ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645
Indian Journal of Science and Technology, *Vol 11(1), DOI: 10.17485/ijst/2018/v11i1/116314, January 2018*

ECG Signal Compression using Parallel and Cascade Method for QRS Complex

K. S. Surekha[1]* and B. P. Patil[2]

[1]Sinhgad College of Engineering Pune, Army Institute of Technology, Pune – 411015, Maharashtra, India; surekhaks@yahoo.com
[2]Army Institute of Technology, Pune – 411015, Maharashtra, India; bp_patil@rediffmail.com

Abstract

Objectives: In this paper we present, compression of QRS complex of ECG signal by hybrid technique. The methodology employs both cascade and parallel combination of DCT and DWT. **Methods/Statistical Analysis:** QRS complex is an important part of ECG signal used by doctors for diagnosis purpose. The transmission of QRS complex requires less memory and complexity as compared to the complete ECG signal.The methodology employs both cascade and parallel combination of DCT and DWT. The performance measures such as PRD (Percent Root mean square Difference) and CR (Compression Ratio) are used to validate the results. **Findings**: MIT-BIH ECG database is used for the study. The threshold based technique is implemented on both cascade and parallel system. The cascade technique shows improved CR and proved to be better than the parallel sytem in terms of storage and transmission. The lower value of PRD also demonstrates the improved quality of the reconstructed signal in the cascade and parallel system. **Application/Improvements:** The cascade system with a high CR requires less memory. Both the cascde and parallel system show good reconstruction quality with the low PRD.

Keywords: Cascade, ECG, Parallel, QRS complex

1. Introduction

An ECG can provide important information related to heart abnormalities. The information obtained is useful for diagnosis purpose. ECG is observed by placing electrodes at different positions. The ECG signal has different peaks and valleys such as P, QRS complex and T wave[1]. The ECG signal is shown in Figure 1.

Transform based compression techniques produces better CR. Hence researchers are focussing on techniques such as DCT[2], Burrows-Wheeler Transformation[3], KL transform, DCT Wavelet transform[4], etc. The important goal is to achieve higher CR and lower PRD. Hence there is a lot of scope for ECG signl compression. This paper presents a QRS complex compression of ECG signal.

The paper is presented as follows: Literature Survey is presented in Section 2, The Technique of compression is highlighted in Section 2. The Method used and Results and Discussion are covered in Sections 3 and 4 respectively. Conclusion and References are included as concluding sections.

*Author for correspondence

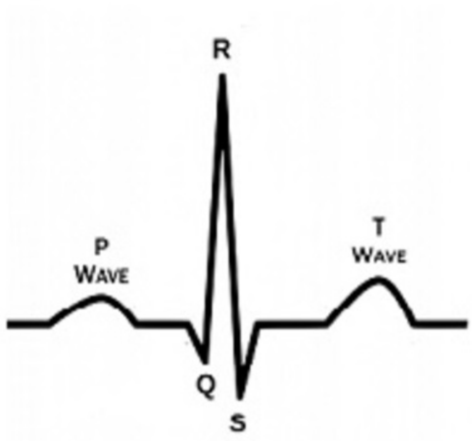

Figure 1. The ECG signal.

2. The Technique of Compression

The main classification of compression techniques are: Direct method, Transformation method and parameter extraction method.

2.1 Direct Method

Time domain samples are analysed in this methodology. FAN, ZTEC are some of the examples[5].

2.2 Transformational Methods

Different transforms such as Fourier Transform, Walsh Transform, Discrete Cosine Transform and Wavelet Transform etc. are used in this methodology.

2.3 Parameter Extraction Methods

A set of parameters used in the reconstruction process.

Compression technique[6–10] is employed for transmission and storge of ECG signal.

2.4 The Wavelet Transform

The mathematical representation of wavelet basis function is:

$$\Psi_{a,b(t)} = \frac{1}{\sqrt{a}}\Psi\left(\frac{t-b}{a}\right) \quad (1)$$

The variable 'a' is the scale of a basis function. The variable 'b' is the translated position [1]. Discrete Wavelet Transform (DWT) can be defined as:

$$f^{(t)} = \sum c_{m,n\Psi m,n(t)} \quad (2)$$

2.5 Discrete Cosine Transform (DCT)

The mathematical representation of DCT[2] of sequence x is given by:

$$y(k) = w(k)\sum \frac{N}{n_{=1^{x(n)}}} \cos\frac{\pi(2n-1)(k-1)}{2N} \quad (3)$$

DCT has better energy compaction properties than the DWT.

3. Method Used

- Select an ECG .dat file signal from MIT- BIH Database.
- Apply pre-processing.
- QRS complex extraction.
- Compute DCT and apply threshold.
- Perform IDCT.
- Repeat the same procedure using DWT and IDWT.

The signal initially goes through preprocessing stage to remove noise and interference. After the preprocessing, QRS complex is extracted. Then the signal goes through

DCT followed by the IDCT (Inverse Discrete Cosine Transform). A threshold based technique is used to remove the redundant coefficients. The coefficients falling below the set threshold value are removed. The same procedure is repeated with the DWT and IDWT (Inverse Discrete Wavelet Transform). In the parallel form, the DCT and DWT are applied in parallel. The algorithm is tested for different wavelets. The threshold value helps in achieving compression.

4. Results and Discussion

The results for the QRS complex compression for cascade structure is shown in Table 1. Similarly, the results for a

Table 1. DCT and DWT in cascade for QRS complex compression

Signal	Threshsold	DCT		DWT	
		CR%	PRD	CR%	PRD
16265 Db1	0.01% of R peak	1.56	0.02	90.23	0.0085
16265 Sym3		1.56	0.02	81.44	0.02
16265 Db1	0.5% of R peak	15.23	0.78	90.23	0.24
16265 Sym3		15.23	0.78	83.59	0.53

Table 2. DCT and DWT in parallel for QRS complex compression

Signal	Threshold	DCT		DWT		PRD New
		CR%	PRD	CR%	PRD	
16265 Db1	0.01% of R peak	1.17	0.02	1.92	0.01	0.01
16265 Sym3		1.17	0.02	2	0.01	0.01
16265 Db1	0.5% of R peak	12.3	0.77	3.84	0.08	0.39
16265 Sym3		12.3	0.77	15	0.37	0.46

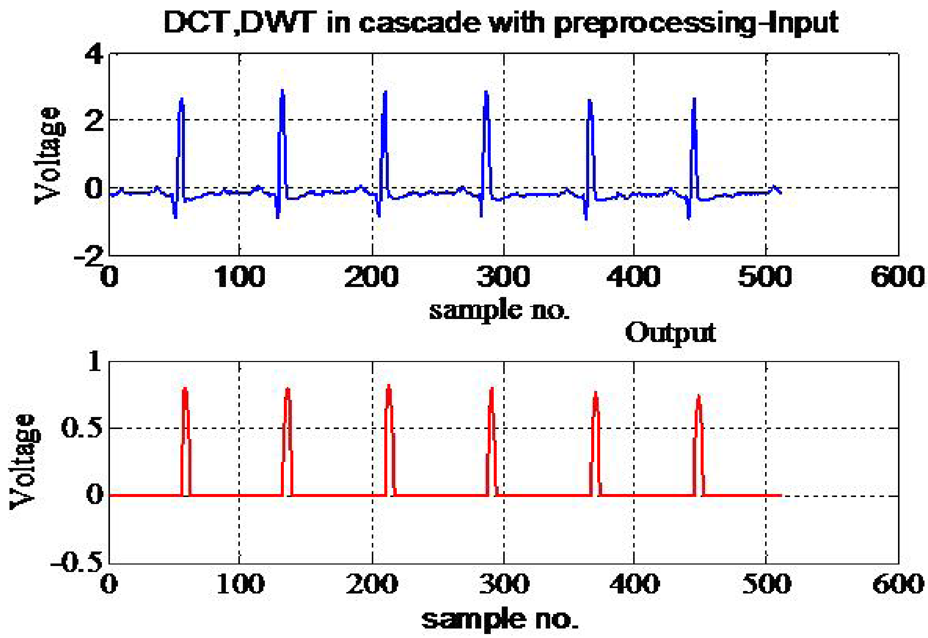

Figure 2. Input and output waveform-cascade system.

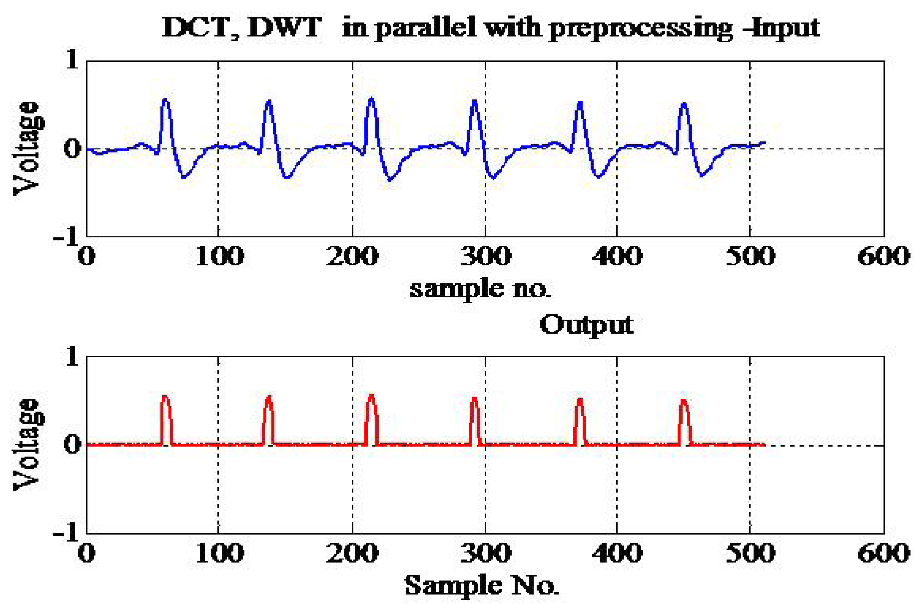

Figure 3. Input and output waveform-parallel system.

parallel structure are tabulated in Table 2. The experiment is done using MIT-BIH database. MATLAB tool is used for the simulation. The threshold is selected in terms of R peak percentage. The threshold value is carefully selected and it helps in removing the redundant coefficients. From the result table, it is clear that the cascade system has achieved better CR as compared to the parallel system. The low value of the PRD also indicates good reconstruction quality of the QRS complex. As shown in Table 2, the parallel system has achieved a very low CR. One important observation is made in terms of the new PRD of the parallel mode. The new value of PRD for the parallel system is calculated after the parallel operation of DCT and DWT. As far as the reconstruction quality, both the system have performed well. The experimentation is carried out using both db1 and sym3 wavelets. The db1 wavelet has shown better results as compared to the sym3. The input and output signals for both cascade and parallel system are shown in Figures 2 and 3 respectively. The waveforms clearly show good reconstruction quality of the signal.

5. Conclusion

The QRS complex compression of ECG signal on both cascade and parallel system are implemented using a threshold based method. The cascade system is proved to be better due to higher CR. In terms of PRD, the cascade and parallel system have performed well. This shows good quality of the reconstructed signal. The careful selection of the threshold helps in achieving higher CR. Encoding techniques can be added to improve the CR.

6. Acknowledgement

We are grateful to the Principal, Head of Department and Ph.D coordinator of Sinhgad College of Engineering, for helping us to publish this research work. We are grateful to the Director and the Joint Director, Army Institute of Technology for their motivation to carry out research in the Institute.

7. References

1. Surekha KS, Patil BP. QRS complex compression of ECG signal using hybrid transform. Proceedings of Fifth International Conference on Advances in Recent Technologies in Communication and Computing; 2013. p. 261–5. Crossref.
2. Vibha A, Manjeet SP. Quality controlled ECG Compression using Discrete Cosine Transform (DCT) and Laplacian Pyramid (LP). Proceedings of International Conference on Multimedia, Signal Processing and Communication Technologies; 2009. p. 12–5.
3. Sarada PD, Jyotinder SS. Lossless ECG compression for event recorder based on Burrows-Wheeler transformation and move-to-front coder. International Journal of Recent Trends In Engineering. 2009 May; 1(3):120–3.
4. Ktata S, Ouni K, Ellouze N. A novel compression algorithm for electrocardiogram signals based on Wavelet Transform and SPIHT. World Academy of Science Engineering and Technology. 2009; 3(11):342–7.
5. Jalaleddine SS, Hutchens C, Strattan R, Coberly W. ECG data compression techniques - A unified approach. IEEE Transactions on Biomedical Engineering. 1990; 37:329–43. PMid: 2186997. Crossref.
6. Surekha KS, Patil BP. ECG signal compression using the high frequency components of the wavelet transform. International Journal of Advanced Computer Science and Applications. 2016; 7(3):311–5.
7. Pooyan M, Taheri A, Moazami-Goudarzi M, Saboori I. Wavelet compression of ECG signals using SPIHT algorithm. International Journal of Information and Communication Engineering; 2005. p. 219–25.
8. Tahere IM, Mohammad RKM. ECG compression with Thresholding of 2D-Wavelet transform Coefficients and

run length coding. European Journal of Scientific Research. 2009; 27(2):248–57.

9. Morteza MG, Mohammad HM. Electrocardiogram signal compression using Multiwavelet Transform. Transactions on Engineering, Computing and Technology. 2005; 6:332–6.

10. Tatiparti PM, Madhavi L, Abrar A. ECG compression and labview implementation. Journal of Biomedical Science and Engineering. 2009; 2:177–83. Crossref.