EEG SIGNAL COMPRESSION USING WAVELET BASED ARITHMETIC CODING

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***ABSTRACT*:**

EEG is to record the electrical activity of the human brain. The compression of EEG signal is the greatest interest to many applications in the biomedical community. Lossless compression of EEG is to recover the data for diagnostic and analysis purposes .The objective is to develop an efficient algorithm EEG lossless compression. It uses the wavelet based transform followed by arithmetic coding on the residual. From this we find the performance measurement parameters for the EEG signal such as compression ratio (CR), percent root mean square distortion (PRD).

KEYWORDS:

EEG, Wavelet Transform, Arithmetic coder, quantizer, Compression ratio.

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.

EEG signals are analysed in two different ways: 1.visual inspection by human beings 2.automic analysis by using signal processing algorithms. In the medical applications, transmitting the large amount of data through the compressed form [1].

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 necessity of efficient data compression methods are widely used in biomedical signals. The transmitter and receiver predict the value of the current sample on the basis of samples which have already been transmitted [1]-[3]. If we denote the current sample by xi and its predicted value by $x_i\hat{}$, then for each sample only the prediction error, $e_i = x_i\hat{} - x_i$, needs to be transmitted. The EEG signal can be treated as a realization of a time series x_k generated as

$$x_k = \sum_{i=1}^{p} a_i x_{k-i} + e_k \qquad (1)$$

Where, e_k is the unpredictable part of x_k. In order to determine the auto regressive, an order P is chosen and then the parameter set $\{a_i, i = 1\ldots..,\ P\}$ is estimated. The Wavelet Transform is the tool to find signal compression application [4]. In Wavelet Transform analysis, the given equation for wavelet mentioned below.

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

$$S(t) = \sum_k \sum_j a_{i,j}\ c_{j,k}(t) \qquad (2)$$

wherej, k ∈ Z are integer indexes, $a_{j,k}$ are the wavelet coefficients of the expansion, and $c_{j,k}$ is a set of wavelet functions in t.

Transmission of biomedical signals through communication channels are used in some clinical practices [7]. This technique requires dealing with large amount of information, and the example is the EEG signal. Wavelet can be used to extract the information from different kinds of data, including audio signals and images.

The set of function is performed by the quantizer is called as quantization. The round off error in the quantization is termed to as quantization error. Quantization is present in all digital signal processing and it is the process of representing a signal in digital form and rounding off the values.

Compression is used to reduce more files and it is also easy to handle. Compression is done by encoding and the data can be obtained in the original form by decoding. Lossless compression methods are categorized by the type of data and then they get compress [8]. Some of the commonly used Lossless coding techniques are Run length encoding**,** Huffman encoding, Arithmetic encoding, Entropy coding.

Arithmetic coding is a widely used in entropy coding scheme, it generates the sequence of intervals by the probability of the symbols in the sequences. This has the small interval at the end of last symbol and the code is generated by selecting a real number from the interval and converted them to binary. Then the code values are uniformly distributed.

PROPOSED METHOD:

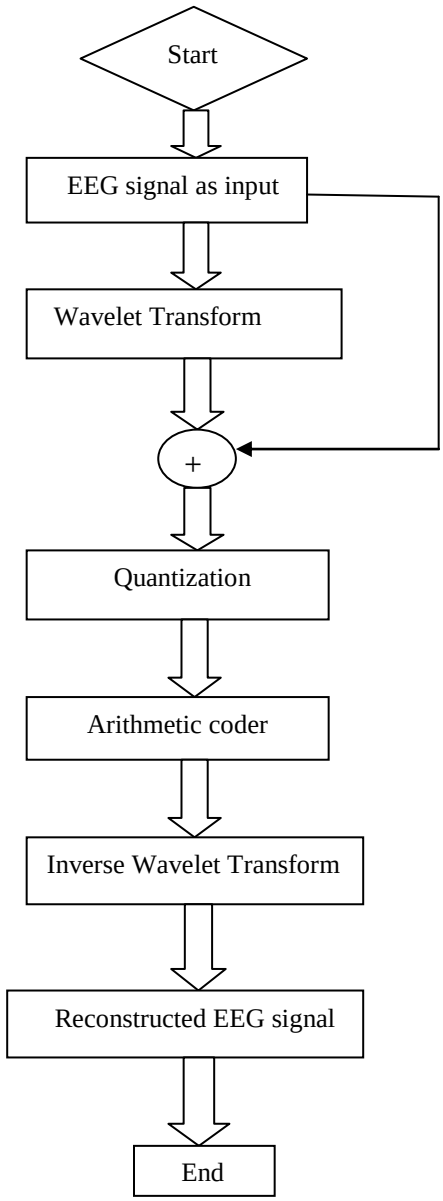

Fig 1: Flowchart for EEG Signal Compression

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ALGORITHM:

STEP 1: EEG signal is taken as input for our compression techniques.

STEP 2: Wavelet transform is applied to the input signal.

STEP 3: Now add both the original EEG signal and wavelet transformed output.

STEP 4: Then the output signal is quantized for eliminating less significant values and save the memory space.

STEP 5: Arithmetic coding is applied for quantized output signal. This is used to reduce the coding redundancies present in the signal.

STEP 6: Inverse wavelet transform is applied.

STEP 7: Finally, we get the reconstructed EEG signal is same as that of the original input signal.

WAVELET TRANSFORM:

It is the mathematical tool used in signal compression applications. It is a signal representation and it is used to recover the signal [4]. Wavelet transform is decomposing the signal to a set of functions called as wavelet. It is limited in small duration. Orthogonal, Biorthogonal, Atrous are the types of wavelet transform.

Lossless coding Techniques:

* Huffman coding
* Arithmetic coding
* Bit-plane coding
* Run-length coding

In this paper we are going to use the arithmetic coding for compression. We can use the wavelet for decompose the signals. It computes the inner products of a signal with the family of wavelet. The properties of wavelet are irregular in shape and also have finite in length. The wavelet transform has two tools and they are continuous and discrete wavelet tool.

The continuous wavelet for a signal has self similarity analysis and time frequency analysis [11]-[12] .The discrete wavelet for a signal to provide noise reduction, data compression.

QUANTIZATION:

It is the process of compressing the range of values to single value. It also maps the large set of input values to the smaller set of values. There are two ways to improve the effectiveness of quantization in wavelet coding. The first one is by introducing the quantization interval around zero and another is size of the quantization interval is adapted.

ARITHMETIC CODING:

In this arithmetic coding, it generates the non-block codes between the source and code symbols in which a code word is present in each source symbol. A group of source symbols are assigned to a single arithmetic code word. The code word defines an interval of the real numbers between 0 to 1.

When the number of symbols in the message get increases means two changes are happen they are,

1. The interval for the message becomes smaller and it is based on the probability of each symbol.
2. The number of bits represent in the interval becomes larger.

RESULTS AND DISCUSSIONS:

In this paper we applied an approach on wavelet transform and arithmetic coding. We have compared the performance of different terms of compression ratio and percent root mean square distortion. Wavelet transform analyses the signals in both spatial and temporal domain.

PERFORMANCE MEASUREMENTS:

COMPRESSION RATIO:

The ratio of original length to the compression length and it can be given as follows:

$$CR = \frac{L_{orig}}{L_{comp}} \quad (3)$$

PERCENT ROOT MEAN SQUARE DISTORTION:

PRD is the ratio of energy of the error signal to the energy of original signal. The PRD used in distortion measurement. It also gives the average distortion in the reconstructed signal.

$$PRD = \frac{\sqrt{\sum_{i=1}^{N} |x(i) - \tilde{x}(i)|^2}}{\sqrt{\sum_{i=1}^{N} x(i)^2}} \times 100 \quad (4)$$

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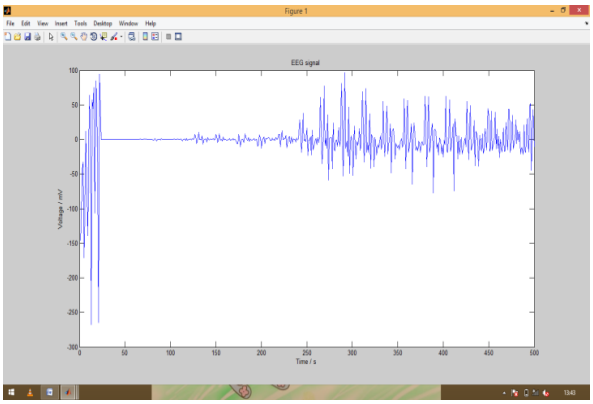

Fig 2: original EEG signal

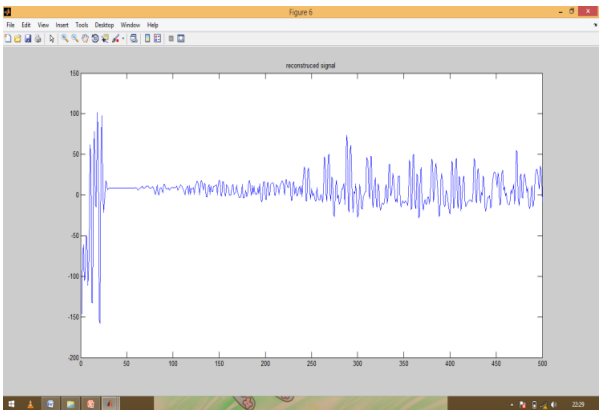

Fig 3: Reconstructed signal

TABLE I: Performance parameters

METHODS	***CR***	***PRD***
Arithmetic Coding	***0.7560***	***0.9351***
Arithmetic Coding based Wavelet Transform	***0.8403***	***2.8560***
Wavelet Techniques	***0.8080***	***0.770***
Proposed method	***1.8347***	***0.0802***

In this paper, EEG compression techniques are used for compressing the input EEG signal. The preferred compression methods are arithmetic coding and wavelet transform. The performance is evaluated using different parameters. Fig. 2 shows the original EEG signal. This signal is compressed by arithmetic coding and wavelet transform. The reconstructed signal is shown in fig.3. The analysis of compression ratio and percent root mean square for different methods is shown in TABLE I .The performance of the compressed EEG signals are measured. Different wavelet transforms are selected to compare the performance. Finally biorthogonal wavelet 3.5 with five scale decomposition levels gives the best compression result.

As the consequence, both PRD and CR vary from one signal values to another .There will be great signal variability, the algorithm gives better performance and expressed in a high CR, low PRD. From table 1, we can analyse the compression result with different techniques. Among that the proposed method gives the better compression ratio 1.8347 and PRD 0.0802.

CONCLUSION:

The EEG signal is compressed using the lossless compression such as wavelet transform with biorthogonal wavelet and the arithmetic coding technique. The performance parameters like CR and PRD 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 1.8347 and percent root mean square distortion is 0.0802. 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.

REFERENCES:

[1] K. Srinivasan, J. Dauwels, and M.R. Reddy, "Multichannel EEG compression: Wavelet-based image and volumetric coding approach," IEEE Journal of Biomedical and Health Informatics, vol. 17, no. 1, pp. 113–120, Jan 2013.

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[2] Priyanka Khatwani and Archana Tiwari "A survey on different noise removal techniques of EEG signal" IJARCCE,Vol 2,issue 2,Feb 2013.
[3] Julian L.Cardenas-Barrera, Juvan V.Lorenzo-Ginori and Ernesto Rodriguez – Valdivia,"A wavelet –packets based algorithm for EEG signal compression"Med.Inform(March 2004),Vol 29,No 1,15-27.

[4] Fabrizio ARGENTI ,Maurizio MASIERI and alexandro MECOCCI "EEG data compression by means of wavelets transform" DU 13 AU 16 SEP 1993.
[5] Ignacio Capurro, Federico Lecumberry, A´lvaro Mart´ın, Ignacio Ram´ırez, Eugenio Rovira, Gadiel Seroussi "LOW-COMPLEXITY, MULTI-CHANNEL, LOSSLESS AND NEAR-LOSSLESS EEG COMPRESSION"
[6] J. Dauwels, K. Srinivasan, M.R. Reddy, and A. Cichocki, "Near-lossless multichannel EEG compression based on matrix and tensor decompositions," IEEE Journal of Biomedical and Health Informatics, vol. 17,no. 3, pp. 708–714, May 2013.
[7] "An Adaptive error modeling scheme for the lossless compression of EEG signals", N.Sriraam C.Eswaran, IEEE transaction on Information Technology in biomedical, Vol.12 No.5, September 2008.
[8] G. Antoniol and P. Tonella, "EEG data compression techniques," *IEEE Trans. on Biomed. Eng.*,v44, 105– 114, 1997.
[9] K. Srinivasan, and M. R. Reddy, "Efficient pre-processing technique for lossless real-time EEG compression," *Electron. Lett.*, vol. 46, no. 1, pp. 26–27, Jan. 2010.
[10] Y. Wongsawat, S. Oraintara, T. Tanaka, and K.R. Rao "Lossless multi-channel EEG compression," in Proc. 2006 IEEE Int. Symp. Circuits and Systems, May 2006.
[11] S.Yea andW. Pearlman, "A wavelet-based two-stage near-lossless coder," *IEEE Trans. Image Process.*, vol. 15, no. 11, pp. 3488–3500, Nov.2006.
[12] J. L. C´ardenas-Barrera, J. V. Lorenzo-Ginori, and E. Rodr´ıguez-Valdivia, "A wavelet-packet based algorithm for EEG signal compression," *Inf. Health Social Care*, vol. 29, no. 1, pp. 15–27, 2004.

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