Er.Abdul Sayeed / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 3, Issue 1, January -February 2013, pp.422-425

ECG Data Compression Using DWT & HYBRID

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ABSTRACT

Signal compression is an important problem encountered in many applications. Various techniques have been proposed over the years for addressing the problem. In this project Transform based signal compression is proposed. This method is used to exploit the redundancy in the signal. This Paper uses Wavelet and Hybrid Transform to compress the signals. The well known that modern clinical systems require the storage, processing and transmission of large quantities of ECG signals. ECG signals are collected both over long periods of time and at high resolution. This creates substantial volumes of data for storage and transmission. Data compression seeks to reduce the number of bits of information required to store or transmit digitized ECG signals without significant loss of signal quality.

A wide range of compression techniques based on different transformation techniques like DCT, FFT; DST &DCT2 were evaluated to find an optimal compression strategy for ECG data compression. Wavelet and Hybrid compression techniques were found to be optimal in terms of compression.

Index Terms-ECG, Compression, DWT, Hybrid, MSE, PSNR, CR.

I INTRODUCTION:

Transmission techniques of biomedical signals through communication channels are currently an important issue in many applications related to clinical practice. These techniques can allow experts to make a remote assessment of the information carried by the signals, in a very cost-effective way. However, in many situations this process leads to a large volume of information. The necessity of efficient data compression methods for biomedical signals is currently widely recognized.

This chapter introduces the compression of Electrocardiogram (ECG or EKG) signals using Discrete Wavelet Transform (DWT) and Hybrid transform. Although storage space is currently relatively cheap, electronic ECG archives could easily become extremely large and expensive. Moreover, sending ECG recordings through mobile networks would benefit from low bandwidth demands. ECG signal compression attracted considerable attention over the last decade.

The main goal here is to provide an up-to-date introduction to this fascinating field; through presenting some of the latest algorithmic innovations and to stimulate readers to investigate the subject in greater depth using the extensive set of references provide in outside world.

II. ELECTROCARDIOGRAM

ECG or **EKG** from the German Electrocardiogram is a transthoracic (across the thorax or chest) interpretation of the electrical activity of the heart over a period of time, as detected by electrodes attached to the outer surface of the skin and recorded by a device external to the body. An ECG test records the electrical activity of the heart. ECG is used to measure the rate and regularity of heartbeats, as well as the size and position of the chambers, the presence of any damage to the heart, and the effects of drugs or devices used to regulate the heart, such as a pacemaker. The ECG device detects and amplifies the tiny electrical changes on the skin that are caused when the heart muscle depolarizes during each heartbeat. At rest, each heart muscle cell has a negative charge, called the membrane potential, across its cell membrane.

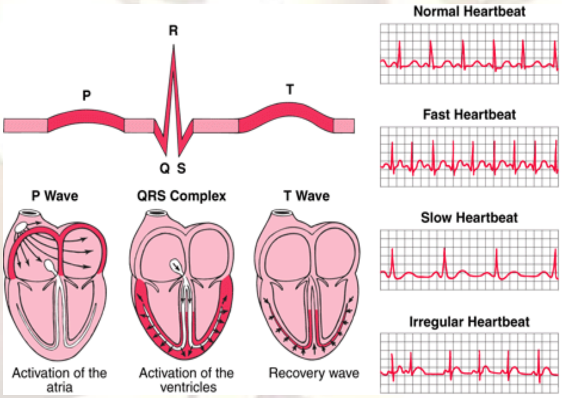

Fig 2.1Schematic Representation of Normal ECG

The above diagram shows the Schematic Representation of Normal ECG waveform. A normal heartbeat has P wave, a QRS complex and a T wave .A small U wave is sometimes visible in 50 to 75% of ECG

III ECG COMPRESSION TECHNIQUE

Many existing compression algorithm have shown some success in ECGG compression ,however algorithm that produces better compression ratios and less loss of data in the recovered data is needed. The techniques used for compression of ECG image is basically DWT. This technique uses transformed based method which helps to convert time domain to frequency domain.

This conversion help to form mathematical co-efficient in matrix form. This conversion helps to form the mathematical coefficient in the matrix form. For an image, high frequency component determines insignificant information and low frequency determines significant information hence, we illuminate high frequency components. Finally, an easy to use computer program will be written in “MATRIX LABORATORY (MATLAB)”,which will allow its user to compare various compression schemes and analyze reconstructed electrocardiogram and Electroencephalography records though a graphic interface without detailed knowledge of the mathematics behind the compression algorithm**.**

3.1 Data compression technique

By compressing the ECG Image more information can be stored & processed for future evaluation. The first sub goal of this project has been to investigate different compression methods to find a potential candidate for future platform.

COMPRESSION REQUIREMENTS:-The strategy for compressing data must fulfill the following requirements:-

- **Information preservation:** Due to diagnostic restriction ,it is imperative that the information found in the original data is preserved after compression .
- **Control of compression degree:** Another preference is the ability to control the amount of data compression. Recent information is preferably stored in an data exact form with low degree of compression .However , with older data a more aggressive compression strategy is accepted.
- **Complexity Issue:** Due to limited processing capacity of the pacemaker , an algorithm for compressing data has to have low complexity.

This fact rules out many compression technique involving extensive calculation, which could be potential candidates in other circumstances.

3.2 ECG Compression scheme

The objective of this project is to obtain a time domain approximation of the ECG signal using compression scheme based on a new emerging method of transformation i.e “Wavelet Transform” & “Hybrid Transform”

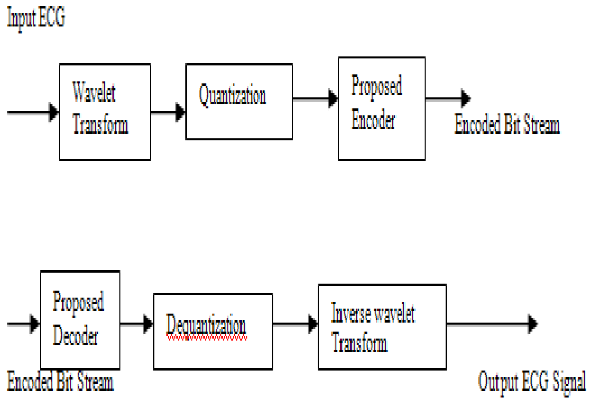

Fig 3.2.1 Block Diagram of ECG Compression technique

IV ECG COMPRESSION ALGORITHM

The algorithm used for compression is transform based. The various transform can be given as follows

4.1 ECG Compression using Wavelet Transform

- **Image Resizing:** First we take a JPEG image. After that compiler will read it. Then it convert color image to grey scale image. Then the image converted to square image having pixel [512* 512]
- **DWT:** We apply wavelet transform to the resize image. It will decompose image into approximate image , vertical, horizontal, diagonal component. Again we apply DWT and decomposition takes place This is called 2nd level decomposition so in all 3 level decomposition takes place. Then we take all images in one window. Then we apply compression technique with respect to compression in %
- **Inverse DWT:** On the compressed image apply IDWT then we get 2nd level IDWT image. This process is repeated again then we get compressed DWT image
- **Calculation of Compression Ratio(CR) & Percentage RMS Difference(PRD)**

$$\text{RMS error}=\sqrt{\left(\sum_{i}(Ri-Vi)2\right)/N}$$

RMS Value=√ [∑ (Vi) ^{2}]/N

PRD = (RMS Error) ¤ (RMS Value) ´ 100 %

Where Vi is the i-th ECG value in the input source,Ri is the i-th value in the re constructed waveform N values in total

- **Calculation of PSNR & MSE:** Depending on compression we calculate the Peak signal to noise ratio(PSNR) & Mean square ratio(MSE)

$$MSE=\sum \frac{\text{size original - size compressed image}}{\text{size}}$$

PSNR=10 Log[(maximum pixels)^2/MSE]

- Display the result

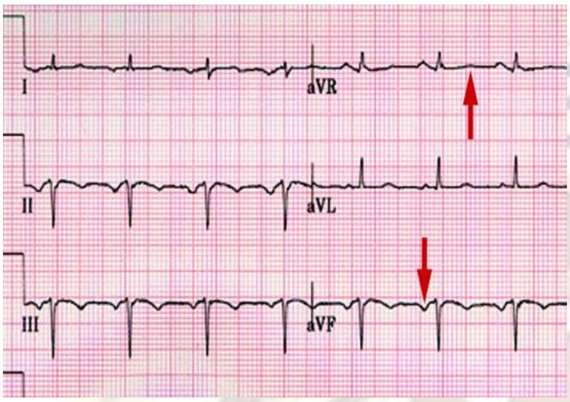

Fig 4.1.1ECG Compressed image using wavelet

4.2 ECG Compression using Hybrid Transform

It is the combination of DCT & WAVELET Transform for better compression ratio. In this method we first apply DCT on ECG image which apply convers image into frequency components. Then we apply wavelet transform on frequency components which helps to obtain precise mathematical coefficient in matrix form. Now we apply compression by eliminating high frequency components.

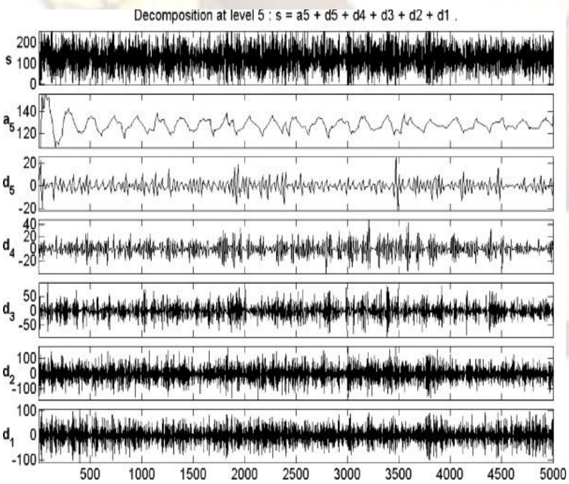

Fig 4.2.1 ECG Compressed image using Hybrid

V. WAVELET TRANSFORM AND WAVELET FAMILY

The word wavelet has been used for decades in digital signal processing and exploration geophysics. The equivalent French word ondelette meaning "small wave" was used by Morlet and Grossmann in the early 1980s. Wavelet theory is applicable to several subjects. All wavelet transforms may be considered forms of time-frequency representation for continuous-time (analog) signals and so are related to harmonic analysis. Almost all practically useful discrete wavelet transforms use discrete-time filter banks. These filter banks are called the wavelet and scaling coefficients in wavelets nomenclature. These filter banks may contain either finite impulse response (FIR) or infinite impulse response (IIR) filters. The wavelets forming a continuous wavelet transform (CWT) are subject to the uncertainty principle of Fourier analysis respective sampling theory: Given a signal with some event in it, one cannot assign simultaneously an exact time and frequency response scale to that event. The product of the uncertainties of time and frequency response scale has a lower bound. One use of wavelet approximation is in data compression. Like some other transforms, wavelet transforms can be used to transform data, then encode the transformed data, resulting in effective compression. Suppose DCT is currently used for compressing data such as images (JPEG), Video (MPEG) and Audio (MP3). However , it can be used for compressing medical signals such as ECG data using original data x with N points DCT can be defined as follows:-

$$X(k)= \propto (k) \sum_{n=0}^{N-1} x(n) \cos[\pi (2n+1)k/2N]$$
$$0< k < N—1$$

Where,

$$\propto(0) = \sqrt{1/N}, \quad \propto(k)= \sqrt{2/N}$$

For 1< k< N—1

Using this equation, it is possible to transform the original signal into a spatial domain. By truncating the signal in the transformed domain and then Run-Length encode the signal, it is possible to achieve high degree of compression.

VII. RESULT AND CONCLUSION

In this paper , we have represented an effective ECG data compression Algorithm to be implemented in MATLAB based on newly developed mathematical tool i.e wavelet and hybrid transformation. There exist many algorithm schemes based on different transformation scheme so for reliability & existence of our presented algorithm, we have compared it with other compression algorithm such as DCT. To achieve our goal we have followed certain steps which include analyzing & observing the different transform and analyzing the following parameters CR, PDR,MSE, PSNR obtaining in MATLAB using three techniques

In such compression it is found that the wavelet compression technique is very effective compared to that of DCT compression method .since using wavelet high degree of compression; we get good result but for large compression percent6age ,there is still some distortion involved in it. But Hybrid transformation is proved to be the best among all the three because it has the property of both WAVELET & DCT . Using this method it has been viewed with both subjective and calculation ; this method provides best possible compression even for larger compression degree

TABLE I.

DCT Compression	**DWT Compression**	**Hybrid compression**
CR=90%	CR=95%	CR=98%
PRD about 1%	PRD less than 1%	PRD minimum
Algorithm Execution Tim 7sec	Algorithm Execution time 3sec	Algorithm Execution time less

In the TABLE II,III.IV an effort is taken to compare the MSE & PSNR of all the three transform to understand better about the transforms and their efficiency

TABLE II. DISCRETE COSINE TRANSFORM

Compression In %	MSE(mean square error)	PSNR(peak signal to noise ratio)
10	0.9	111.8
5o	47.33	72.3
99	1.22e+3	41.49

TABLE III . DISCRETE WAVELET TRANSFORM

Compression In %	MSE(mean square error)	PSNR(peak signal to noise ratio)
10	5.2	94.18
50	41.19	73.64
99	112.7	63.57

TABLE IV . HYBRID TRANSFORM

Compression In %	MSE(mean square error)	PSNR(peak signal to noise ratio)
10	0.9	94.18
50	47.33	73.64
99	1.22e+3	65

A Computer based ECG system are used in hospitals for collection of patients medical history for reviewing patients present condition and continuously monitor ECG of heart patients .For this requirement, as the disk space in computer is limited an effective solution over this is utilized which is compression of such ECG Data , thus storing compressed ECG data reduces disk space .Thus from the obtain result it can be concluded that ECG compression based wavelet transform and hybrid transform is most appropriate and efficient method which can be implemented to save expensive disk space and to allow efficient use of available bandwidth for remote ECG analysis . Moreover it provides Excellent Reconstruction of ECG signals to be used by physicians for correct diagnosis of heart diseases and efficient storage of such information . In these areas are system proves to be invaluable.

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