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QRS Wave Detection In Matlab Using Wavelet Transform

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Abstract

This paper describes application of wavelet transform in determination and analysis of QRS complex of ECG. MATLAB has been used to process signal purification (Removal of noise and baseline wandering) and further analysis of QRS complex.

Keywords−ECG, Wavelet Transform, Thresholding, Haar Wavelet, Matlab.

1. Introduction

ECG (Electrocardiography) is graphical presentation of electrical activity of heart in reference to time. Certain diseases of heart alter this pattern of electrical activity of heart and analysis of these changes can be helpful in identifying and diagnosing the underlying problem.

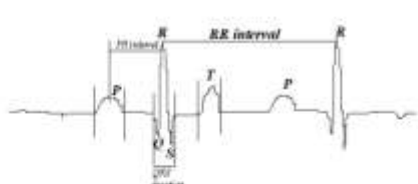

Figure 1. Normal ECG Signal

ECG is made up of P wave, QRS Complex and T wave. P wave represents depolarization of atria; QRS complex correlates with ventricular depolarization and T-wave indicate ventricular re-polarization. P-R and Q-T intervals represent conduction of impulse from atria to ventricles and re-polarization of ventricles respectively. As QRS complex and Q-T interval represents ventricular activity of heart, it can play crucial role in diagnosis of various ventricular abnormalities.

Nagendra.H[1] gives overview of some wavelet techniques published in journals and conferences and also show application of DWT(Discrete Wavelet Transform) and SWT(Stationary Wavelet Transform).

K.V.L.Narayana[2] compare Wavelet based algorithm with the AF2 algorithm/Pan-Tompkins algorithms for signal denoise and detection of QRS complexes meanwhile better results are obtained for ECG signals by the wavelet based algorithm. In the wavelet based algorithm, the ECG signal has been denoised by removing the corresponding wavelet coefficients at higher scales.

C Saritha,V[3] and S.A.Choukari[7] shows that using wavelet transform, the ECG signal is denoised by removing the corresponding wavelet coefficients at higher scales using simulator and classify signal abnormalities. Chuang-Chien Chiu[4] used DWT approach for human identity verification because ECG signal of each person is differ so for security ECG signal can be use in future. The performance of the ECG verification system was estimated by calculating the false acceptance rate (FAR) and false rejection rate (FRR). We have studied Different parameter in ECG signal and also different abnormalities of ECG signal and its characteristics[8].

Gaurav Jaswal[5] gives perfomance evalution and comparision of QRS detection using DWT approach , So and chan method Accuracy achieved with DWT is 95.74 % as compared to 92.55 % of "So and Chan" method.

2. Wavelet transforms

Wavelet transform provides good time resolution and poor frequency resolution at high frequencies and good frequency resolution and poor time resolution at low frequencies[6]. This property of wavelet transform is expected to be useful for the signal which has high frequency for short duration and low frequency for long duration.

ECG signal is not strictly a periodic signal but it differs in both period and amplitude level at each beat. It has high frequency component like 'QRS' complex for short duration and low frequency component like 'P' and 'T' wave is for long duration. Thus wavelet transform can be very useful approach for analysis the ECG signal.

3. Algorithm for QRS complex Detection

Fig.2 shows algorithm for QRS detection. This algorithm is divided into five steps.

Step 1: Removal of base line wander and noise from ECG signal by bringing base line of ECG signal to 0 volt. For that purpose, high pass filter with cutoff frequency is 0.5Hz and also most dominant frequency range of ECG signal is near about 40Hz so that low pass filter with cutoff frequency 40Hz has been used to remove high frequency noise signal.

Step 2: Haar wavelet has been used with low pass filter coefficient of [0.5 0.5] and high pass coefficient of [-0.5 0.5] because these coefficients give better and less number of window signals compare to other coefficients , generated after thresholding process so it is easy to select best window signal. 2nd level detail coefficient and 2nd level approximation coefficient has been used in further processing.

Step 3: Detail coefficient thresholding have been used to remove low amplitude component in 2nd level. Hence, high amplitude component will count one and low amplitude component will count zero. The result plot has been achieved which contains only one and zero value which is called as "window signal".

Step 4: Best window signal has been selected and multiplied by 2nd level approximation coefficient to find out position of QRS complex from ECG de-noise signal.

Step 5: "max() and min()" function from MATLAB is used for estimation and detection of QRS complex and discovery of P-R, R-R intervals.

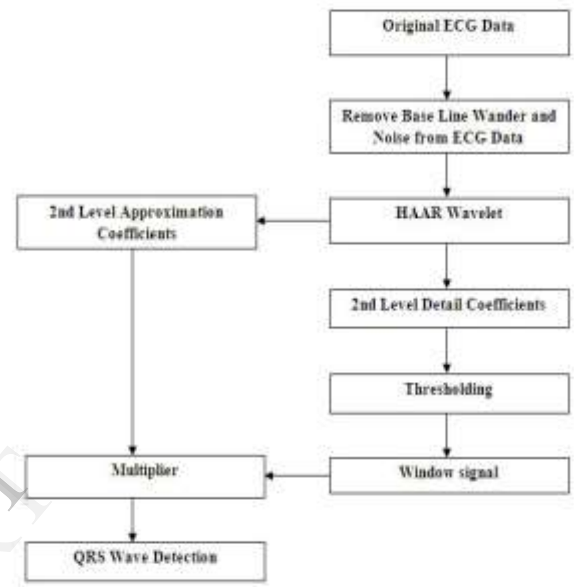

Figure 2. Algorithm for QRS Detection

Input Data is taken from physio.net site[9], Folder= ptbdb/patient255/s0491_re. Fig.3 demonstrates baseline wonder and noise. Figure 4 shows removal of noise and baseline wondering from signal using filter method explained in step 2. 2nd level approximation coefficient and 2nd level detail coefficient is generated using Haar Wavelet as shown in figure 5.

Window signals with different threshold have been obtained by application of thresholding at 2nd level detail coefficient and selected window signal has been multiplied by 2nd level detail coefficient.

Peaks of Q, R & S waves of QRS complex is detected using "max() and min()" function from MATLAB once position of QRS complex is detected(Figure 7)

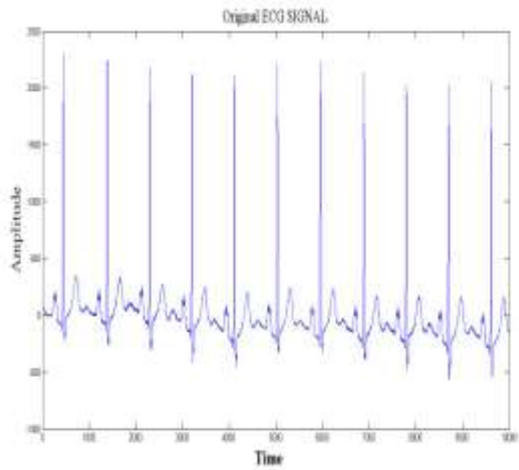

Figure 3.Original ECG Signal

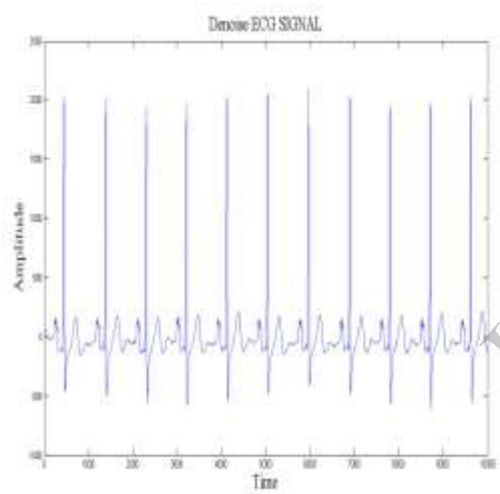

Figure 4.De-noised ECG Signal

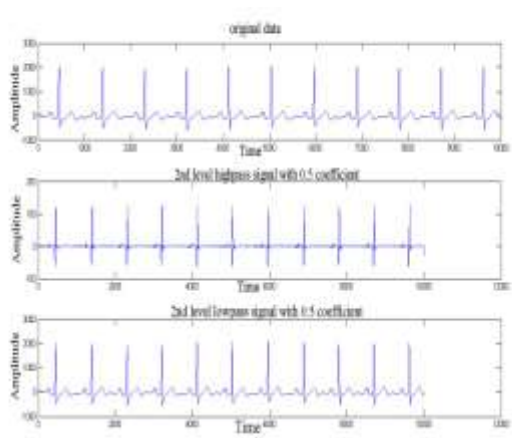

Figure 5.original data , 2nd level high pass and low pass coefficients respectively.

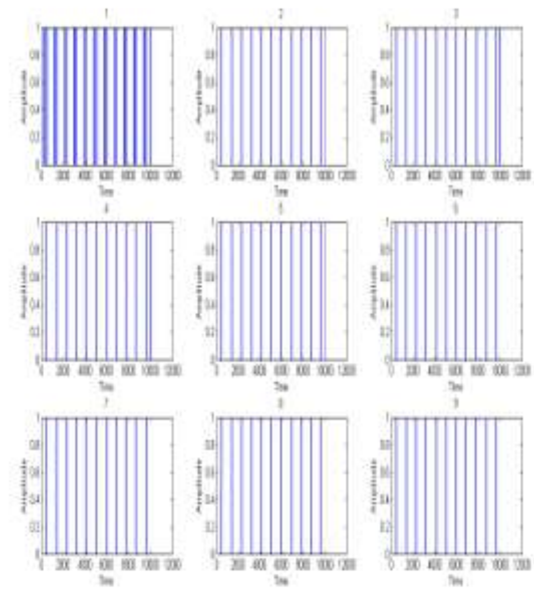

Figure 6.Window signals.

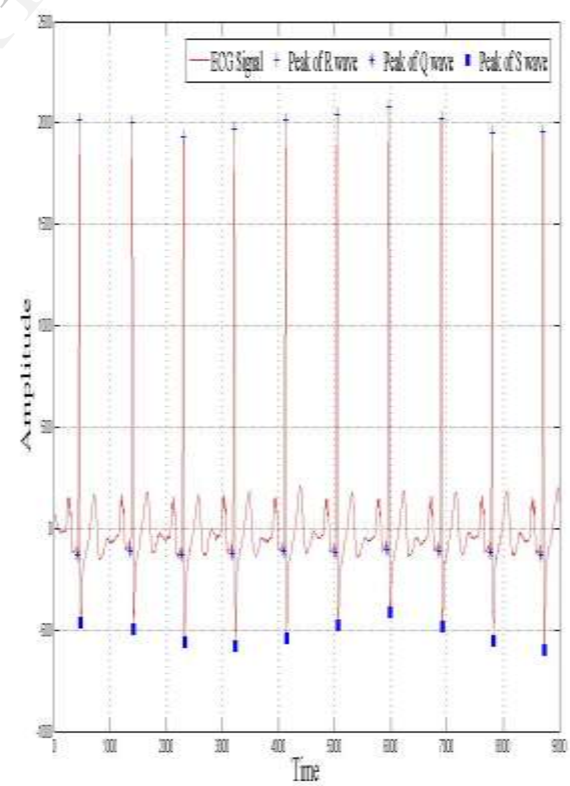

Figure 7.QRS wave detection

4. Results

Results obtained by application of this algorithm on PTB[9] Database has been demonstrated in Table 1..

FP=False Positive means total no. of wrong beats are detected (indicates specificity of algorithm).
FN=False Negative means total no of right beats are missed ((indicates sensitivity of algorithm).
Accuracy % = (1-(FP+FN)/Total no. of beats)*100.

Table 1. QRS wave detection

ECG Data (Lead II)	condition of heart	Total no. of bits	F P	F N	Accu-racy %
s0015lre.mat	Myocardial Infraction	13	0	0	100
s0021arem.mat	Myocardial infraction	15	0	0	100
s0316lrem.mat	Myocardial infraction	15	0	0	100
s0030lrem.mat	Valvular heart disease	13	1	0	92.30
s0349lrem.mat	Dysrhythmia	07	0	0	100
s00364lrem.mat	Bundle branch block	13	1	0	92.30
s0484lrem.mat	Myocarditis	10	0	0	100
s0491lrem.mat	Healthy control	12	0	0	100
s0301lrem.mat	Healthy control	11	0	0	100
s0299lrem.mat	Healthy control	09	0	0	100
s0275lrem.mat	Healthy control	09	0	0	100

5. Conclusion

In our experiments we have received 100% accuracy in detection of QRS complex in normal condition of heart where 97.8% accuracy in abnormal conditions with average of 98.6% accuracy. More research is needed to detect accuracy in real life scenarios.

6. Acknowledgement

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7. Future work

We have used Haar wavelet in our algorithm for QRS detection. It is expected that application of various Wavelets from different Wavelet families may enhance the accuracy of current algorithm in terms of both specificity and sensitivity.

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