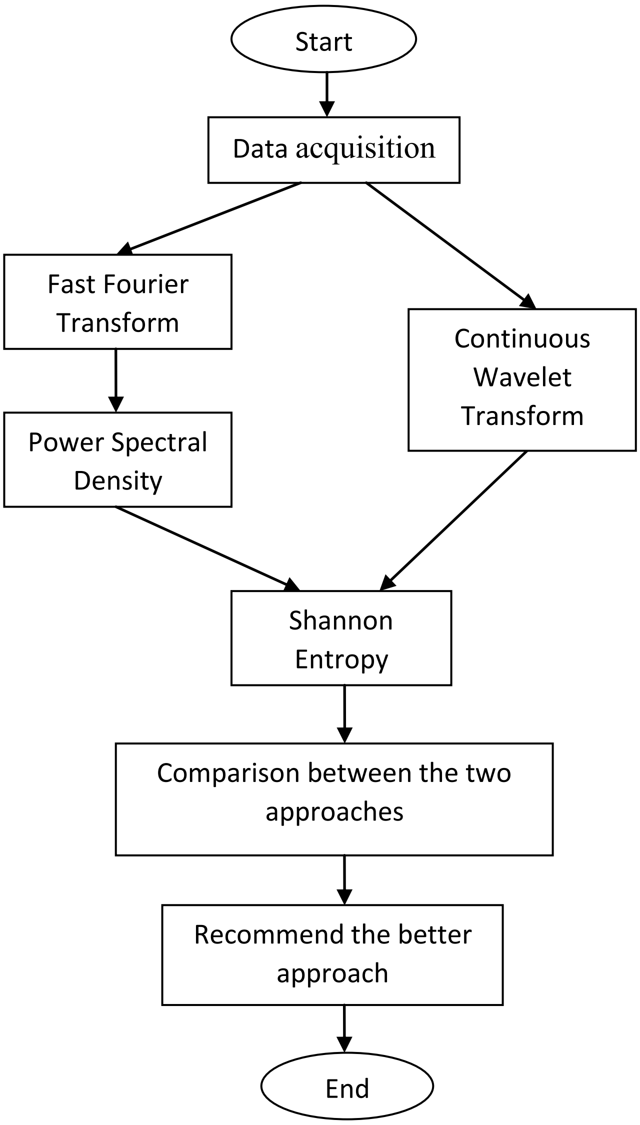

Figure 1: Flow chart of Project

CHAPTER 4

RESULT AND DISCUSSION

The result from the mean data, FFT, PSD, CWT, and SE of the two approaches will be shown and discuss in this chapter. The first section is on using 1 minute duration of data. The next section is on using 2 seconds duration of data to help better discussion on the result. The following section is of discussion for 1 minute duration result while the last section is of discussion for 2 seconds duration result. The main comparison will be done to situation (ii). The better approach will be recommended.

4.1 Result of 1 minute data

All the result using the 1 minute duration data is shown at this section.

4.1.1 Mean Data

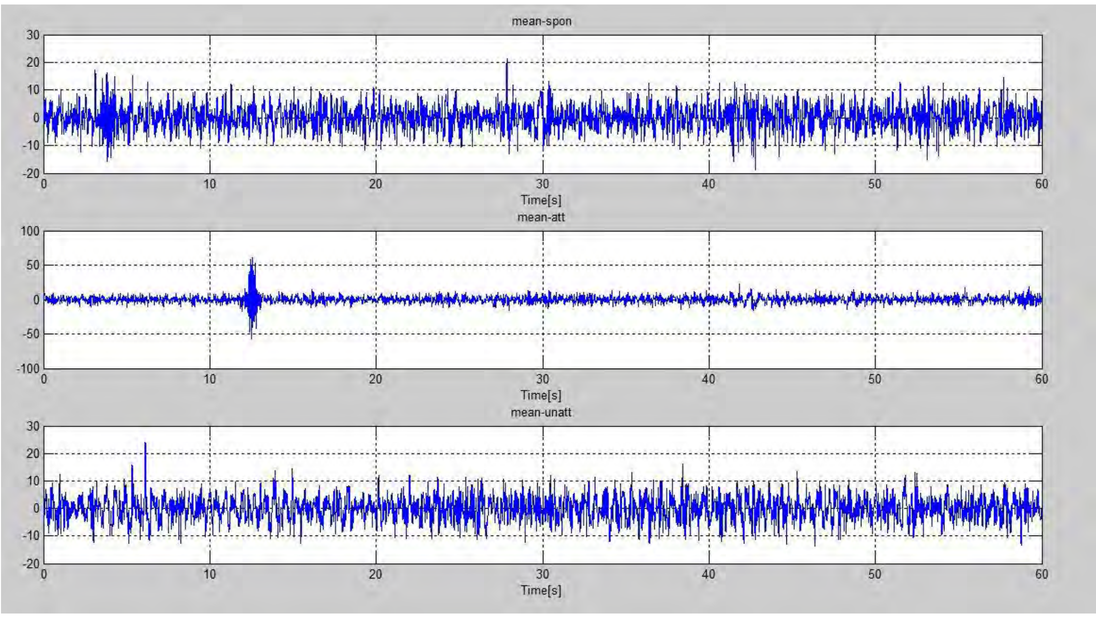

Figure 2: Mean Data of 1 minute duration

Figure 2 shows the mean value waveform of brain signal for each situation where situation (i) refers to first graph in the figure and respectively. From the figure, in situation (ii), around t=12s, there is a big difference in the waveform that matches the time when subjects are introduced to certain audio playback.

4.1.2 Fast Fourier Transform

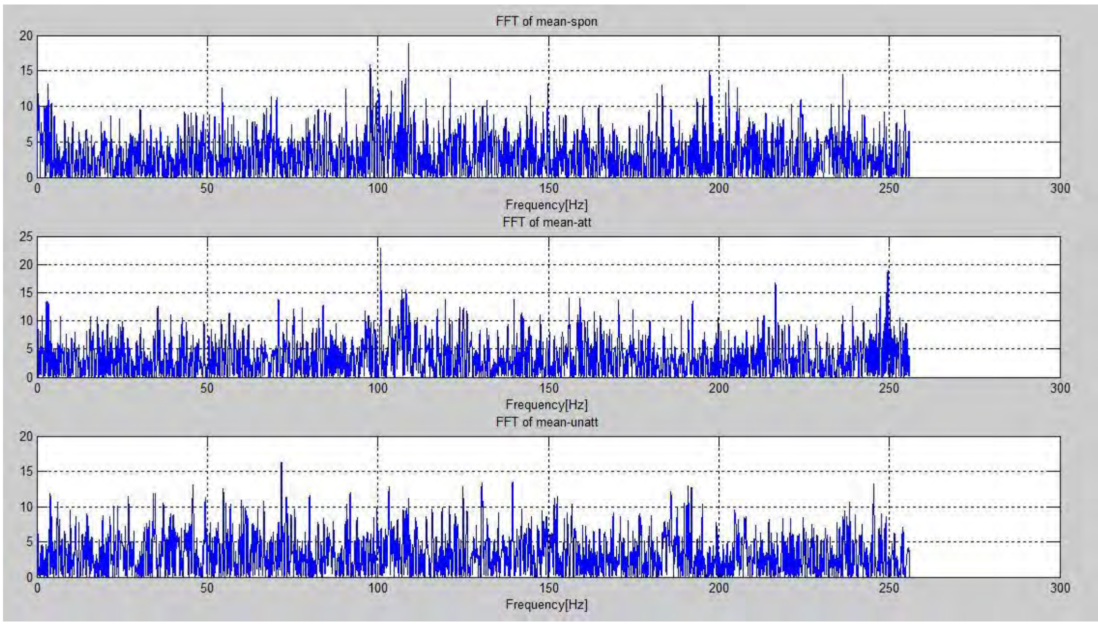

Figure 3: FFT of 1 minute duration

In order to perform SE onto the mean data, transforming the data representation into frequency domain is necessary. Figure 3 shows the mean value data in frequency domain. There is not much information to be obtained from this figure.