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Reducing Interference of Involuntary Movements In EEG Signal Analysis

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Abstract. Electroencephalogram (EEG) signal has conventionally been recorded with some devices, leads, an electrode cap, amplifier units, and A/D converters. The EEG signal can be contaminated by interference or sensor failures. Among the several artifact sources, an involuntary movement of patient is one of the main sources of interference in the EEG recording. The main objective of this study is to find the time of patient's movement and to reduce noise effects from involuntary movements.

Introduction

Brain is an electrochemical organ, functions as the portal for integrating and processing information and controlling center [1]. The electroencephalogram in today's science as a non-invasive method and with the capability of long term monitoring of the EEG signal, plays an important role in brain examination and study. Electroencephalography is the measurement of the electrical activity of the brain by means of placing electrodes on subject's scalp and recording the information. The resulting traces are known as EEG signals. The EEG signal measures the voltage differences between different parts of the brain. Some of the applications of EEG signals are to monitor and diagnose certain clinical situations, such as epilepsy, sleeping disorders and abnormal behavior [2]. The EEG signal ranges in frequency from 0.5-100[Hz], with amplitudes of 1-300[μV] measured at the surface of the skull [3]. The EEG signals are categorized into five basic groups which are delta (0.5-4 [Hz]), theta (4-8[Hz]), alpha (8-13[Hz]), beta (13-30[Hz]), and gamma (>30[Hz]) [4, 5]. Each signal is believed to have its own frequency rhythm which is intensely correlated to the physical, emotional and spiritual state of the human body. The EEG is very susceptible to various artifacts causing problems for analysis and interpretation. In current data acquisition, involuntary body movements are often dominant over other as well as external interferences due to power sources [6].

In this paper we use energy Es values of EEG signal to enhance the classification of signals between movements and normality during the test. Normal distribution of Es values was used to determine a threshold. In order to investigate the frequency rhythm a Fast Fourier Transform algorithm (FFT) was applied during fixed time interval.

In a frequency domain, involuntary movements almost bring about contaminations in delta band. To analysis the states of patients, contaminated dates caused by interference were discarded and replaced by averaged values using the Moving Average (MA) method with information of previous dates in a frequency domain. Averaged values were used for contaminated dates and extended available dates.

The main objective of this study was to indicate patient's involuntary movement and extend available data quantity for analysis in case there were involuntary movements.

This paper is organized as follows. In Section II, we briefly explain EEG Data collection process, signal energy, standard deviation, normal distribution, spectral analysis, Moving average. The results obtained are reported in Section III, followed by concluding remarks in Section IV.

Materials and Methods

An EEG Data Collection

Electroencephalography is a medical imaging technique that reads scalp electrical activity generated by brain structures [7]. They are a non-invasive measure of brain electrical activity which is represented as changes in potential difference between points on the human scalp [7] [8].The EEG data is obtained by placing electrodes on the scalp. In this study, we acquired 10 samples of EEG data with voluntary movements (Fig. 1).

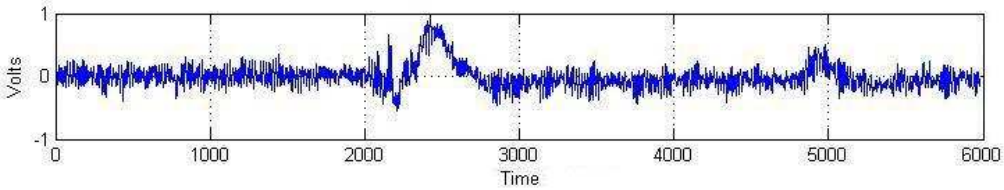

Fig. 1. EEG data acquisition with MP150

The 10-20 International Standard electrode placement system was used for EEG recording with enough sample rate (250 Hz). Electrode impedance was ensured to be below 5kΩ. All channels were referenced to the right earlobe and notch filtered at 60 Hz. Signals continuously were collected and processed while the subjects were free to move. The EEG signals were amplified using a MP150, version 3.8.1, BIOPAC System, Inc. and data acquisition was achieved using a Acqknowledge, version 3.8.1, BIOPAC System, Inc.

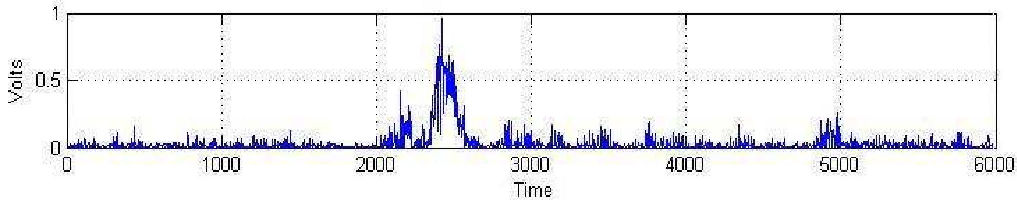

Fig. 2. Processed EEG data.

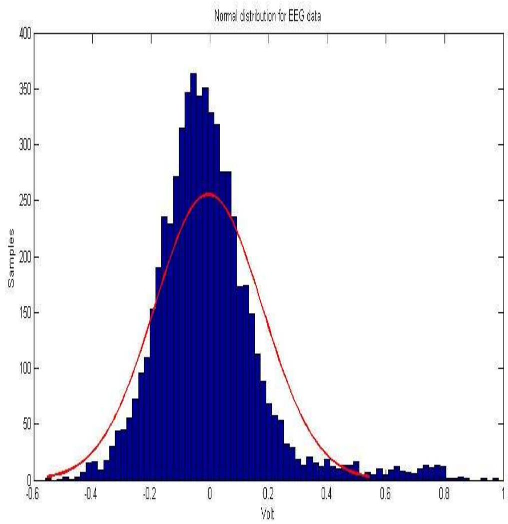

Fig. 3. EEG distribution.

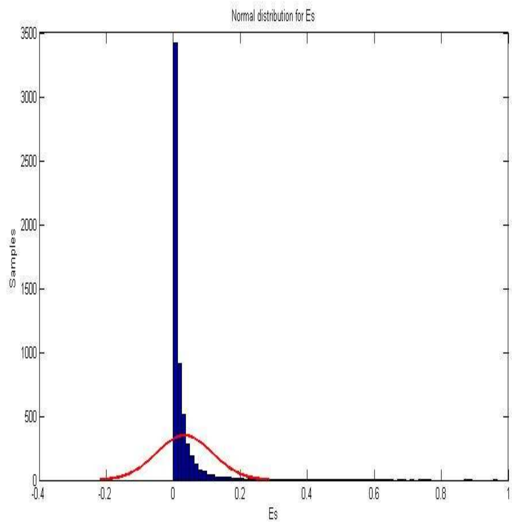

Fig. 4. Es distribution.

B Signal Energy

In this study, we applied energy Es value of EEG signal to check involuntary movements of patients. Values of Es would be high to threshold at the time of involuntary movements (Fig. 2). Population mean and population standard deviation of Es value during fixed time interval were applied for Normal distribution of Es value (Fig. 3,4) [9].

$$E_s = \int_{-\infty}^{\infty} |x(t)|^2 \, dt \quad (1)$$

where, $x(t)$ represents the potential of the electrical signal.

C Spectral analysis

In order to investigate the frequency rhythm during the test, spectral analysis is used (Fig. 5). Spectral analysis provides information about the presence of different frequencies in EEG that reflects the general arousal levels of the brain. Spectral analysis is typically performed with EEG segments by computing the Discrete Fourier Transform (DFT). DFT of the given EEG signal $\chi\ (n)$ is given by

$$\mathrm{X}(k) = \sum_{n=0}^{N-1} x(n)\, exp\left(-j\frac{2\pi}{N}kn\right) \quad k = 0, 1, 2, \ldots, N-1 \quad (2)$$

where N is the number of EEG samples taken for analysis. The DFT is typically computed using the FFT which computes the Fourier transform coefficients $X(k)$ quickly.

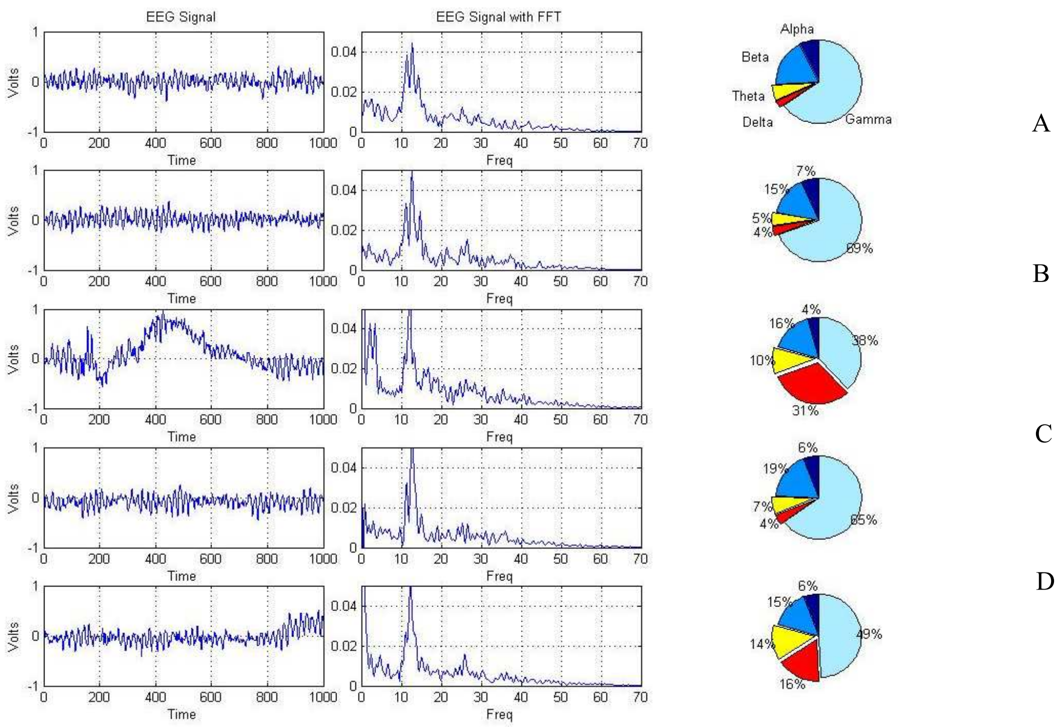

Fig. 5. Spectral analysis by interval.

D Moving Average

A moving average is a type of finite impulse response filter used to analyze a set of data points by creating a series of averages of different subsets of the full data set [10]. Given a series of numbers and a fixed subset size, the moving average can be obtained by first taking the average of the first subset. The fixed subset size is then shifted forward, creating a new subset of numbers, which is averaged.

Result

With selected threshold using distribution of EEG and Es, A Suggested method indicates 4-s EEG epochs of patient's involuntary movements even voluntary movements. After FFT transform process contaminated data in a low frequency a delta band and a theta band caused by interference are discarded by threshold. Fig. 6 shows expected values replaced for contaminated data using MA method. We had more 2 epochs to verify the states of patients then before. This method could extend a total amount of useful data and considerably enhance reliability of EEG tests, if there were involuntary or voluntary movements.

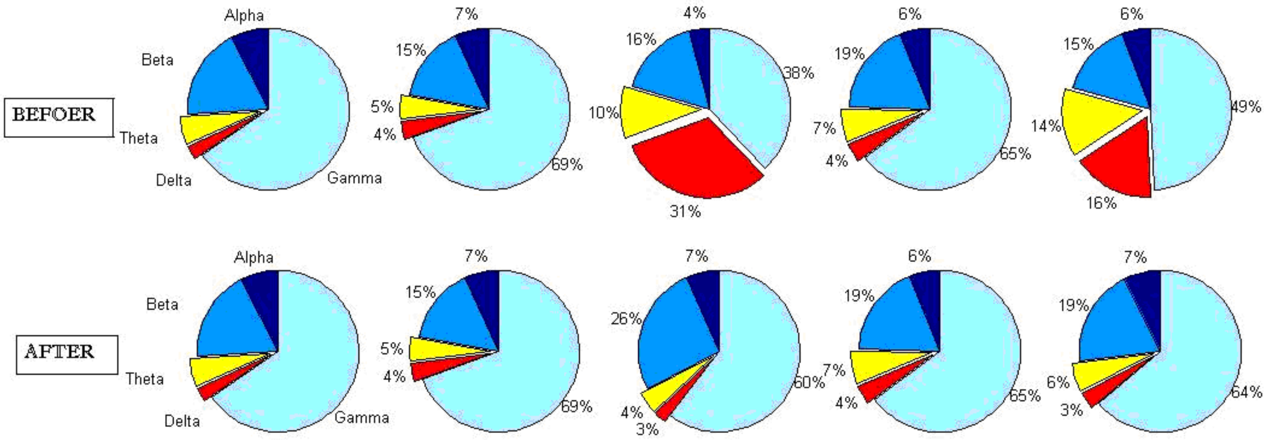

Fig. 6. Moving Average of FFT data

Conclusion

In this paper we consider an involuntary movement of patients is one of the main sources of interference in the EEG recording. From this reason, we replaced contaminated data which is in a low frequency with averaged data after FFT process. With FFT and MA method, an increased number of data is applied to verify the states of patients compare with unprocessed data and enhances a reliability of decisions for the states of patient. Therefore, this method can be applied to EEG practical application likely a ploysomnogram or EEG tests during physical activities.

This method however requires the better threshold to verify contaminated data epochs. We think of improving methods using a neural network which will enable us to improve the threshold.

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