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A STUDY ON EVALUATION OF HETEROGENEOUS ELECTROCARDIOGRAM (ECG) SIGNAL COMPRESSION METHODS

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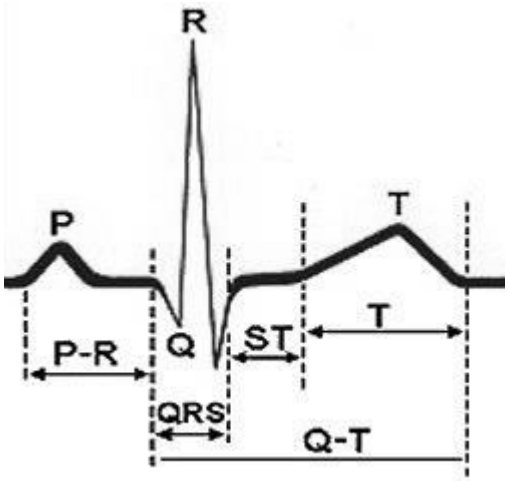
Abstract

ECG i.e., Electrocardiogram plays a big role in identification most of the heart related diseases. ECG signal is a continuous signal with many cycles where one cycle consists of the P-QRS-T wave components. These P-QRS-T wave components are useful in analyzing the signal. ECG signal recordings will generate a massive quantity of information. ECG compression becomes necessary to expeditiously store and retrieve this information from database. Recently, varied analysis and techniques are developed for compression of the signal. These techniques are essential to a range of application starting from diagnostic to ambulant ECG's. Thus, the requirement for effective ECG compression techniques is necessary. Several existing compression algorithms have shown some success in graph compression; but, algorithms that turn out higher compression ratios and fewer loss of information within the reconstructed signal are required. This paper focuses on numerous techniques projected earlier in literature for compression of ECG signal and making a comparative study of those techniques.

I. INTRODUCTION

An ECG is just an illustration of the electrical activity of the center muscle because it changes with time, typically reproduced on paper for easier analysis. Like different muscles, muscular tissue contracts in response to electrical depolarization of the muscle cells. This electrical activity is amplified and recorded for simply some seconds, which is known as an ECG [1]. ECG signal is a continuous signal with many cycles where one cycle consists of the P-QRS-T wave components. These P-QRS-T wave components are useful in analyzing the signal. One cycle of ECG signal with PQRST components is shown in below diagram.



PQRST Diagram

Electrocardiogram (ECG) information is employed to diagnose cardiovascular disease of a patient. In a ambulant watching system, the quantity of ECG information is essentially massive, as a protracted amount of your time is needed so as to collect enough info regarding the patient. Therefore, an efficient information compression theme for ECG signals is needed in several sensible applications including: a) ECG information storage; b) ambulant recording systems; and c) transmission of ECG information over phone line or digital telecommunication network.

The goal of ECG compression techniques is to realize a reduced info rate, whereas protect the relevant diagnostic info within the reconstructed signal. Economical and low computationally complexness compression schemes for medical signals are helpful in applications associated with mobile health care and time period patient watching however additionally in optimized databases. An information compression algorithmic rule ought to permit reconstruction of the info with acceptable fidelity.

Compression techniques are categorized as those within which the compressed information is reconstructed to make the initial signal with none error and techniques within which higher compression ratios may be achieved by introducing some error within the reconstructed signal i.e. reconstruction error.

II. PERFORMANCE EVALUATION CRITERIA

The effectiveness of an ECG compression technique is delineated in terms of:

1) Compression Ratio (CR):

Compression Ratio (CR) is outlined as the quantitative relation of sum of bits representing the initial signal to the sum of bits needed to represent compressed signal. Usually a high compression ratio is preferred. Compression Ratio may be hyperbolic by reducing the redundancy within the bits. This additionally reduces the info storage needs. Compressed information should additionally represent the info with higher fidelity whereas achieving high compression ratio. The CR is given by:

$$compression\ ration = \frac{uncompressedsize}{compressed\ size}$$

Higher the CR, smaller the compressed file size.

2) Root Mean sq. (RMS)

Defining error criterion is one in every of the foremost troublesome drawback in ECG signal compression and reconstruction. Root Mean sq. (RMS) is employed to gauge the standard of compression algorithmic rule and it's additionally used to estimate error. The RMS is outlined as:

$$rms = \sqrt{\frac{1}{n}\frac{x2}{1} + \frac{x2}{2} + \cdots + \frac{x2}{n}}$$

3) Percentage Mean Square Difference (PRD)

$$PRD = \sqrt{\frac{\in [ri-vi]2}{\in v2i}} * 100\%$$

It is the measure of error loss. This criterion evaluates the distortion between the initial and therefore the reconstructed signal. PRD calculation is as follows:

Where ORG is that the original signal and REC is that the reconstructed signal. The lower the PRD, the nearer the reconstructed signal is to the initial ECG information.

1. Sampling/Time-Domain Techniques

A direct technique performs the compression directly on the ECG signal. These are referred to as time domain techniques. To urge a high performance time domain compression algorithmic rule, intelligent sample choice criteria ought to be used. The initial signal is reconstructed by an inverse method, usually by drawing straight lines between the extracted samples. The key to a prospering algorithmic rule is that the development of an honest rule for deciding the foremost important samples [3]. The direct strategies are sensitive to rate of sampling, quantization levels, and high frequency interference [4].

The sampling rate at which the ECG signal can be reconstructed without any errors can be obtained according to Shannon-Nyquist sampling theorem.

2. Transform Frequency Domain Techniques

They divide the signal into frequency parts and assign bits within the frequency domain expeditiously. The sign is split into blocks of information and so hold on within the frequency domain within the variety of a vector. Then the entries within the vector are de-correlated that helps one to retain solely the helpful info. Their main focus is to reduce the quantity of addition and multiplication operations by utilizing the symmetry property of the transformation techniques for ECG signal compression is evaluated and compared. The different compression techniques are mentioned below:

In transformation techniques, first off preprocessing of the signal is finished by means that of a linear orthogonal transformation and so properly coding the remodeled output (expansion coefficients) and reducing the quantity of information needed to adequately represent the initial signal. For signal reconstruction, an inverse transformation is performed and therefore the original signal is obtained with an explicit degree of error.

Many distinct orthogonal transforms [5]-[6] are utilized in digital signal illustration like Cosine Transform (CT), Fourier Transform (FT), Discrete Wavelet Transform (DWT), Karhunen-Loeve Transform (KLT), Walsh Transform (WT), Haar Transform (HT), etc.

- **Fourier Transform (FFT)**

Fourier descriptors [7], involves the determination of numerous coefficients within the FT illustration of a closed contour. The two-lead ECG information is divided into QRS complexes and S-Q intervals, indicated as a complex sequence, and so Fourier remodeled to get the FD's. Whereas compression ratios of 10:1 are attainable for the S-Q interval, the medical info needs limit this quantitative relation to 3:1 for the QRS advanced. With an overall CR larger than seven, the standard of the reconstructed signal is well appropriate for morphological studies.

- **Discrete Wavelet Transform (DWT)**

Discrete Wavelet Transform decomposes the signal into multiple frequency bands. Wavelet transformation permits users to resolve the resolution drawback as its having multi resolution capability. There are 2 kinds of wavelet transforms. They're the Continuous Wavelet transform (CWT) and Discrete Wavelet Transform (DWT). DWT is straightforward to implement and has the advantage of extracting no overlapping info regarding the signal than CWT. Wavelet transform compresses all types of ECG with average PRD and average compression ratios that are far better than the others strategies used for comparison in [8].

- **Huffman coding technique**

Huffman code is an optimized prefix code that has shortest average codeword length. Since it's a prefix free code, cryptography method is easy. Additional often times occurring symbols are related to short code words and fewer often times occurring symbols with long code words. Major disadvantage is that the hardware complexness is incredibly high. Selective Huffman coding to writing encodes solely most often occurring symbols, whereas the opposite symbols stay not encoded. This more reduces the hardware complexness. Another technique referred to as modified Huffman coding is employed for reduce size of ECG signal. Here the initial code for all symbols is mounted. A replacement image is the primary transmitted image that indicates the looks of a replacement image. At every time once a replacement image seems this image code is send [9].

- **KL Transform**

The best transform is that the KLT (also referred to as the principal components transform or the eigenvector transform) since during this minimum range of orthonormal functions is needed to represent the sign for a given RMS error. And also, the KLT leads to decorrelated transform coefficients (diagonal variance matrix) and supply higher result than the other transformation because the total entropy is reduced. However, the procedure time needed to calculate the KLT basis vectors (functions) is incredibly intensive as a result of KLT basis vectors are supported deciding the eigenvalues and corresponding eigenvectors of the variance matrix of the initial information. The protracted process demand of the KLT has caused the employment of suboptimum transforms with quick algorithms (i.e., FT, WT, CT, HT, etc). Not like the KLT, the premise vectors of those suboptimum transforms are input-independent (predetermined). For example, in fourier transform vectors are merely sines and cosines, whereas basis vectors for WT are sq. waves of various sequences. It ought to be according out that the performance of those quick algorithms is overcome by the KLT.

There are other techniques like Simple Bit Packaging Scheme, parameter extraction methods like Peak Picking Compression of ECG, ECG Compression by Long Term Prediction etc. Also a curvature based method is also there which is more efficient than previous methods.

IV. CONCLUSION

The examination of the ECG has been comprehensively used for identification of several heart related diseases. Numerous techniques are projected earlier in literature for ECG information compression. This paper provides a summary of assorted ECG compression techniques and algorithms projected in literature. There are several ECG compression methods as mentioned in this paper. But most of them are not used in the present monitoring and medical systems. The vital reason appears to be the worry that the recovery distortions created by compression ways with loss of data would possibly result in inaccurate interpretations. In future, by combining

different techniques, a more efficient framework can be developed which may enable us to make a lossless compression with accurate PQRST components.

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