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A SURVEY ON COMPRESSION TECHNIQUES FOR ECG SIGNALS

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Abstract: Electrocardiogram (ECG) signal play important role in diagnosis and survival analysis of heart diseases. Various techniques have been proposed over the years addressing the signal compression. Compression of ECG signals is desirable for three reasons- economic use of storage data, reduction of the data transmission rate and transmission bandwidth conversation. In this paper a comparative study of Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT), Discrete Cosine compression and Discrete Wavelet Transform (DWT) is used. Different ECG signals taken from MIT-BIH arrhythmia database are tested. The experimental results are obtained for Percent Root Mean Square Difference (PRD) and Compression ratio (CR). The result of ECG signal compression shows better compression performance for DCT and DWT with appropriate PRD. The main purpose of this research work is to compare the major techniques of ECG signal compression in a single view.

Keywords: ECG, Data compression technique, Compression ratio, PRD.

I. INTRODUCTION

In recent years, many researches have made on ECG compression technique but still there is a need for a compression technique which provides higher compression with quality reconstruction. ECG signal contain large amount of information that requires much more storage space, large transmission bandwidth and long transmission time, therefore it is advantageous to compress the signal by storing only the essential information needed to reconstruct the signal [8]. From engineering point of view, an ECG signal is periodic. Figure 1 show one cardiac cycle of the signal which is also known as the R-R interval with three indicated parts: P wave, QRS complex, and the T wave. These waves are the result of contraction and expansion of the heart muscles. The P wave is due to the depolarization of atria whereas QRS complex reflects the rapid depolarization of right and left ventricles. The T-wave represents the repolarisation (or recovery) of the ventricles [1].

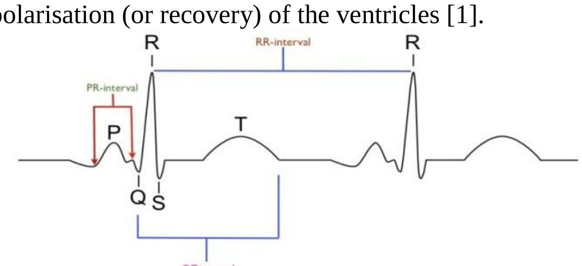

Fig1. ECG waves (source: Google image)

ECG compression methods are classified as: Lossless and Lossy. In lossless method, compressed signal is reconstructed in exact form of original signal. And in lossy method, compressed signal is reconstructed with some cost of error [8][9]. Compression algorithms are classified into: 1) Direct time domain technique 2) Transformational approaches 3) Parameter extraction technique In direct methods, the original ECG signal samples are compressed directly, and in transformed and in transformation method the original samples are first transformed and then compressed. In parameter extraction methods, the features of the processed signal are extracted and then these features are used for reconstruction of the signal [2]. Various time domain compression algorithms for ECG signals can be found in the literature. These methods are based on the idea of extracting few significant signal samples to represent the signal and then decoding the same set of samples. The time domain algorithms are based on fast heuristics in the sample selection process. These techniques are faster but suffer from sub optimality. Examples of such techniques are the FAN algorithms [3] and the AZTEC algorithms [4]. Time domain algorithms were further improved by SLOPE [5] and AZTDIS [6] techniques. The cardinality constrained shortest path (CSSP) algorithms presented in [7] is based on a mathematical modeled as nodes in graph and then optimization techniques are applied for achieving higher compression ratio.

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II. METHODOLOGY

Following transform are generally used

A. Discrete Sine Transform (DST):

DST is fourier related transform similar to discrete fourier and it uses purely matrix. It implies different boundary conditions [13]. The DST is implemented by equation (1):

$$y(x) = \sum_{n=1}^{N} x(n) \sin\left(\pi \frac{kn}{N+1}\right) \qquad (1)$$

Where k= 1, 2, 3………N and n= 1, 2 ...N

B.Fast Fourier Transform (FFT):

FFT is an algorithm to compute the Discrete Fourier Transform & its inverse. The number of complex multiplication to compute DFT is N^2. But in FFT it reduces the computation to $N\log_2 N$ [7]. The FFT of any function is computed by equation (2):

$$X(k) = \sum_{j=1}^{N} x(j)\omega_N^{(j-1)(k-1)} \qquad (2)$$

Where,

$$x(j) = (\tfrac{1}{N}) \sum_{k=1}^{N} X(k)\omega_N^{-(j-1)(k-1)} \qquad (3)$$

$$\omega_{N=e^{(-2\pi i)/N}} \qquad (4)$$

is an Nth root of unity[13].

C .Discrete cosine Transform (DCT):

DCT is closely related to DFT. It transforms a signal from spatial representation into frequency representation. DCT represents a signal as a sum of varying magnitude and frequency. It implies different boundary condition & often used in signal & image processing for lossy data compression has strong "energy compaction property" & it provide high de-correlation [8][15].

$$y(k) = \omega(k) \sum_{n=1}^{N} x(n) \cos\left(\frac{\pi(2n-1)(k-1)}{2N}\right) \quad k = 1, 2, \ldots. N \qquad (5)$$

Where

$$\omega(k) = \begin{cases} \frac{1}{\sqrt{N}} & k = 1 \\ \sqrt{\frac{2}{N}} & 2 \le k \le N \end{cases} \qquad (6)$$

D. Discrete Cosine Transform-II (DCT-II):

The DCT-II is the most commonly used form, and is often simply referred to as "the DCT". This transform is exactly equivalent (up to an overall scale factor of 2) to a DFT of $4N$ real inputs of even symmetry where the even-indexed elements are zero. That is, it is half of the DFT of the $4N$ inputs y_n where y_{2n}, y_{2n+1} =0, for 0≤ n<N, y_{2n}=0, and y_{4N-n} = y_n for 0<n<N.

$$X_K = \sum_{n=0}^{N-1} x_n \cos\left[\frac{\pi}{N}\left(n + \frac{1}{2}\right)k\right] \qquad k = 0, \ldots \ldots \ldots, N-1 \qquad (7)$$

The DCT-II implies the boundary conditions: x_n is even around n=-1/2 and even around n=N-1/2; X_k is even around k=0 and odd around k=N [17][18][19].

The testing criteria for the compression algorithm performance consist of the compression ratio and error values. The compression ratio (CR) is defined as the size (data storage bytes) ratio of the original signal to that of the compressed signal. The error is measured as the percent mean square difference (PRD) between original and reconstructed signal. The aim of ECG compression is to maximise the CR (8) while minimising the PRD (9). The CR and the PRD definitions are indicated below:

$$CR = \frac{Data\ size\ before\ compression}{Data\ size\ after\ compression} \qquad (8)$$

$$PRD = \sqrt{\frac{\sum_{i=1}^{N}(s(t_i) - \hat{s}(t_i))}{\sum_{i=1}^{N}(s(t_i))^2}}\ .100 \qquad (9)$$

Where N is the number of data samples, $s(t)$ is the original signal and $s\hat{}(t)$ is the reconstructed signal[12].

III .RESULTS

This section basically dealt with the results obtained for DCT, FFT, DST and DCT-II transform applied over ECG data taken from MIT-BIH database. The following table shows the values of compression ratio and percentage root mean square difference. It is found in the literature that for compression domain higher CR and lower PRD are required.

TABLE: 1
THIS RESULT IS TAKEN FROM [16][20].

METHODS	CR		PRD	
DCT	91.6800	90.4600	0.8392	0.9414
FFT	89.5723	89.5900	1.0237	1.1683

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DST	70.4073	85.1800	1.1967	1.2584
DCT-II	94.28	95.7800	1.5729	1.3320

IV. CONCLUSION

The main objectives of this paper are to present the major techniques of ECG signal compression. This paper surveys techniques of past years. Among the four techniques presented, DST provides lowest CR and distortion is also high. FFT improves CR and lowers PRD. So FFT is better choice than DST. Next is DCT which gives higher CR up to 91.68 with PRD as 0.8392. But DCT-II provides an improvement in terms of CR of 94.28 but PRD increases up to 1.5729. Thus an improvement of a discrete cosine transform (DCT)-based method for electrocardiogram (ECG) compression is presented as DCT-II. In future more advance techniques like polynomial approximation, can be employed to achieve higher CR and lower PRD. Similarly more performance parameters like saving percentage can be included to make an accurate compression system for ECG signals.

REFERENCES

[1] Textbook of medical physiology, 9th ed. Saunders W. H., 2010.
[2] Sateh M. S. Jalaleddine, chriswell G. Hutches, Robert D. Strattan & William A. Coberly. *"ECG Data Compression Techniques-A Unified Approach"*, IEEE Transaction on Biomedical engineering, vol.37, no.4, April 1990.
[3] L. N. Bohs And R. C. Bar, *"Real-time adaptive sampling with the fan algorithm,"* Medical and biological engineering and computing, vol. 29, no. 6,pp. 565-573,1988.
[4] J. R. Cox, F. M. Noelle, H. A. Fozzard and G. C. Oliver, *"Aztec a pre-processing program for real-time ecg rhythms analysis,"* IEEE Transaction on Biomed. Engg. Vol. 15, no.2,pp. 128-129.
[5] S. C. Tai, "Slope *a real –time ecg data compressor",* Medical and biological engineering and computing, vol. 29, no.2, March1991, pp.175-179.
[6] S. C. Tai, "*Aztdis a two phase real –time ecg data compressor*", journal of Biomed. Engg., vol. 15, no.6, Nov 1993, pp 510-515.
[7] D. H. Haughland. And J. Haughland, "*Optimisation algorithms for ecg data compression*," Medical and biological engineering and computing,vol.35, n0. 4, july1997 pp,420-424.
[8] M. Kartik & N. Sathish,*"An optimized quantization of DCT technique".* Indian Journal of Innovation and Developments, Vol.1, No.8, 2012, pp 141-144.
[9] Raimon Jane, Pablo Laguna, Nitish V. Thakor and Pere Caminal, *"Adaptive Baseline Wander Removal in the ECG: Comparative Analysis with Cubic Spline Technique".*IEEE conference on computers in cardiology, 1992, pp 143-146.
[10] P. Laguna, R. Jané, P. Caminal "*Automatic detection of wave boundaries in multilead ECG signals: Validation with the CSE Database",* Computers and Biomedical research 1994, pp 45-60.
[11] Khalid Sayood, Introduction to data compression, Morgan Kaufmann, 3rd edition (2005).
[12] Huang-Nan Huang, Shyu-Yu Wu, Shuo-Tsung Chen and Chih-Yu Hsu, "QRS *Complex Detection using Cubic Splines"*, Fourth International Conference on Genetic and Evolutionary Computing, 2010, pp 787-790.
[13]M Püschel, J M F Moura, "The algebraic approach to the discrete cosine and sine transforms and their fast algorithms",pp.1-37.
[14] Bashar A. Rajoub, *"An Efficient Coding Algorithm for the Compression of ECG Signals Using the Wavelet Transform"*, IEEE Transactions on Biomedical Engineering, VOL. 49, NO. 4, APRIL 2002.
[15] Ruqaiya Khanam, Syed Naseem Ahmad, *"ECG Signal Compression for Diverse Transforms",* Information and Knowledge Management, Vol 2, No.5, 2012
[16] Ms. Manjari Sharma, Dr. A. K. WadhwaniA. Ashok, Neelesh Agarwal, Mukesh Kumar, A.K.Jaiswal & Sanjiv Kumar Sachan, *"Efficient Algorithm for ECG Coding",* International Journal of Scientific & Engineering Research Volume 2, Issue 6, June-2011.
[17] G. Steidl and M. Tasche, *"A Polynomial Approach to Fast Algorithms for Discrete Fourier-Cosine and Fourier-Sine Transforms"* mathematics of computation, Vol 56, No. 193, January 1991, pages 281-296.
[18] R. Harikumar & S. N. Shivappriya, *"Analysis of QRS Detection Algorithms for cardiac abnormalities-A review",* International journal of soft computing & engineering", Vol.1, Issue-5, 2011, pp.80-85.
[19] Nitin Waghmare, Prof. T.B. Mohite-Patil, *"Study of ECG Signal Compression using modified discrete cosine and discrete wavelet transforms",* International Journal of Advanced Research in Computer Engineering & Technology (IJARCET) Vol 1, Issue 7, September 2012,pp.7-9.
[20] A.Ashok Neelesh, Agarwal Mukesh Kumar, A.K.Jaiswal, Sanjiv Kumar Sachan, *"Performance Analysis of Various Types of ECG Compression Techniques In Terms of CR",* International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE) Volume 1, Issue 1, July 2012.

BIOGRAPHIES

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