ECG Data Compression for MIT-BIH Record No. 100/ML II with DCT and DCT-2 Frequency Transformation Techniques

Anurag Agarwal[1] , Ambaika Sharma[2], M L Devel[3]

[1] Assistant Professor, Electrical Engineering Department, M I T Moradabad, U P, India
[2] Assistant Professor, Electrical Engineering Department, I I T Roorkee, U K, India
[3] Assistant Professor, Electrical Engineering Department, I I T Roorkee, U K, India

---***---

Abstract - The electrical activity of the heart called Electrocardiagram (ECG) is a very important diagnostic parameter for the measurement of the heart activity and the health condition of the patient for the treatment purpose, so for the long term monitoring and analysis of the ECG data, compression techniques are very much important and necessary for the record of large data signals in a space, as small as possible for the storage with the high accuracy while retaining the important diagnostic clinical parameters in case of reconstruction of the original compressed signal. In this paper the Frequency Transformation Techniques, DCT and the DCT 2, are proposed for achieving these required conditions based on MATLAB Programming for Standard MIT-BIH Database Record Signal No 100/ML II ECG and the high compression and low error are achieved from this work.

Keywords: ECG compression, Electrocardiogram, Compression Ratio (CR), Percentage Root Mean Square Error (PRD), Transformation Techniques, Discret Cosine Transform (DCT).

1. INTRODUCTION

The Electrocardiogram (ECG) is a record of the electrical activity of the heart muscle over time. Because of its noninvasive nature and its clinical significance, the ECG still remains the most widely used diagnostic tool in cardiology. The Electrocardiogram (ECG) is the electrical manifestation of the contractile activity of the heart, and can be recorded fairly easily with surface electrodes on the limbs or chest. The rhythm of the heart in terms of beats per minute may be easily estimated by counting the readily identifiable waves.

ECG wave shape is altered by cardiovascular diseases and abnormalities such as myocardial ischemia and infarction, ventricular hypertrophy and conduction problems [1].

Following figure shows the ECG waves, peaks, segments and intervals more clearly.

The period of the ECG signal reflects one cardiac cycle. The ECG signal is the series of waves labeled as P, QRS, and T. If we view the cardiac cycle as a series of events, we have the epochs in an ECG waveform as illustrated in Figure 1.

The necessity and the importance for the ECG signal compression are that with the help of compression we have

Increased storage capacity of ECG's as databases for subsequent comparison or evaluation. (b) Feasibility of transmitting real-time ECG's over the public phone network

(c) Implementation of cost effective real-time rhythm algorithms (d) Economical rapid transmission of off-line ECG's over public phone lines to a remote interpretation center

(e) Improved functionality of ambulatory ECG monitors and recorders.

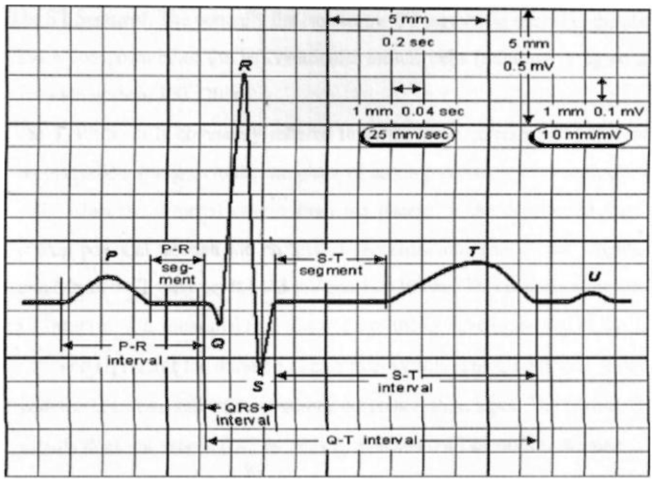

Figure 1: The Human ECG Signal Over One Cardiac Cycle [2]

2. PERFORMANCE METRICS

Compression Ratio (CR) and Percentage Root Mean Square Error (PRD) are the Performance Metrics for the evaluation of compression Technique. High value of CR indicates the high degree of compression and low value of PRD gives the indication of less error in the reconstructed signal for same the compressed signal. Compression

Ration (CR) is defined as the ratio of the number of bits in the original signal to the number of bits in the compressed signal. [3]

$$\text{Compression Ratio (CR)} = \frac{\text{Number of bits in original signal}}{\text{Number of bits in compressed signal}} \quad ...(1)$$

The Compression Ratio can also be define in terms of number of samples of the signal as the ratio of the number of samples before compression to number of samples after compression

$$\text{Compression Ratio (CR)} = \frac{\text{Number of samples before compression}}{\text{Number of samples after compression}} \quad ...(2)$$

and PRD is defined as

$$PRD = \sqrt{\frac{\sum_{n=0}^{N-1} (x[n] - x[n])^2}{\sum_{n=0}^{N-1} (x[n])^2}} * 100\% \quad ...(3)$$

Where x[n] and x[n], n = 0, 1,..., N - 1, represent the values, in mV, of the samples of the original and reconstructed signal, respectively then PRD is calculated as [3] For an effective compression techniques high value of CR and Low value of PRD is desirable.

3.COMPRESSION TECHNIQUES

Data compression methods have been mainly classified into three major categories 1: (a) direct data compression, (b) transformation methods, and (c) parameter extraction techniques. Data compression by the direct data compression methods or by the transformation method contains transformed or actual data from the original signal,whereby, the original data are reconstructed by an inverse process. The direct data compressors ,base their detection of redundancies on direct analysis of the actual signal samples. In contrast, transformation compression methods mainly utilize spectral and energy distribution analysis for detecting redundancies. On the other hand, the parameter extraction method is an irreversible process with which a particular characteristic or parameter of the signal is extracted. The extracted parameters (e.g., measurement of the probability distribution) are subsequently utilized for classification based on a prior knowledge of the signal features.

Frequency transformation technique DCT and DCT 2 are used with MATLAB programming for this work and the same proposed study are used for the comparing the results with the existing method [4] for the same record signal of MIT-BIH Record No. 100/ML II [5] For the proposed work first the .dat file is converted into .m file for the MATAB program as an input and then with the program developed for the compression for DCT and DCT2 it is compressed and then with the help of the inverse DCT and DCT2 the original signal is reconstructed and the performance evaluation have been made and the value of CR and PRD are recorded. The following waveforms are achieved with the proposed techniques for DCT and DCT 2 are shown below:

4. RESULTING WAVEFORMS BY COMPRESSION

4.1 DCT Compression Waveforms

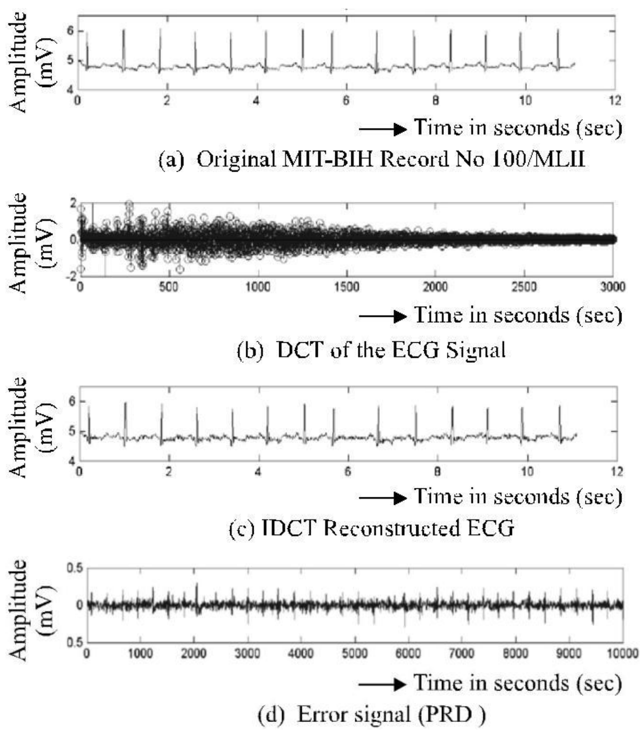

Figure 2: DCT Compression Waveforms (a) Original MIT-BIH Record No 100/MLII (b) DCT of the ECG Signal (c) IDCT Reconstructed ECG (d) Error signal (PRD) Where X-axis represent the time in second (sec) and the Y-axis represent the Amplitude in millivolt (mV)

4.2 DCT2 Compression Waveforms

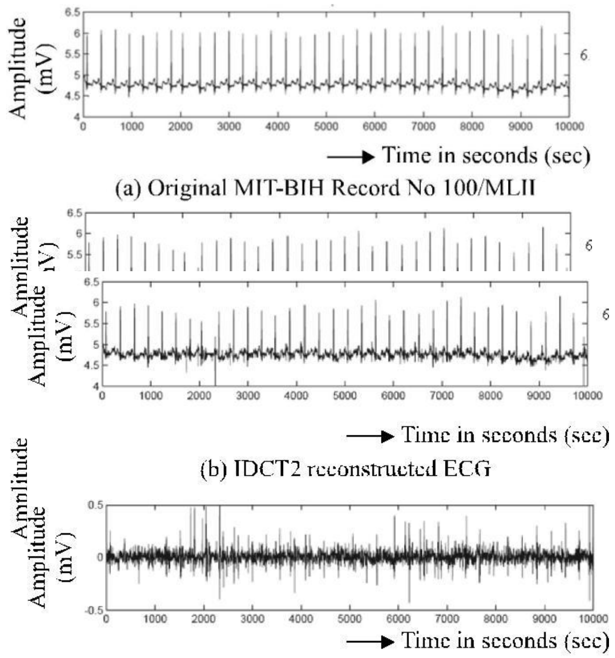

Figure 3: DCT2 Compression Waveforms (a) Original MIT-BIH Record No 100/MLII (b) IDCT2 reconstructed signal (c) Error signal (PRD). Where X-axis represent the time in second (sec) and the Y-axis represent the Amplitude in millivolt (mV)

5. RESULT EVALUATION AND COMPARISION

The result obtained with above program can be tabled as follows:

Table 1: The Comparison of the Performance Metrics CR and PRD for the MIT-BIH Arrhythmia Record No. 100/MLII

S.No.	Parameter / Name of Technique	DCT	DCT2
1.	Compression Ratio (CR)	90.4300	95.7700
2.	Percentage Root Mean Square Difference (PRD)	0.9382	1.3319

The comparison shows that CR is highest (95.7700) for DCT2 compression technique and PRD is lowest (0.9382) for DCT compression technique used for work. The DCT has the second highest value of CR (90.4300).

6. COMPARISON WITH EXISTING TECHNIQUE

The derived result are compared for DCT and DCT2 with the existing techniques [4] for the same MIT-BIH ARRHYTHMIA
Record no 100/MLII.

Table 2: Comparison with the Existing Technique

S.No.	Technique / Parameter	CR	%PRD
1.	DCT[4]	9.1	2.5
2.	DCT[4]	5.9	1.5
3.	DCT[4]	7.6	2.0
4.	DCT[4]	10.2	3.0
5.	DCT [BY PROGRAM]	90.4300	0.9382
6.	DCT 2 [BY PROGRAM]	95.7700	1.3319

From the Table 2, we see that the techniques used [4] for DCT compression for same Record No. 100/MLII gives the value of CR in the range of (5.9–10.2) and for the PRD ranging between (1.5–3.0). Our developed MATAB Program provides the value of CR 8.86 times for DCT and 9.38 times for DCT 2 for the maximum of CR taken as 10.2 .whereas the value of % PRD has been reduced to approximately 60% for DCT and 12% for DCT 2 from the stated value of PRD [4] i.e. error in the reconstructed signal has been reduced effectively and the quality of the reconstructed signal has been improved with achieving high CR and low value of PRD.

7. CONCLUSION AND FUTURE SCOPE

The above achieved results for CR and PRD show that the value of CR (95.7700) is maximum for DCT2 compression. The lowest value of PRD (0.9382) is achieved for DCT compression. On implementation of compression techniques in present study, it is concluded that the higher compression of the signal could be achieved that takes the small memory space for storage and save the bandwidth of transmission channel. The reconstruction of original signal could be achieved with the lower value of error present in the signal and retaining important clinically parameters for diagnosis. This could be achieved at remote location by sending compressed signal through transmission channel and decompressed (reconstruction) at the remote location that will contain the same important clinically characteristics. Future research is always needed to get higher Compression Ratio (CR) and low

Percentage Root Mean Square Difference (PRD) for hi-fidelity ECG compression and reconstruction by better and efficient programming designed that retain the clinically important parameters and the characteristics points of ECG wave.

It is necessary that the reconstructed wave should be suitable for the cardiologist for the analysis and interpretation about the health of the patient. This would be helpful for better diagnosis of disease with low cost suitable processing tools and techniques. The above advancement for the higher quality processing techniques should be to provide more and more feasibility to interpret the large amount of recorded data at later stage. This will provide the cardiologists to have more understanding of signal and they could serve the mankind to have better world.

REFERENCES

[1] R. M. Rangayyan, "*Biomedical Signal Analysis: A Case-Study Approach*", IEEE Press. 2001.

[2] S.T.Hamde, Ph.D. Thesis on "*Analysis & Interpretation of ECG Signal Using Wavelet Transform*", IIT Roorkee, 2000.

[3] Manuel Blanco-Velasco, Fernando Cruz-Roldan, Juan Ignacio Godino-Llorente, and Kenneth E. Barner, "*Wavelet packets feasibility study for the design of an ECG compressor*," IEEE Transactions on Biomedical Engineering, Vol. 54, No. 4, April 2007.

[4] Leonardo Vidal Batista, Elmar Uwe Kurt Melcher and Luis Carlos Carvalho, "*Compression of ECG signals by optimized quantization of discrete cosine transform coefficients*", Medical Engineering & Physics 23, p. 127-134.

[5] http://www.physionet.org/physiobank/database/mitdb/

BIOGRAPHIES

Er. ANTRAG AGARWAL

Er Anurag Agarwal has done his M.Tech from IIT Roorkee. UK,India in Electrical Engineering Department and have 11 Years of Teaching Experience and currently working as Assistant Professor in M I T Moradabad, UP , India in Electrical Department. Research area of his is Biomedical Signal Processing and Control System Techniques.