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Research Article

LINEAR PERFORMANCE OF ECG DATA COMPRESSION AND TRANSMISSION ALGORITHM FOR TELE-MEDICINE

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ABSTRACT

A real-time data compression and transmission algorithm for a periodic ECG signal is used for tele-medicine. It is used for storing and transmission purposes without affecting the signal quality, they are capable of recording and processing long records of bio signals. The requirements of memory in the storage device having 250Hz sampling rate, 12 bit resolution and 52 megabits of memory. For transmission applications, highly integrated compression and decompression methods are used. The aim of bio signal compression scheme is to minimize the storage space without losing any clinically relevant information, which can be done by means of reducing eliminating redundancies in the signal. The algorithm is used to detect the peaks of differenced ECG data and then to perform DWT between the current peak and the previous peak of data stream. The performance level is compared to provide the optimal level of compression by shorter symbols of sequence identical signals by RLE. The bio signal data transmission method is used to limited bandwidth for long distance communications.

Keywords: Tele-medicine, Electrocardiogram, Discrete wavelet transform, Run length, Compression.

INTRODUCTION

E-health devices are based on a ubiquitous sensor network, to which various devices with different functions and types are connected. In the case of a real-time ECG monitor or multichannel bio signal acquirement devices, a real-time data compression and transmission method is required for the effective use of wired or wireless communications resources. Data compression techniques can be divided into loss and lossless methods[1]. For ECG data compression, the loss type has been applied due to its capability of a high data compression ratio. In lossless data compression, the signal samples are considered to be realizations of a random variable or a random process and the entropy of the source signal determines the lowest compression ratio that can be achieved. In lossless coding the original signal can be perfectly reconstructed[1]. In lossy methods, there is some kind of quantization of the input data which leads to higher CR results at the expense of reversibility. But this may be acceptable as long as no clinically significant degradation is introduced to the encoded signal. Therefore, lossy coding methods which introduce small reconstruction errors are preferred.

An electrocardiogram (ECG or EKG, abbreviated from the German Elektrokardiogram) is a graphic produced by an electrocardiograph, which records the electrical activity of the heart over time. Analysis of the various waves and normal vectors of depolarization and repolarization yields important diagnostic information. It is the gold standard for the evaluation of cardiac arrhythmias[2]. It guides therapy and risk stratification for patients with suspected acute myocardial infarction. It helps detect electrolyte disturbances (e.g. hyperkalemia and hypokalemia). It allows for the detection of conduction abnormalities (e.g. right and left bundle branch block). It is used as a screening tool for ischemic heart disease during a cardiac stress test. It is occasionally helpful with non-cardiac diseases (e.g. pulmonary embolism or hypothermia). The following figure shows the representation of ECG Waveform A wide range of normal variability is in the 12 lead ECG. The "normal" ECG characteristics, is the "Method of ECG Interpretation" are as follows: Measurements**,** Rhythm**,** Conduction**,** Waveform Description. Heart Rate: 60 - 90 bpm, PR Interval: 0.12 - 0.20 sec, QRS Duration: 0.06 - 0.10 sec, QT Interval $QT_c \leq 0.40$ sec. The P waves in leads I and II must be positive if the rhythm is coming from the sinus node.

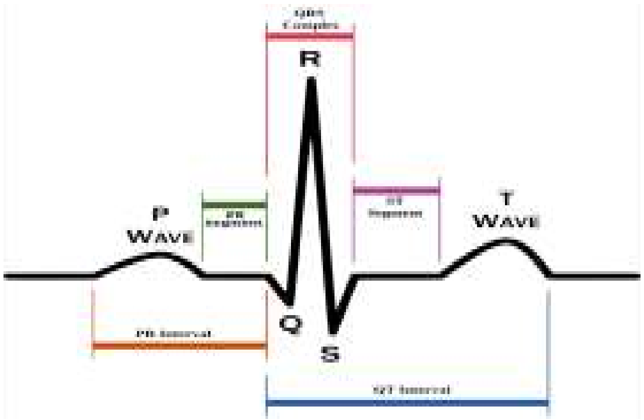

Figure 1

Normal Sino-atrial, Atrio-ventricular and Intraventricular conduction**.** The P wave represents the sequential activation of the right and left atria, and it is notch or biphasic P waves of right and left atrial activation. P duration < 0.12 sec, P amplitude < 2.5mm, Frontal plane P wave axis: 0° to +75°. The QRS represents the simultaneous activation of the right and left ventricles, although of the QRS waveform is derived from the larger left ventricular musculature. QRS duration ≤ 0.10 sec, QRS amplitude is quite variable from lead to lead and from person to person[2]. Two determinates of QRS voltages are: Size of the ventricular chambers. Proximity of chest electrodes is attached to ventricular chamber.

The normal QRS axis range (+90° to -30°), this implies that the QRS be mostly positive (upright) in leads II and I. Normal q-waves reflect normal septal activation, they are narrow and small. Septal q waves should not be confused with the pathologic Q waves of myocardial infarction. Small r-waves begin in V1 or V2 and progress in size to V5. The R-V6 is usually smaller than R-V5. In reverse, the s-waves begin in V6 or V5 and progress in size to V2. S-V1 is usually smaller than S-V2[4]. The usual transition from S>R in the right pericardial leads to R>S in the left pericardial leads is V3 or V4. Small "septal" q-waves may be seen in leads V5 and V6.

A discrete ST segment distinct from the T wave is usually absent. More often the ST-T wave is a smooth, continuous waveform beginning with the J-point, slowly rising to the peak of the T and followed by a rapid descent to the isoelectric baseline or the onset of the U wave. This gives rise to an asymmetrical T wave. The normal T wave is usually in the same direction as the QRS except in the right pericardial leads. In the normal ECG the T wave is always upright in leads I, II, V3-6, and always inverted in lead AVR. This occurs in leads with large S waves and the normal configuration is concave upward. ST segment elevation with concave upward appearance may also be seen in other leads. This is called as early repolarization. U wave amplitude is usually < 1/3 T wave amplitude in same lead. U wave direction is the same as T wave direction in that lead. U waves are more prominent at slow heart rates and usually best seen in the right pericardial leads[4]. Origin of the U wave is thought to be related to after depolarization's which interrupt or follow repolarization. There are three compression techniques are used here. they are obtained as follows: The direct data compression schemes is developed specifically for ECG data compression, which are basically based on the compression methods for directly analyzes and compresses data in the time domain [5]. The original samples of ECG are subjected to a linear transformation and the compression is performed in the entirely new domain. The transform method converts the time domain signal to the frequency or other domains and analyses the energy distributions. The parameter extraction method is used to extract some features, that are used to reconstruct the signal.

METHODOLOGIES FOR ECG COMPRESSION

A down slope trace waveform (DSTW) is applied for detecting the peak of the differenced ECG signal, to detect the peaks of the signal in real time. The DSTW algorithm can be used, in various fields, to detect the P-wave, QRS complex, or T-wave segments of ECG, to reduce a power source noise or a baseline wandering, or to detect peaks of a signal which is mixed with various noises[8]. The performance of the peak detection capability of the DSTW algorithm for all 48 instances is in the MIT-BIH arrhythmia database and the process of the peak-to-peak interval after peak detection. DWT is any wavelet transform for which the wavelets are discretely sampled. It captures both frequency and location information[5]. Then the error compensation reduces the signal distortion, which is critical in the signal reconstructed without error compensation.

A. COMPRESSION RATIO

Compression Ratio is defined as the ratio of original signal and after compression signal. The compression ratio can be defined by,

$$CR = \frac{\mathbf{Ninp}}{\mathbf{Nout}}$$

B. PERCENT RMS DIFFERENCE

Percent RMS difference is the ratio between the predicted model and actually observed model. The PRD can be denoted by

$$\textbf{PRD (100\%)} = 100^{*}\sqrt{\sum_{n=0}^{N=1}(Xs(n)-Xr(n))2} \Big/ \sqrt{\sum_{n=0}^{N=1}(Xs(n))2}$$

C. MEAN SQUARE ERROR

Mean Square Error is the squared normalization of the data and approximation divided by the elements.

$$MSE = \sum m,n \; \frac{I1(m,n)-I2(m,n)}{m*n}$$

Peak Signal To Noise Ratio is the ratio of peak signal to noise ratio in decibals. PSNR can be denoted by,

$$\textbf{PSNR=log}\left(\frac{R2}{MSE}\right)$$

Quality Factor is the ratio between compression ratio and percent rms difference. Quality factor can be denoted by,

Quality Factor=Compression Ratio/PRD

Run length compression is very simple compression method for sequential data. It is useful in repetitive data. This technique replaces sequences of identical pixels called by shorter symbols. It is used for signal coding, to represent a discrete signal in a more redundant form, for data compression[6]. It is implemented as analog filter bank in biomedical signal processing for ultra widebank (UWB) wireless communications.

EXPERIMENTAL EVALUTIONS

The MIT-BIH arrhythmia datasets of 48 recordings as test signals. Each data file includes two lead ECG data, and each lead contains 650 000 binary data instances in a 16-bits-data format, including the index and amplitude[6]. The implementation of the algorithm, the average CR, PRD, PRDN, RMS, SNR, and QS values and the standard deviation value were obtained and evaluated. An effective ECG compression technique is based on designed quantization strategy for ECG signals. Results obtained for the 48 records of the MIT-BIH Arrhythmia Database showed the capable of achieving good average CR values with low distortion. The quality of the reconstruction signals at various distortion levels. These traces present different characteristics and indicate an excellent preservation of all important signal features. The electrocardiogram (ECG) is a noninvasive and the record of variation of the bio-potential signal of the human heartbeats [2]. The ECG detection which shows the information of the heart and cardiovascular condition is essential to enhance the patient living quality and appropriate treatment. The statistical data will be utilized for evaluating the performance of an algorithm in ECG compression. Improving the accuracy of diagnosing the cardiac disease at the earliest is necessary in the case of patient monitoring system.

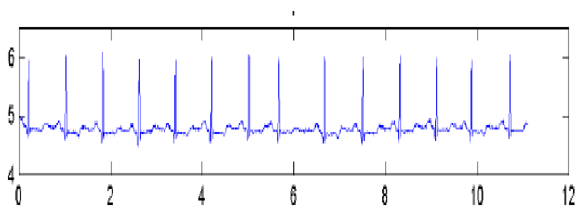

Figure 2: Represents the result of DWT input signal

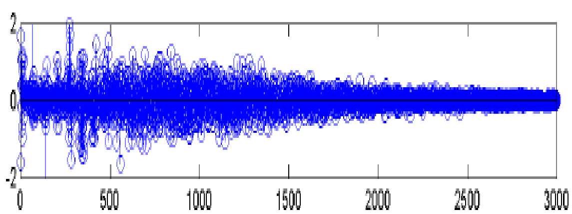

Figure 3: Represents the compressed DWT signal

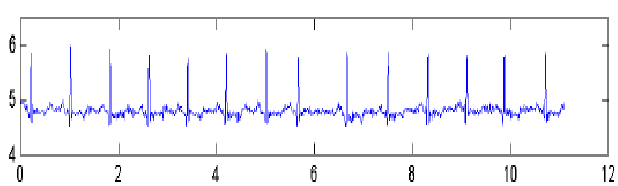

Figure 4: Represents the decompressed DWT signal

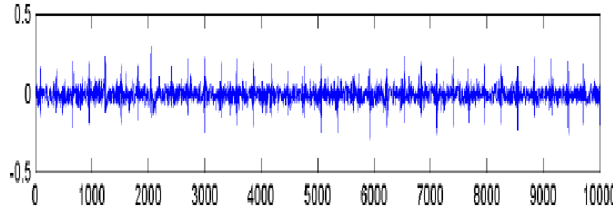

Figure 5: Represents the Error ratio between input and output signal.

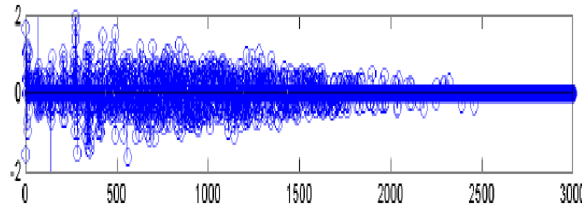

Figure 6: Represents the compression ratio between input and output signal.

In ECG signal, the algorithms transform the original signals into the frequency domain and remove some frequency components for data compression, the algorithm transforms the difference signal into the frequency domain and removes some frequency components of the difference signal, showing reduced signal distortion after the reconstruction process[7]. The periodicity of the ECG signals, is maintained after DWT and enables the use of a high compression rate during Runlength coding. The parameter of ECG signals is to be obtained as follows:

Time sampling is the observation technique that determines the give period and recording the frequency**.** Percent RMS difference is the ratio between the predicted model and actually observed model. Normalised Percent RMS Difference is the ratio between the normalization of the predicted model and actually observed model. Root Mean Square is the stastical mean of magnitude of varying quantity. Signal to Noise Ratio is the ratio between signal power to the noise power in dB.

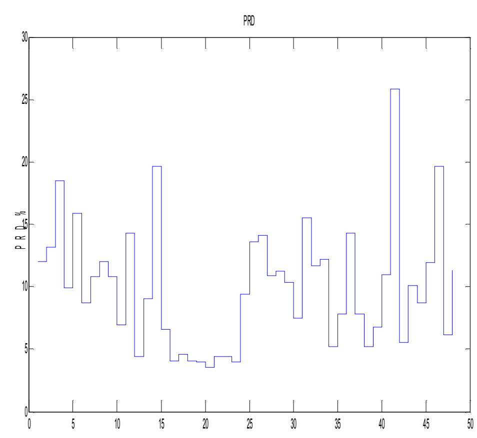

Figure 7: Shows the characteristics of PRD, which indicate the ratio between the predicted model and actually observed model.

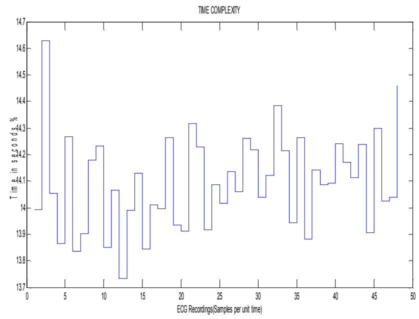

Figure 8: Represents characteristics of Time complexity, which indicates the sequence of ECG signal.

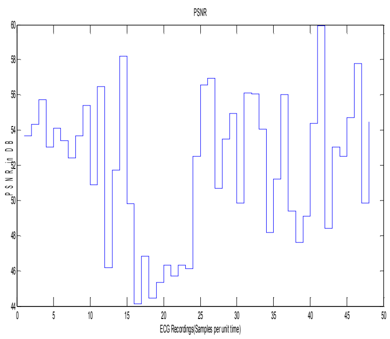

Figure 9: Shows the Characteristics of PSNR which indicates the ratio of peak signal to noise ratio.

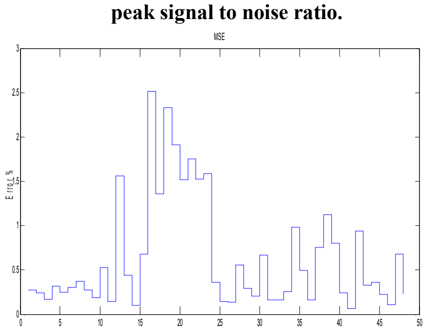

Figure 10: Shows the characteristics of MSE, which denotes the squared normalization of the data and approximation divided by the elements.

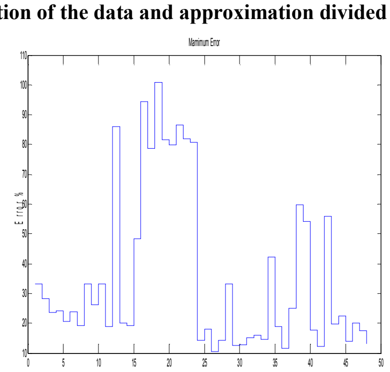

Figure 11: hows the characteristics of Maximum Error, which indicates maximum absolute squared deviation of the data.

CONCLUSION AND FUTURE WORK

To evaluate the performance of the developed algorithm, it was applied to all of the MIT-BIH arrhythmia databases. It is also found that incorrect peak detection was affected by the PRD, PRDN, RMS, SNR, and QS at a high compress ratio. To improve the quality of the ECG signal, the DWT is used in enhanced coding algorithms. The advantage of the compression algorithm is its superior performance of data compression. The algorithm can be applied to any periodic biomedical signal and records consisted of different rhythms, QRS complex morphologies and ectopic beats. This algorithm compresses all kinds of ECG data very efficiently, perhaps more efficiently than any previous ECG compression method. The user can truncate the bit stream at any point and obtain the best quality reconstruction for the truncated file size.

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