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Detection of QRS Complexes of ECG Waveform Based On Empirical Mode Decomposition Using MATLAB

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Abstract*—Electrocardiogram (ECG) has been treated as one of the simplest non-invasive techniques. has been used as a diagnostic tool and its measurement become routine part of any complete medical evaluation. an efficient and automatic detection of QRS complex and R-Peak is essential for reliable health condition monitoring. Many algorithms have been developed during the last five decades for accurate and reliable detection of QRS complex in the ECG signal featuring high percentages of correct detection, In the widely used transformative techniques for QRS detection, Hilbert, wavelet and cosine transform are used to characterize signals by spectral energy and slope, etc. an EMD algorithm has been used for the accurate detection of QRS complex. EMD is one of the adaptive time-frequency data analysis method. The performance of this method in QRS detection algorithm has been tested using records from Fantasia database in case of sensitivity of S_e(%) = 99.97% and Positive predictivity of +P(%) = 99.97% on fantasia database for 72543 beats that shows good reliability of the proposed R-Peak detection algorithm.

***Index Terms*— ECG Signal, QRS Complex, Empirical mode decomposition, IMF.**

I. INTRODUCTION

In present times, there is increasing population of world suffering from cardiac related abnormalities. Cardiovascular disease is caused by disorders of the heart and blood vessels, and includes coronary heart disease (heart attacks), cerebrovascular disease (stroke), raised blood pressure (hypertension), peripheral artery disease, rheumatic heart disease, congenital heart disease and heart failure. The major causes of cardiovascular disease are tobacco use, physical. Inactivity and an unhealthy diet [1]. The Electrocardiogram (ECG) is the graphical recording or display of the time variant voltages produced by the myocardium during the cardiac cycle. Figure illustrates the wave components of the ECG signal. The normal ECG is composed of a P wave, a QRS complex and a T wave. The P wave represents a trial depolarization and the QRS represents ventricular depolarization [2]. The T wave reflects the phase of rapid repolarization of the ventricles. . The PR interval is the duration of time between the beginning of the P wave, signifying atria depolarization, and the beginning of the QRS complex. It represents the time between the beginning of the contraction of the atrium and the beginning of the contraction of the ventricle The heart is a muscular organ with a circulatory system that is responsible for pumping blood throughout the blood vessels by repeated, rhythmic contractions, in recent number of techniques developed for ECG feature extraction [3], [4], [5].previously proposed method of ECG Signal analysis was on time domain method. [14].

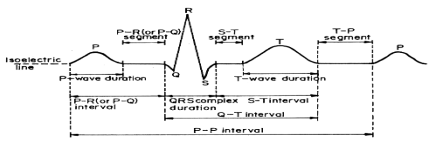

Fig.1. ECG Signal

II. EMPIRICAL MODE DECOMPOSITION

Most of the signals in practice are time-domain signals in their raw format the time domain signals are transformed using an analysis function. There are many transforms that are used quite often by engineers and mathematicians such as Fourier Transform (FT), Short Time Fourier Transform (STFT), Hilbert-Huang transform (HHT), Wigner distributions, Radon Transform, Wavelet Transform (WT).EMD [6] [7] [8] using cubic splines as an essential tool to create the upper and lower ASA Goddard Space Flight Center (Huang et al., 1998) Interpolation technique (cubic spline).siftting process to extract and identify intrinsic modes functions (IMFs) which are defined as Functions with equal number of extreme and zero crossings (or at most differed by one).Signal must have a zero-mean.

III. EMPIRICAL MODE DECOMPOSITION ALGORITHM

1. Locate local maxima and minima of $d_0(t) = x(t)$.
2. Interpolate between the maxima and connect them by a cubic spline curve. The same applies for the minima in order to obtain the upper and lower envelopes $e_u(t)$ and $e_l(t)$, respectively.
3. Compute the mean of the envelopes
   $M(t) = \frac{e_u(t)+e_l(t)}{2}$
4. Extract the detail $d_1(t) = d_0(t) - m(t)$ (sifting process).

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5. Iterate steps 1-4 on the residual until the detail signal $d_k(t)$ can be considered an IMF: $c_1(t)= d_k(t)$.
6. Iterate steps 1-5 on the residual $r_n(t) =x(t) - c_n(t)$ in order to obtain all the IMFs $c_1(t),.., c_N(t)$ of the signal.
7. The procedure terminates when the residual signal is either a constant, a monotonic slope, or a function with only one extreme Mathematical Expression of EMD processed signal $\mathbf{(t)=\sum^{N}_{n=1}c_n(t)+r_N(t).}$
8. Lower order IMFs capture fast oscillation modes while higher order IMFs capture slow oscillation modes [9].
9. Criteria used for Numerical Convergence
10. The sifting process ends (IMF extraction) when the range of the mean of the envelopes m (t) is lower than 1‰ (0.001) Candidate IMF.

IV. BLOCK DIAGRAM

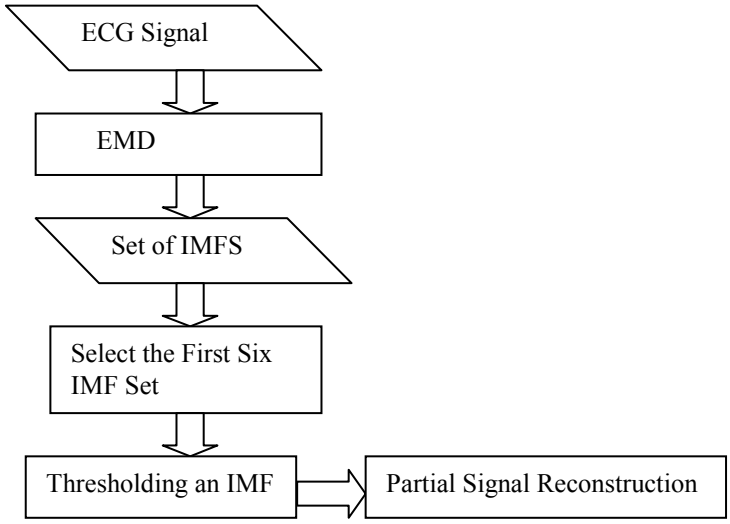

Fig.2. Block Diagram

V. RESULT ANALYSIS

The QRS detection algorithm has been firstly tested on 20 sets of ECG signal record files F1o01, F1o02, F1o03, F1o04, F1o05, F1o06, F1o07, F2o01, F2o03, F2o04, F1y01, F1y02, F1y03, F1y06, F1y08, F1y09, F1y10, F2y01, F2y02, F2y03 from Fantasia database[10]. Each record in this database is a 1 hours ECG recording of different young and old patients. The result in tabular form after applying EMD based QRS algorithm detection are given in table In term of visual representation of the result, detected R-peak in records are shown in figures.

$$S_{e(\%)}=\frac{TP}{TP+FN}\times 100$$

Where

TP is the number of true positives (true detection).
FN is the number of false negatives (missed detection).
FP is the number of false positives (Erroneous Detection) [12].

Record No.	Test Results							
	No of Samples	Actual No of Beats	No of detected Beats	TP	FP	FN	S_e (%)	+P (%)
F1o01	900000	3593	3594	3593	1	0	100	99.9
F1o02	900000	3434	3432	3429	3	5	99.8	99.9
F1o03	900000	3650	3651	3647	4	3	99.9	99.8
F1o04	900000	3092	3090	3080	2	4	99.8	99.9
F1o05	900000	3355	3357	3354	3	1	99.9	99.9
F1o06	900000	3066	3066	3066	0	0	100	100
F1o07	900000	3633	3633	3032	1	1	99.9	99.9
F1y01	900000	4449	4449	4449	0	0	100	100
F1y02	900000	3582	3582	3582	0	0	100	100
F1y03	900000	3864	3864	3864	0	0	100	100
F1y06	900000	3503	3504	3503	1	0	100	99.9
F1y08	900000	3702	3702	3702	0	0	100	100
f2o04	900000	4072	4072	4072	0	0	100	100
f2o01	900000	4438	4438	4438	0	0	100	99.9
F2y01	900000	3823	3823	3822	1	1	99.9	100
F2y02	900000	3396	3396	3396	0	0	100	100
F2y03	900000	3474	3474	3474	0	0	100	100
Total	15300000	62126	62127	61511	16	15	99.9	99.9

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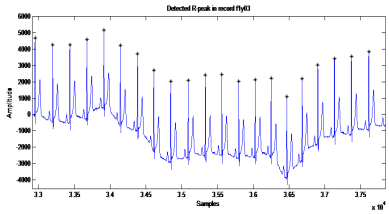

Fig.3. Detected R-peaks in Record f1o01 from Fantasia database

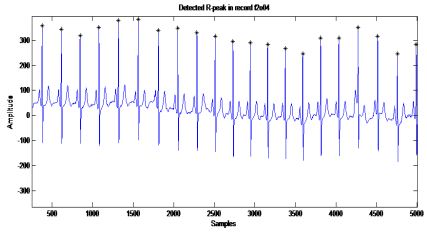

Fig.4. Detected R-peaks in Record f1o02 from Fantasia database

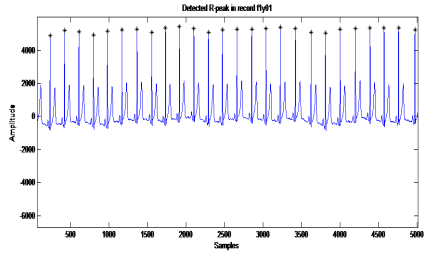

Fig.5. Detected R-peaks in Record f1o03 from Fantasia database

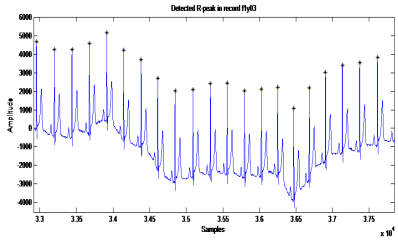

Fig.6. Detected R-peak in recorded f1y01 from Fantasia database

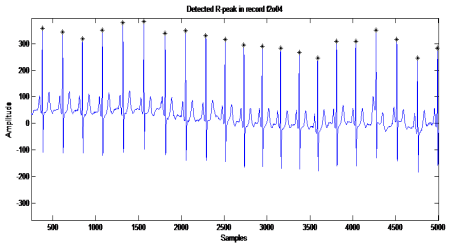

Fig.7. Detected R-peak in recorded f1y03 from Fantasia database

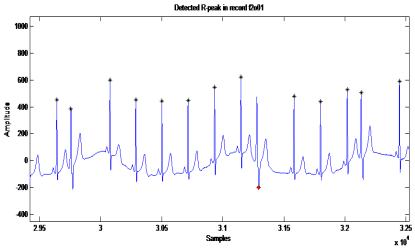

Fig.8. Detected R-peak in recorded f2o04 from Fantasia database

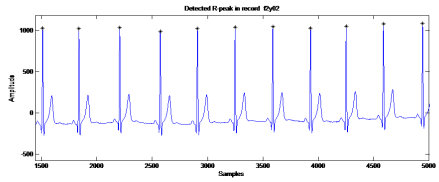

Fig.9. Detected R-peak in recorded f2o01 from Fantasia database

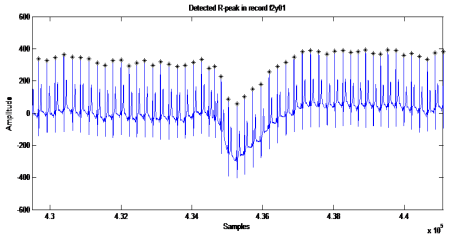

Fig.10. Detected R-peak in recorded f2y01 from Fantasia database

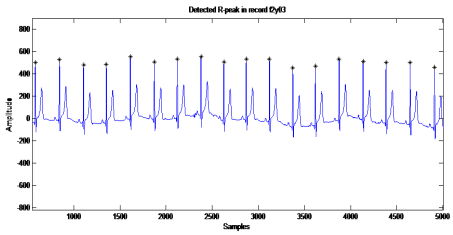

Fig.11. Detected R-peak in recorded f2y02 from Fantasia database

VI. CONCLUSION

A new QRS detection algorithm using EMD has been proposed. Empirical mode decomposition (EMD) method has found a powerful method for nonlinear non-stationary data analysis. The algorithm is implemented in MATLAB Using Fantasia database algorithm performed high effectively with accurate QRS peak detection. Previous work based on EMD shows that QRS region is better captured in first three IMFs and second and third IMFs [11]. In this algorithm, we use first six IMF to extract the required information, the proposed algorithm exhibits better performance and achieves high sensitivity for the QRS complex detection.

VII. FUTURE SCOPE

Further this algorithm can be extended by making the algorithm versatile for P wave and T wave detection (the onsets and offsets of P, QRS and T waves) which can be very helpful in numerous clinical applications.

- The R-Peak obtained from the Empirical Mode Decomposition method can be used to measure Heart Rate.
- The proposed algorithm based on Empirical Mode Decomposition may further explore for T-Wave Alternan (TWA). It is considered as an indicator of sudden cardiac death (SCD) and ventricular tachycardia (VT). Diabetic patients show a higher probability of TWA in their ECG signals.

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- Future work can be done by improving the adaptive selection of IMF based on their frequency spectrum and energy content.

REFERENCES

[1] WWW. Who.int/topics/cardiovascular_diesease/en/.

[2] P.W. Macfarlane and T.D.V.Lowrie, Comprehensive Electrocardiography, Vol I and II, NY: Pergammon press 1989.

[3] Juan Pablo Martinez, Rute Almeida, Salvador Olmos, Ana Paula Rocha, and Pablo Laguna, "A Wavelet-Based ECG Delineator: Evaluation on Standard Databases," IEEE Transactions on Biomedical Engineering.

[4] Krishna Prasad and J. S. Sahambi, "Classification of ECG Arrhythmias using Multi-Resolution Analysis and Neural Networks," IEEE Transactions on Biomedical Engineering, vol. 1, pp. 227-231, 2003.

[5] Cuiwei Li, Chongxun Zheng, and Changfeng Tai, "Detection of ECG Characteristic Points using Wavelet Transforms," IEEE Transactions on Biomedical Engineering, Vol. 42, No. 1, pp. 21-28, 1995.

[6] Benitez DS, et al. A new QRS detection algorithm based on the Hilbert Transforms. Computers in cardiology, 27:379-382, 2000.

[7] WeiFang Zhu, HeMing Zhao and XiaPing Chen, "A new QRS detector based on empirical decomposition", 10th Int.Conf. on Signal Processing (ICSP), pp.1-4,2010.

[8] Arafat A., Hasan, K.,"Automatic detection of ECG wave boundaries using Empirical Mode Decomposition", Int Conf. on Acoustic, Speech and Signal Processing (ICASSP), pp.461-464, 2009.

[9] Rilling, G. MATLAB code for computation of EMD and Illustrative slides.

[10] Pal, Sand and Mitra,M "QRS Complex detection using Empirical Mode Decomposition based Windowing Technique '',Int.conf .On Signal Processing and Communication (SPCOM),pp.1-5,2010.

[11] Jaya prakash sahoo, sheemarani behera samit ari "A Novel Technique for QRS Complex detection in ECG Signal Based on Hilbert Transform and Autocorrelation''8 jun 2011.

[12] Application of EMD as a Robust Adaptive Signal Processing Technique in Radar/Sonar Communications Ch.Kusma Kumari, Prof. K.Raja Rajeshwari, Vol. 3 No.12 December 2011.

[13] http://en.wikipedia.org.