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A Wavelet Packet Denoising of Eeg Signal for High Speed Transmission

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Abstract:
Electroencephalography is the recording of spontaneous electrical activity of the brain used for the diagnosis of conditions such as seizures, epilepsy, head injuries, dizziness and brain tumours. EEG signals are low voltage signals that are easily contaminated by various types of noise such as eye blinking, hand movement etc which can lead to misdiagnosis of the disease. Thus denoising of EEG is a crucial task for the better diagnosis. In this study Wavelet Packet Denoising (WPD) method is used for improving the Signal to Noise Ratio of the EEG Signal. In the second part an attempt has been made to develop a high performance and multi channel EEG compression Algorithm using fast Discrete Cosine Transform (fDCT). And finally to provide high data security while transmission the Least Significant Bit Watermarking Technique (LSB) is applied on the EEG Signal.

Keywords: Electroencephalography, Fast Discrete Cosine Transform, Least Significant bit Watermarking, Signal to Noise Ratio Wavelet Packet Denoising.

I.INTRODUCTION

Electroencephalography (EEG) signal is the recording of spontaneous electrical activity of the brain over a small period of time. The language of communication with the nervous system is electric. The neurons of the human brain process information by changing the flow of electrical currents across their membranes. These changing currents generate electric and magnetic fields that can be recorded by placing electrodes on the surface of the scalp. The potentials between different electrodes are then amplified and recorded as EEG. Different types of EEG waves recorded are Alpha waves (7.5-14Hz), Beta waves (14-40Hz), Theta waves (4-7.5Hz), Delta waves (0.5–4Hz). Since EEG signals are having very small amplitudes, it can be easily contaminated by noise. The noise can be electrode noise or can be generated from the body itself. The noises in the EEG signals are called the Artefacts and these artefacts are needed to be removed from the original signal for the proper analysis. Other than electrode noise other artefacts affecting EEG signals during recordings are baseline movement, electromyography disturbance and so on. Various denoising techniques have been implemented for removal of the artefacts from the EEG signal. Some of the techniques are independent component analysis denoising. Principal component analysis method of denoising. In this paper we are introducing an efficient way to denoise EEG signals using Wavelet Packet decomposition based denoising. In the second part of the work we include the compression of EEG signal. High quality transmission of EEG signal is a basic problem to success of wireless health care system. To reach this goal the large amount of data must be transmitted. Practicably this consumes the large power and high quality EEG recordings are currently not feasible at large time. Therefore data reduction and data compression have a key role for decreasing the amount of information and consumption power. The compression of EEG signal is one of great interest to many in the biomedical community. There are mainly two types of compression methods namely lossless compression and lossy compression. Lossless compression methods are characterised by the type of data and then they get Compressed. Some of the commonly used lossless coding techniques are Run length coding, Huffman coding, Arithmetic coding, Entropy coding.EEG signals are simply measured from different electrode positions on human scalp. Therefore, the neighbouring channels of EEG signals usually have a high degree of similarity in their structures. In order to efficiently compress the multi channel data, this inter channel redundancy must be exploited. Computerised EEG monitoring system are generally, installed for continuous acquisition and digital storage of subjects, mural records over prolonged time periods at extremely high resolution and thus possess enormous data size. This may lead to large storage space for database construction more transmission bandwidth requirement in digital telehealth care systems for remote EEG signal. Compression of EEG data enables the representation of cardiac/neural signal with comparatively lower number of bits while retaining the important diagnostic information in reconstructed signal. Here a new efficient way of compression of EEG signal is introduced .We all know that Discrete cosine transform is a very popular unitary transform in modern digital signal processing. It is the most widely used transforms in the processing of biomedical data. Thus a Fast discrete cosine transform algorithm has been developed which provides a factor of six improvements in computational complexity when compared to conventional discrete cosine transform algorithm using the fast Fourier transform. In the final part of the work LSB based watermarking is done. Watermarking is a technique in which a digital signal or pattern is inserted into a digital image for security reasons. It can be easily applied to images, audio, video and to any software also. LSB is one of the simplest algorithm in which each 8 bit pixel's least significant bit is over written with a bit from the watermark. Although the number was embedded into the first 8 bytes of the grid, the 1 to 4 least bits need to be changed according to the embedded message. On the average, only half of the bits in an image will need to be modified to hide a secret message using a cover image. Since the quality of the watermarked image is low, changing the LSB of a pixel results in small changes. But these changes cannot be perceived by the human eye system.

II. PREVIOUS WORK

Various artefact removal techniques have been implemented for the removal of artefacts from the EEG signal. They are Linear Combination and Regression, Principal component Analysis Independent Component Analysis, Linear Filtering and Blind source Separation. The journal [2] works based on Linear combination and regression, which only removes the ocular artefacts of the EEG signal which is a complicated task. The main problem with this is the electrooculograph signal has to be subtracted from this EEG signal which may remove some parts of the EEG. The work [3] proposes a method to recover independent source signals after they have been mixed with unknown matrix. Since EEG is a multichannel signal it is difficult to perform this independent component analysis since the source are not independent. The journal [4] is useful for removing artefacts located in certain frequency bands i.e. low pass filtering can be used to remove Electromyogram artefacts and high pass filtering can be employed to minimise electrooculograph artefacts. The limitation is that this method won't work when the artefacts lie in the same frequency band. The journal [5] presents a generalized method that separate the EEG signals into components that build he EEG signal. The disadvantage is that specialist should be available to recognise and reject the artifactual components. Also this takes more time which can lead to cerebral activity distortion if will not be performed with great care.

III. PROPOSED METHOD

Wavelet packets are particular linear combination of wavelets. They form bases which retain many of the orthogonality, smoothness, and localization properties of their parent wavelets. Also wavelet packet transform is applied to low pass results (approximation) and high pass results(details).In this paper wavelet packet based denoising is taken into account by employing Daubechies wavelet of level 8.In wavelet decomposition we leave the high frequency part alone and keep splitting the low frequency part. But by using this wavelet packet decomposition both high frequency and low frequency components are splitted. So in general, wavelet packet decomposition divides the frequency space into various parts and allows better frequency resolution of the signals. After the decomposition denoising is done using discrete wavelet transform by selecting suitable thresholding. Here steins unbiased risk rule based thresholding is taken into consideration for the denoising purpose. This step is followed by performing the compression of the obtained EEG signal. Fast DCT algorithm is used as the compression method, Also computed the performance parameters such as signal to noise ratio and percent root mean square distortion. Finally for high security while transmission of these EEG signal watermarking is applied to the reconstructed signal. Least Significant Bit watermarking is used as a digital watermarking technique for the obtained signal.

IV. METHODOLOGY OF THE STUDY

1.DENOISING PROCEDURE

The sample data of EEG is obtained from the MIT-Arrythmia database. The wavelet packet decomposition algorithm is as follows:

- Generate wavelet packet tree by applying wavelet packet transform to the noisy signal.
- Compute the threshold value by using sure shrink rule. Then apply the threshold to the coefficients by using a thresholding filter selected and obtain modified coefficients.
- Use inverse wavelet packet transform to the thresholded coefficients and obtain denoised signal.

2. FAST DISCRETE COSINE TRANSFORM COMPRESSION.

Fast DCT uses real computations unlike the complex computations used in other compression methods. The Algorithm showing the Fast DCT operation is shown below:

- Each trial is partitioned into set of 8 samples.
- DCT transform is applied to every set of samples.
- 3 number R of last DCT coefficients is removed and a new shorter data vector is constructed.
- Removed coefficients are filled up with zeroes.
- Inverse DCT transform is applied to every set of coefficients.
- Percentage root mean square distortion of each trial is computed.
- Average PRD is computed.

3. LEAST SIGNIFICANT BIT WATERMARKING

- Initially our reconstructed EEG raw signal is selected and fixed as the base image for watermarking.
- An another image is taken as the watermarked image which will be added to the base image.Here ideal matlab image ' cameraman.tif' is taken as the watermarking image.
- The most significant bit will be read and these will be written on the least significant bit ,henceforth will be mentioned as LSB of base image .
- Thus watermarking is done resulting in the formation of watermarked signal.

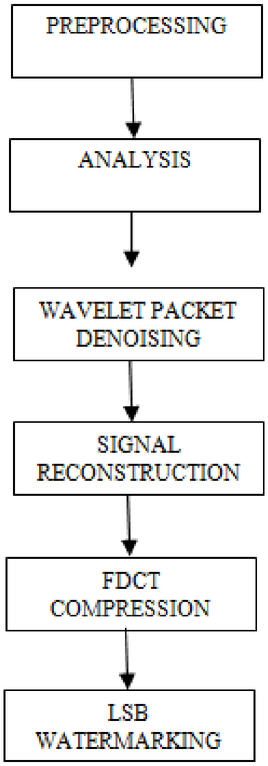

Figure.1. the proposed system

The Algorithm of the proposed system is shown below.

- Get the EEG signals in the database.
- Split the level of the EEG signal.
- Set up the threshold value.
- Add noise to the decomposed signal.
- Perform denoising using wavelet transform.
- Compute the Performance Parameters like mean square error, signal to noise ratio and peak signal to noise ratio.
- Apply Fdct to the decomposed signal for compression.
- Plot the compressed signal.
- Perform watermarking.

IV. RESULTS

MATLAB has been used as the platform for the implementation of the proposed method. The main objective of this work is to provide reliable transmission for the biomedical EEG signal by carrying out suitable Denoising, Compression and Authenticity .The removal of artefact from the scalp EEGs is very important in the case of diagnosis of brain disorders. A small variation in the signal can lead to the misdiagnosis of the disease. Thus denoising is a crucial task for the proper analysis of the signal. Here Wavelet Packet based denoising is applied to the sample EEG signal and obtained the denoised results as shown below.

The figure shows the input sample image of size 612x612 pixels taken from the MIT-Arrhyhmia Database.

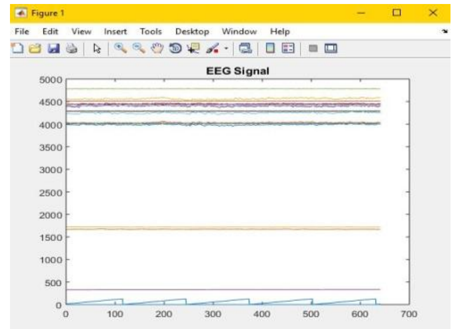

Figure.1.The Input Eeg Signal

Since EEG belongs to a multilevel signal, we cannot perform any operations directly to the input sample. Here analysis can be done by considering one EEG wave obtained from one channel only. As said before EEG is the graph of brains activity obtained from different electrode channels. The figure showing the single channel EEG is shown below.

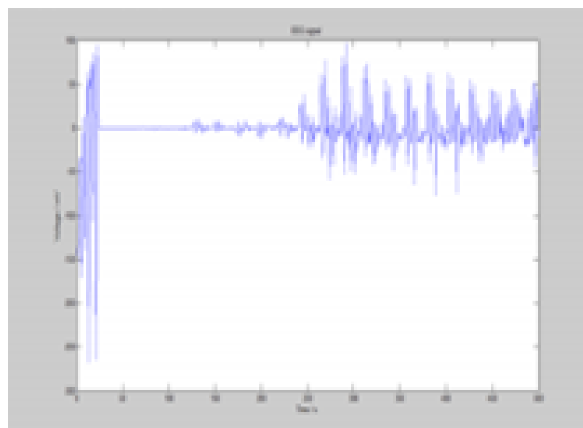

Figure.2.Input From One Channel

After that the input from one channel is pre processed for removing baseline noise present in it and undergone wavelet packet denoising. For that wavelet packet is used for the decomposition of the EEG signal into Alpha, Beta ,Gamma, Delta and Theta waves, following by denoising using discrete wavelet transform .The figures 3,4,5,6,7 showing denoising of the decomposed alpha, beta ,gamma ,delta and theta waves is as follows:

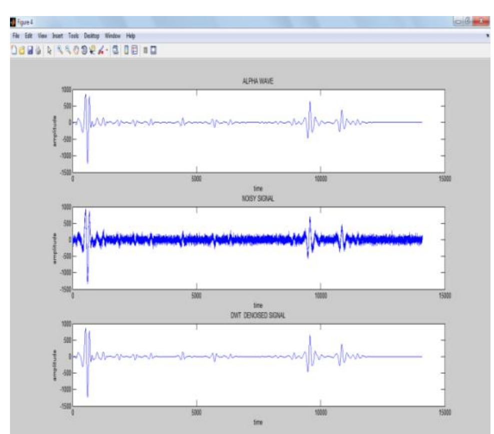

Figure.3. signal decomposition and denoising of alpha wave.

In Fig 3 first figure represents the signal decomposed alpha wave. Then Gaussian noise is added to the alpha wave for performing denoising. Finally discrete wavelet transform is used for the denoising purpose and the denoised image is shown .The following procedure applies for the other decomposed waves such as beta, gamma, delta and theta.

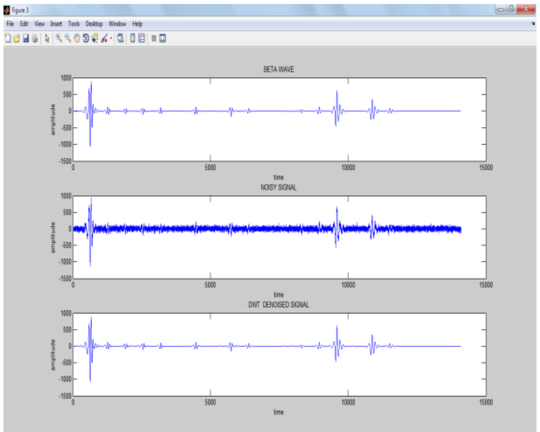

Figure.4.Signal Decomposition And Denoising Of Beta Wave

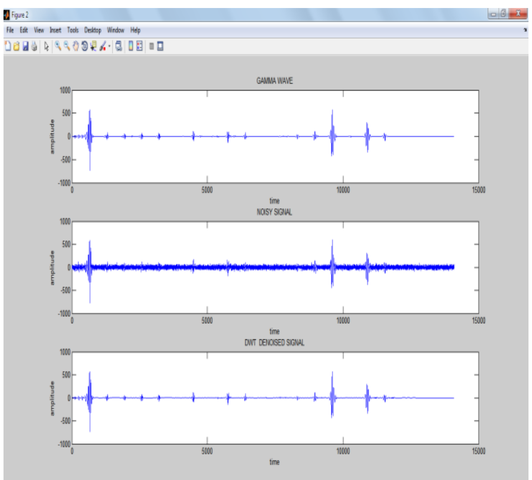

Figure.5.Signal Decomposition And Denoising of Gamma Wave

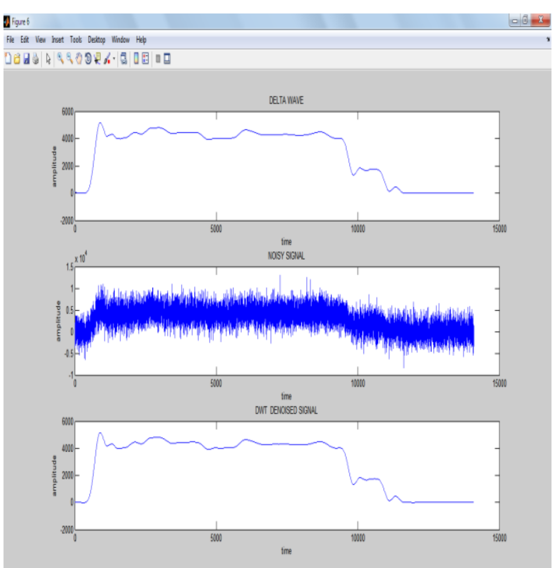

Figure.6. Signal Decomposition and Denoising of Delta Wave

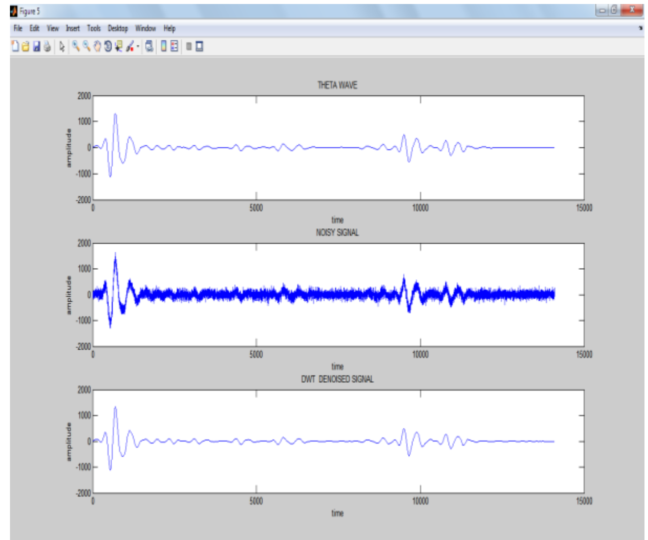

Figure.7. signal decomposition and denoising of theta wave.

Next is the signal obtained undergoes compression using Fdct. The algorithm explaining the Fdct procedure was explained above. After performing the compression the outputs obtained is as shown below.

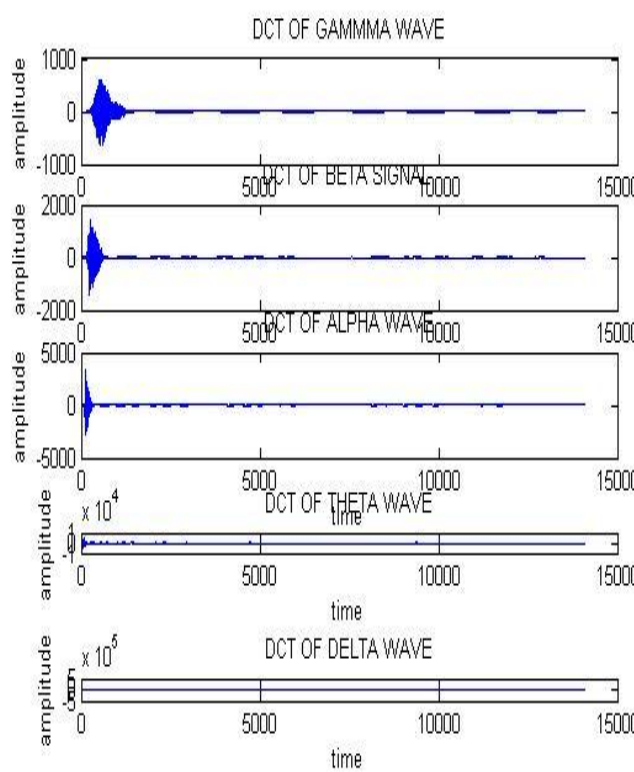

Figure.8. Fdct Applied For the Decomposed Waves

After the denoising procedure inverse wavelet transform is used for the reconstruction of the signal. Thus the reconstructed signal is obtained after the IDWT process. The reconstructed image is as shown below. After compression the signal will be having high compression ratio and low percentage mean square difference. Since the signal is compressed it requires only less storage space and less bandwidth it can be transmitted with less transmission time. At the sender side this compressed image canbe decompressed and the signal can be reconstructed.

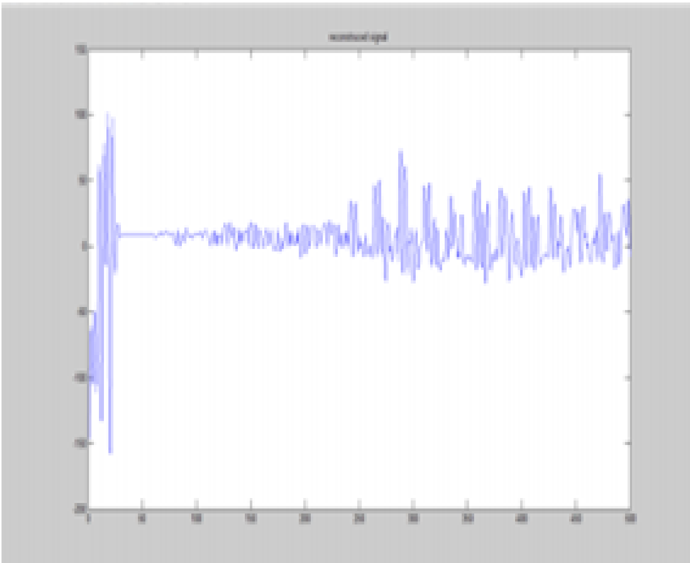

Figure.9.Reconstructed Signal

Finally the aunthenticity of the signal is maintained by applying least significant watermarking to the EEG signal. It is done by considering the base image and the cover image. The base image chosen here is the EEG image and the watermarking image is cameraman.tif image. Initially the image to be hidden is considered and plotted its histogram for finding the distribution of the gray levels. Then a thresholding is done to the cover image with value 70.After that our base image is converted into its gray scale image and plotted, following by converting the cover image into 6 bit planes. Then the insertion of base image into cover image is done and thus watermarking procedure is completed. Next step is to note the difference between noisy watermarked image and noise free watermarked image. For that Gaussian noise is added to the watermarked image and then denoising process is done for obtaining the noise recovered image. From the two noisy and noise free images watermark is recovered and their difference is noted.

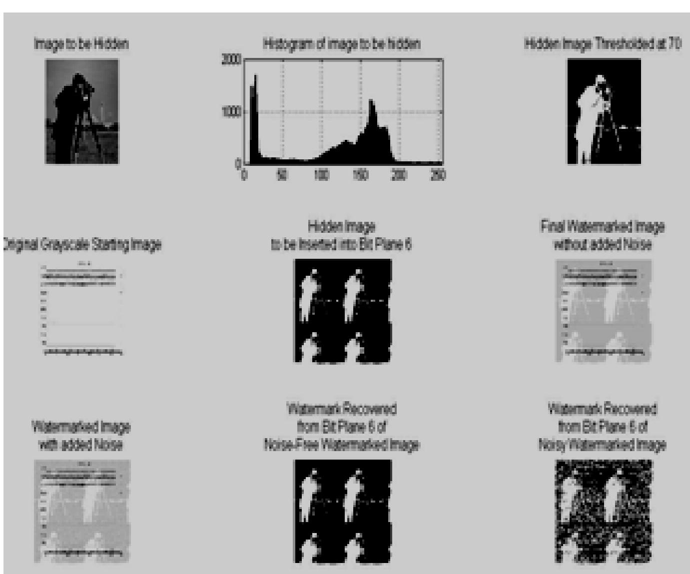

Figure.10. Watermarking Algorithm

Table.1. Performance of proposed methods with existing methods

METHOD	COMPRESSION RATIO	PERCENTAGE ROOT MEAN SQUARE DISTORTION
ARITHMETIC CODING	0.7560	0.9341
ARITHMETIC CODING BASED WAVELET TRANSFORM	0.8403	2.8560
WAVELET TECHNIQUES	0.8080	0.770
PROPOSED METHOD	1.8347	0.0802

The Table-1 shows the comparison of the different existing methods for denoising with our proposed method By observing the table we can see that the proposed method gives the high compression ratio with low distortion which means that that it can be considered as an efficient method .

Table.2. Comparison between wavelet and wavelet packet transform

METHOD	RETAINED ENERGY	SIGNAL TO NOISE RATIO(SNR)db	MEAN SQUARE ERROR
WAVELET TRANSFORM	69.13	83.78	0.97
WAVELET PACKET TRANSFORM	84.42	96.93	0.24

The Table-11 shows the comparison of SNR, Energy, Mean Square Error with the wavelet packet decomposition. By observing this we can see that wavelet packet transform has retained highest energy than wavelet transform with highest signal to noise ratio and low Mean square error.

V. CONCLUSION

Several denoising techniques were present for the noise removal in biomedical signals. In this work wavelet packet denoising is used for the noise suppression which decomposes the signal into high pass and low pass component and shown SNR improvement of 13 db[5].Also we examine the use of fast discrete cosine transform for EEG data compression. Experimental results showed that this compression methods gave high compression ratio with low percent root mean difference. As an easy method of authentication while transmission watermarking is introduced in the EEG signal. Here Least bit watermarking method is employed for watermarking.

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