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An Efficient Lossless Algorithm for EEG Signal Compression using Wavelet Transform

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ABSTRACT:

Transmission of biomedical signals through communication channels is being used increasingly in the clinical practice. This technique requires to deal with large volumes of information. The electroencephalographic (EEG) signal is an example of this situation. In the EEG, various channels are recorded during several hours, resulting in a great demand of storage capacity or channel bandwidth. This situation demands the use of efficient data compression systems. The objective of this work is to develop an efficient algorithm for EEG lossless compression. In this algorithm, the EEG signal is segmented and then decomposed through Wavelet Packets (WP). Extensive experimental tests were made by applying the algorithm to EEG records and measuring the compression rate (CR). The WP transform showed a high robustness, allowing a reasonably low distortion after the compression and decompression process, for CR typically in the range. The algorithm has relatively low computational cost, making it appropriate for practical applications.

1. INTRODUCTION:

Electroencephalography is the bio-signal which deals with recording the electrical activity of the human brain. It can produce the signals of up to 256 channels of up to 32 bps each, and it is sampled at the frequency of 1000Hz [5]. The EEG is used in the evaluation of brain disorders and it is used to find the brain damage. It has a high temporal resolution but poor spatial resolution. It can be efficiently stored and also transmit the huge amount of EEG signal by using the compression techniques. EEG compression has two types. They are lossy compression and lossless compression.

In the medical applications, transmitting the large amount of data through the compressed form. An excellent way to determine the performance by lossless EEG compression techniques.

Lossless data compression techniques allow perfect reconstruction of the original waveform; they yield the high compression ratios. There is some kind of quantization of the input data which leads to compression ratio. The lossless compression has the effective and economic data storage along with real time transmission of the signals. The most efficient data compression technique is the lossless data compression techniques. The efficient compression algorithms are required for the fast transmission of signals. So the signals are compressed before transmission with better accuracy.

The Wavelet Transform is the tool to find signal compression application. In Wavelet Transform analysis, the given equation for wavelet mentioned below.

A signal s (t) can be described by a linear decomposition method as,

S (t) = ∑∑, cj,k(t) (1)

Where j, k ∈ Z are integer indexes, aj,k are the wavelet

Coefficients of the expansion, and cj, k is a set of wavelet

Functions in it.

The paper is organized as follows: Section II discusses about the methodology, applied; detailing the clinical data used for the study and various data pre-processing, feature extraction techniques. Section III, the evaluation procedure and the obtained experimental results are presented. Finally, further discussion and conclusions are included in Section IV.

2. MATERIALS AND METHODS:

In this work, EEG data sets are analyzed by wavelet transform to decompose the signal in order to extract five physiological EEG bands, delta (0–4Hz), theta (4–8Hz), alpha (8–13 Hz), beta (13–30 Hz), and gamma (30–60 Hz).

Then features were extracted from both wavelet decomposed and raw EEG data. The block diagram of proposed approach is shown in fig.1

2.1. DATESET:

On the layout to assess the proposed method, experiments are performed on publicly obtainable EEG dataset (CHB-MIT) which is described in the Children's Hospital Boston, consisting of EEG recordings from pediatric subjects with intractable seizures.

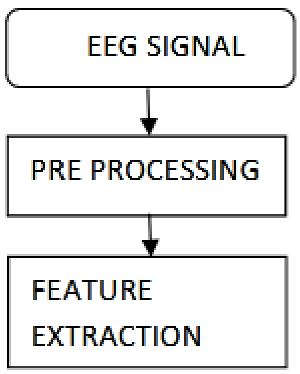


Fig.1 Block diagram of proposed approach

2.2. FEATURE EXTRACTION:

The feature extraction process is a crucial step in processing non-stationary EEG signals because it reduces the space dimension and improves the accuracy of the classification process.

2.2.1. Frequency domain:

EEG signal has non-stationary and transient characteristics. Thus, using only time domain feature is not enough to diagnosis. Moreover, frequency is one of the top fundamental characteristic of the EEG signal. In order to extract the synchronization character of EEG signal in frequency domain, the paper filters the EEG signal with wavelet Transform algorithm to do signal transformation of each epoch data and get the amplitude of the entire frequency component.

2.3. SOFTWARE

MATLAB SOFTWARE

MATLAB (Matrix Laboratory) is a programming language developed by math works and understanding concepts like variables, constant, expressions, statements, etc.

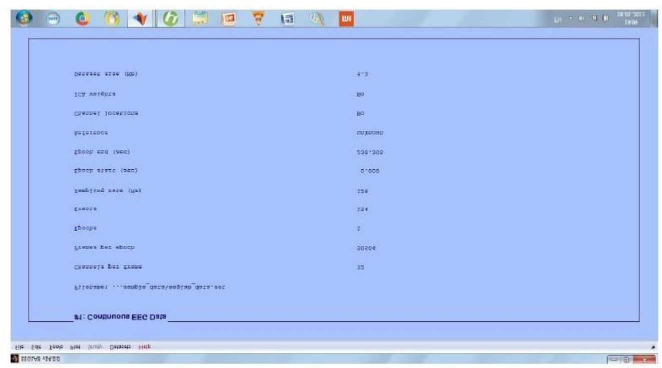
It integrates computations, visualization and programming in an easy-to-use environment where problems and solutions are expressed in failure mathematical notations. It is a technical computing environment for high performance numerical computation and visualization. MATLAB allows us to express the entire algorithm in few dozen of lines, to compute the solutions great accuracy display of the in color.

2.3.1. *CHARACTERISTICS OF MATLAB*

Programming language based on matrics

- *Automatic memory management, easy to use*
- *Compact*
- *Many application-memory-specific tool boxes available*

2.3.2. *MATLAB EEG LAB*



EEG lab is an interactive MATLAB tool box for processing continuous and even related EEG, MEG and other electrophysiological. The toolbox called ICA/EEG toolbox. Analysis of data as an individual dataset containing multiple dataset could be with the help of MATLAB. It makes use of flexibility and range offered by MATLAB for scripting. The toolbox is counted among the most widely-used signal processing environment by EEG data processing.

3. RESULTS:

This algorithm compares the compression rate of different EEG database and obtain the power spectral density of Alpha, Beta, Gamma, Theta and Delta of EEG band.

3.1. Performance measures:

Compression rate (CR) is defined as,

$$CR = \frac{\text{Signal storage demand before compression, bytes}}{\text{Signal storage demand after compression, bytes}}$$

Finally this paper proposed the lossless EEG signal compression algorithm for various datasets all of them are based on CHB-MIT Scalp EEG Database. It is summarized in the Table1

CASE	COMPRESSION RATE
Chb03_34	2.72
Chb20_22	2.38
Chb24_07	2.00
Overall	2.366

Table 1: Patient- by-patient compression rates for database

CHB

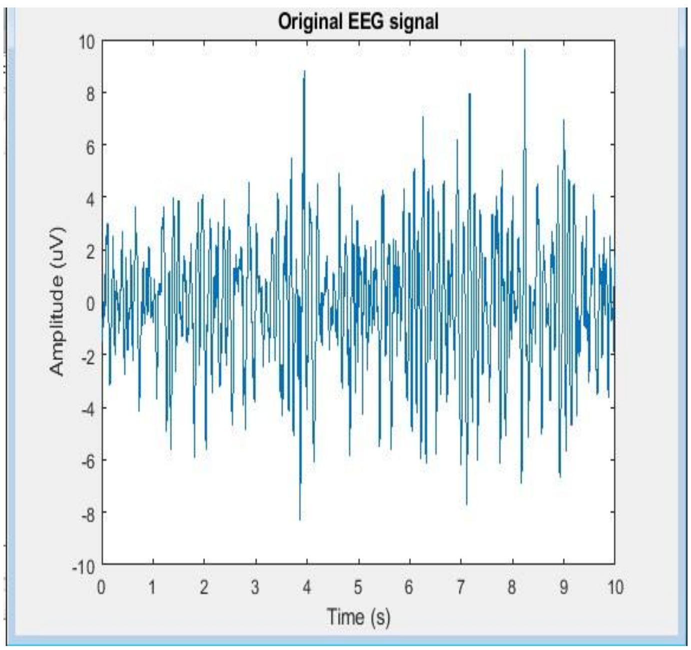


Figure 1.Original EEG Signal

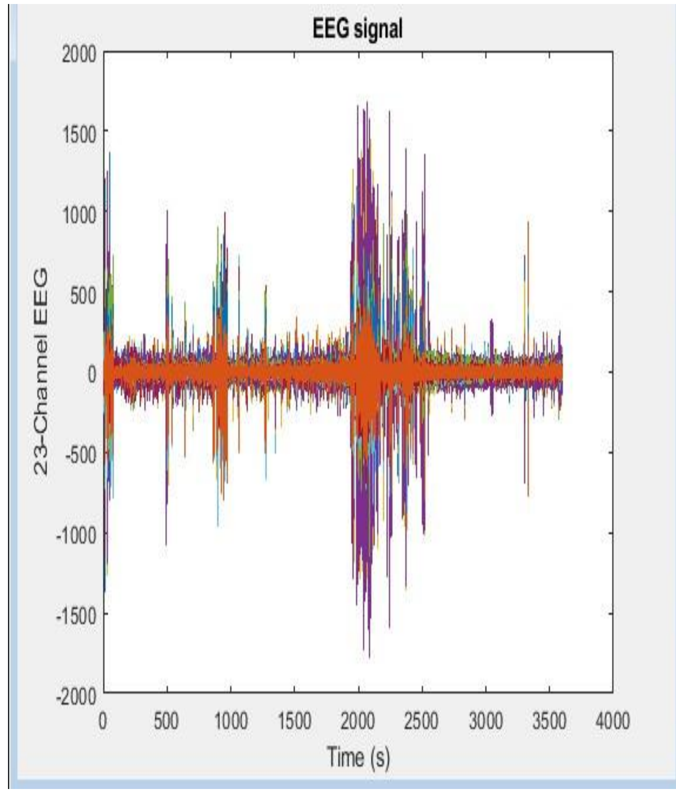


Figure 2.Compressed EEG Signal

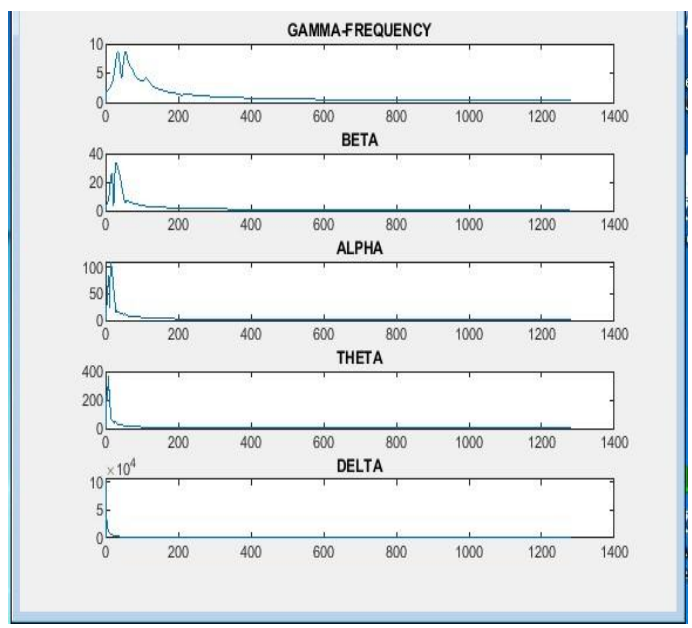


Figure 3.Wavelet Decomposition

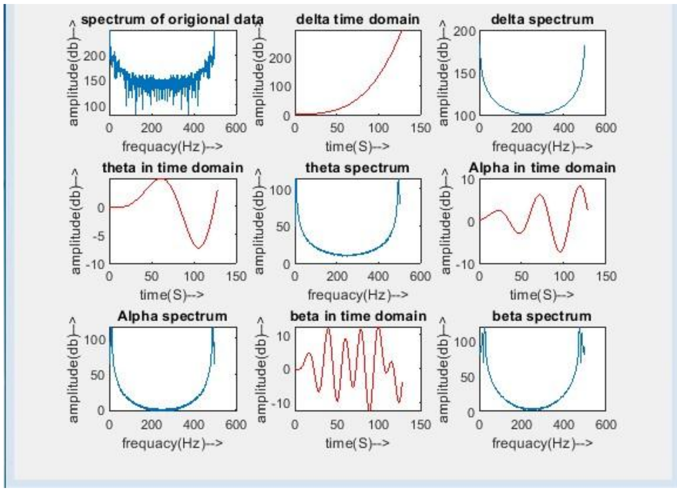


Figure 4.Power Spectral Density in Time Domain

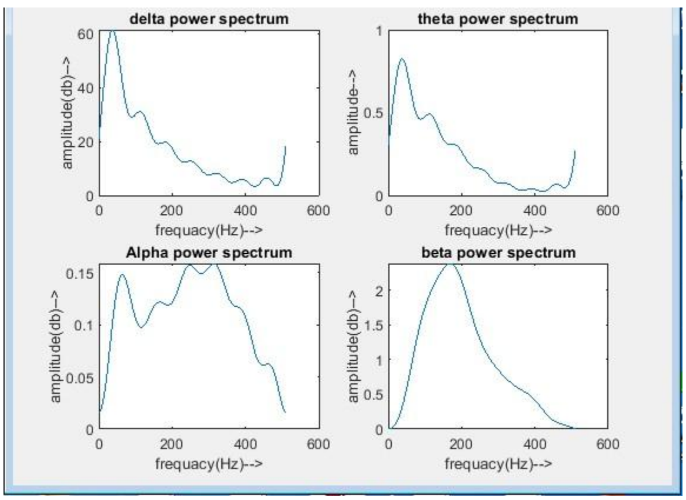


Figure 5.Power Spectrum of EEG Bands

4. CONCLUSION:

The EEG signal is compressed using the lossless compression such as wavelet transform with BAYES wavelet and the arithmetic coding technique. The performance parameters like Compression Rate (CR) and Power Spectral Density(PSD) are used to evaluate the performance of the proposed method. Different methods are used to analyze the performance which is compared by evaluation parameters. The proposed method shows the better result in which the compression ratio is 2.86. This algorithm is easily programmable and it has low computational load. It will make easy for storage and transmission of EEG signals and used in real time applications. In future the compression result can be improved by using different approaches without increasing the computational burden.

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