Compression and clustering of ECG Signal

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Abstract–Electrocardiogram(ECG) denotes the potential fluctuations, the electrical activity of heart recorded from the source. As it is a very long signal and require lots of time to preprocess . Compression technique are required to extract the useful data for diagnosis of diseases. ECG Signal compression also improves the transmission speed of real time real signal. A ECG signal consist of QRS complexes, P and T waves. Various research have been developed for ECG Compression. For compression there will be good compression ratio and less loss of data after compression. This paper discuss about the techniques proposed earlier in literature for ECG classification . In addition it also describes the Wavelet Compression technique for compression.

Keywords-ECG (Electrocardiograph), Compression ratio(CR), percentage mean square difference(PRD).

I.INTRODUCTION

Electrocardiogram(ECG) represents the electrical activity of heart showing the regular contraction and relaxation of heart muscle. ECG waveform consist of threebasic waves P wave, QRS wave and T wave . ECG signal is recorded with the help of electrodes on the body and a recording apparatus. It is a very long signal recorded with the help of recording apparatus. So lots of data is surplus and replacable. Any arrhythmia in ECG Signal arerelevant to heart diseases so it is necessary to detect the diseases as soon as possible. So ECG compression techniques are important for extraction of useful data only.Compression algorithms are the methods that reduce the number of symbols used to represent source information, therefore reducing the amount of space needed to store the source information, or the time amount necessary to transmit it for a given channel capacity. Signal compression technologies, more and more Signal content is stored and transmitted in compressed formats. Signal signals has unique properties that differ from a general audio/music signals. First, Signal is a signal that is more structured and band-limited around 4 kHz. These two facts can be exploited through different models and approaches and at the end, make it easier to compress.Various important factors that are considered while designing the compression method, particular to the application requirement are as given below.

1.Compression efficiency and distortion:Compression efficiency, measured by compression ratio, is defined as the ratio of the size of the original signal data over the size of the compressed signal data.

$$CR = \frac{Original\ file\ size}{Compressed\ file\ size}$$

Distortion measurement is required if the algorithm is lossy. The common distortion measure is the mean-squared-error (MSE) of the original data and the compressed data, and signal-to-noise ratio (SNR). It is simple to design a compression algorithm that achieves a low bit rate, but the challenge is how to preserve the quality of the reconstructed signal at the same time.

2.Speed

The next feature of importance is the *speed*of the compression and decompression process. In on-line applications the waiting times of the user are often critical factors. In the extreme case, a compression algorithm is useless if its processing time causes an intolerable delay in the signal processing application. Fast decompression is usually desired.

3.Robustness against transmission errors, and memory requirements:

The compressed signal file is normally an object of a data transmission operation. The transmission in the simplest form is between internal memory and secondary storage but it can as well be between two remote sites via transmission lines. The data transmission systems commonly contain fault tolerant internal data formats so that this property is not always obligatory. The memory requirements are often of secondary importance, but may be a vital factor in hardware implementations.

Percentage mean square is used for error loss.

$$PRD = 100\times\sqrt{\frac{\sum_{i=1}^{n}(ORG(i)-REC(i))2}{\sum_{i=1}^{n}(ORG(i))2}}$$

4. COMPLEXITY OF THE ALGORITHM:

Complexity is measured by the number of operations like additions, subtractions, multiplications, divisions, and shift operations, required to perform both encoding and decoding process. Reliability of the software often highly depends on the complexity of the algorithm.

II.COMPRESSION METHODS

Various compression techniques are available for ECG Compression. Mostly used methods are direct compression methods, Transformation methods and parameter extraction methods.

DIRECT COMPRESSION METHODS:

W. C. Mueller, "Arrhythmia detection program for an ambulatory ECG monitor" the Turning Point (TP) data reduction algorithm.

PARAMETER EXTRACTION METHOD:

Parameter extraction method is an irreversible process in which a particular parameter or characteristic of the signal is extracted. are used for classification based on a priori knowledge of the signal features.

Imai et al. [2] presented an ECG peak-picking compression system in which spline functions are used for signal reconstruction. This method finds the maxima and minima and the curvature of the signal.

G. Nave et al.[4] proposed the Long-Term Prediction (LTP) model which uses the Sub-Auto Regression (SAR) model. In this "periodicity" of the ECG signal is used in order to further reduce redundancy, and gives high compression ratios.

TRANSFORMATION METHOD:

In transformation techniques, firstly preprocessing of the input signal is done by using linear orthogonal transformation and then encoding the transformed output and sinking the amount of data required to effectively represent the original signal.

B.R.S.Reddy et al. [5] proposed the method of Fourier descriptors which defines the information of the significant coefficients in the FT representation of a closed contour. . With an overall CR greater than 7, the quality of the reconstructed signal is also good.

This algorithm reduces the frequency of ECG signal from 200 to 100 hz without reducing the amplitude 0f QRS complex. It provides CR of 2:1 and extract the important features of the ECG signal.

The Amplitude Zone Time Epoch Coding (AZTEC) technique was proposed by J.R. Cox et al.,"AZTEC a preprocessing program for real-time ECG rhythm analysis," It converts the ECG signal into horizontal lines and slopes. A zero-order Interpolator algorithm is used to compress the data, where amplitude and a length are stored.

The Coordinate Reduction Time Encoding System (CORTES) algorithm is a hybrid technique. It combines the high compression ratios of the AZTEC system and the high accuracy of the TP algorithm. ECG data compression by Huffman or variable length coding has been implemented by J.R. Cox et al proposed a technique in which Huffman coding has been applied to the frequent codeword set and a fixed word length coding technique was used for the infrequent set. In provides data compression ratio of 2.8 :1 with 250 Hz sampled ECG's.

III. PROPOSED WORK

WAVELET COMPRESSION

Wavelet compression is a transformation method used for ECG compression. Wavelet transform decompose the signal into different frequency bands. Main feature of wavelet Transform is its multi resolution capability due to which there is no resolution problem. Wavelet transform can be either discrete or continuous. Discrete Wavelet transform is used in this paper as it has advantage of extracting no overlapping information of signal. In this signal is taken from MIT-BIH arrhythmia database with a frequency of 360. By using discrete Wavelet Transform ECG signal is transformed. First the value of threshold coefficients is generated. From the values of these threshold coefficients a adaptive threshold value is generated. Apply the threshold value to the signal generated form threshold coefficients. Then a inverse transform is applied to generate the reconstructed signal. To check the reconstructed signal PRD (percentage mean square) and CR (Compression Ratio) is calculated. Results are shown below:-

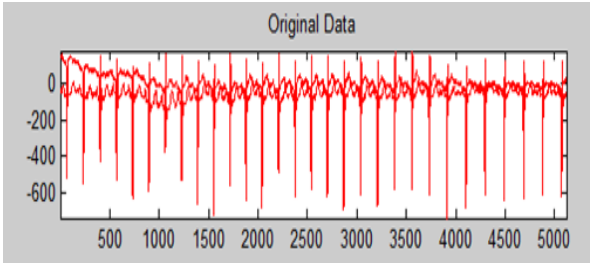

Fig1. Original ECG signal

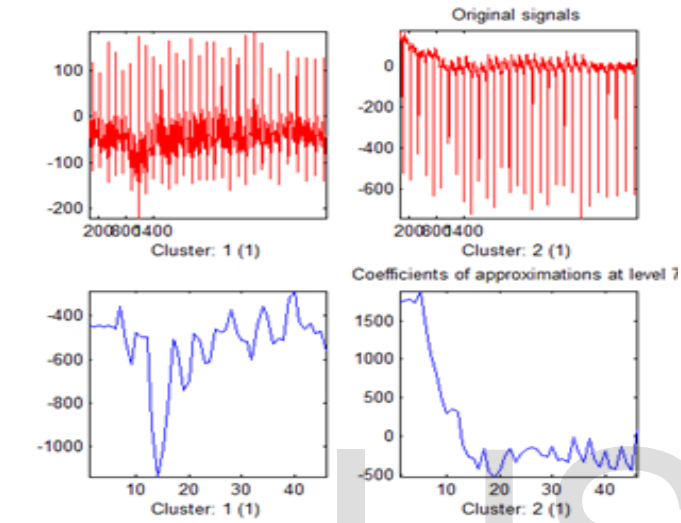

Fig2. Clusters of ECG signal

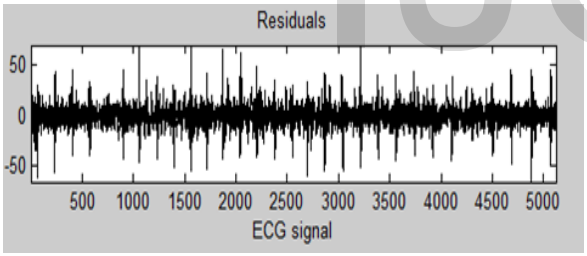

Fig.3. Residual of ECG signal

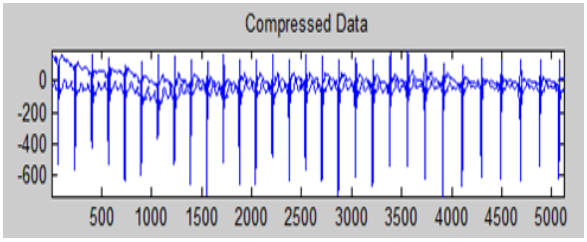

Fig4. Compressed ECG signal

IV. CONCLUSION

It is concluded that a threshold value should be selected that there will be a good data reduction from ECG signal and the quality of ECG signal is also maintained. If threshold value is very high then error ratio (PRD) of signal is also very high. If threshold value is very low then also signal is very poor. In future work compression Ratio (CR) will be improved.

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