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IDENTIFICATION OF TACHYCARDIA AND BRADYCARDIA HEART DISORDERS USING WAVELET TRANSFORM BASED QRS DETECTION

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Abstract: In the recent years Cardiac disorder is a very common problem faced by the people. The ECG is the most important test for the interpretation of cardiac abnormalities. The ECG gives the electrical activity of the human heart and by analyzing the deviation in these electrical activities, conclusion can be drawn. The study is divided into two parts. In the first part it deals with the detection of real time ECG waveform from the MIT-BIT Arrhythmia database and then these signals is further diagnosed by applying Wavelet Transform for R-peak detection. The second part of the study deals with the calculation of heart rate with the help of R-peaks detected and accordingly the cardiac arrhythmia can be analyzed. The study has been inspired by the need to find an efficient method for ECG Signal Analysis which is simple and has good accuracy and takes less computation time.

Keywords*: Electrocardiogram (ECG); Wavelet Transform (WT); QRS detection; Tachycardia; Bradycardia.*

I. INTRODUCTION

Electrocardiogram (ECG) is a nearly periodic signal that reflects the electrical activity of the heart. A lot of information on the normal and pathological physiology of heart can be obtained from ECG. However, the ECG signals being non-stationary in nature, it is very difficult to visually analyze them. Thus the need is there for computer based methods for ECG signal Analysis. A lot of work has been done in the field of ECG signal Analysis using various approaches and methods. The basic principle of all the methods however involves transformation of ECG signal using different transformation techniques including Fourier Transform, Short Term Fourier Transform, Hilbert Transform, Wavelet transform etc. Physiological signals like ECG are considered to be quasi-periodic in nature.

They are of finite duration and non stationary. Hence, a technique like Fourier series (based on sinusoids of infinite duration) is inefficient for ECG. On the other hand, wavelet, which is a very recent addition in this field of research [3,5], provides a powerful tool for extracting information from such signals. There has been use of Continues Wavelet Transform (CWT).

II. THEORY

ECG reflects the state of cardiac heart and hence is like a pointer to the health conditions of a human being. ECG, if properly analyzed, can provide us information regarding various diseases related to heart. However, ECG being a non-stationary signal [2], the irregularities may not be periodic and may show up at different intervals. Clinical observation of ECG can hence take long hours and can be very tedious. Moreover, visual analysis cannot be relied upon.

There is an increasing need for the development of sensitive tools for risk factor stratification because of the danger of cardiac arrhythmias and sudden cardiac death.

The main objective of this study is to detect the R-peak of an ECG signal using MATLAB simulator with the help of MIT-BIH Arrhythmia Database and analyze the ECG signal using the Wavelet Transform (WT). The Continuous Wavelet Transform is defined as

$$C(\tau, s) = \frac{1}{\sqrt{s}} \int_t f(t) \psi^* \left(\frac{t-\tau}{s} \right) dt$$

As seen in the above equation, the transformed signal is a function of two variables, τ(tau) and s, the translation and scale parameters respectively, and the ψ(t) is the transforming function and it is called the mother wavelet [6].

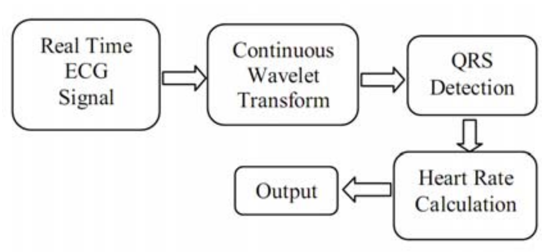

Figure 1: Process Flow of the Study.

The ECG is a technique of recording bioelectric currents generated by the heart [1,4]. Clinicians can evaluate the conditions of a patient's heart from the ECG and perform further diagnosis.

The main components of the human cardiovascular system are the heart and blood vessels. The heart pumps oxygenated blood to the body and deoxygenated blood to the lungs.

The heart pumping process is controlled by an electrical signal generated at the sinoatrial (SA) node and this electrical signal causes the heart to beat rhythmically to move blood through the body.

Thus by realizing these heart rate variations (HRV), Sinus Tachycardia (that is when the heart rate is above 100 beats per minute (bpm)) and Sinus Bradycardia (that is when the heart rate is bellow 60 bpm) can be detected by comparing with normal Sinus Normal Rhythm.

III. METHOD

The following gives the step by step analysis of the study:

- Our first aim is to load the real time ECG signal from the MIT-BIH Arrhythmia database with sampling frequency „Fs‟.
- Then we apply CWT to this real time ECG signal for QRS detection.
- Then we find out the total number of R-peaks detected in the QRS detection and calculate the beat rate using the formula: Beats =(number of R peaks/Fs)*10;
- If beats>100 then abnormality is Tachycardia else if beats<60 then Abnormality is Bradycardia.

IV. RESULTS AND DISCUSSION

We found from the study that the Daubechies of order 3 (db3) of the wavelet family provides the best result for heart rate calculation as compared from the MIT-BIH Arrhythmia database. We compared the result of different wavelet families used, with the Db3 and calculated the error.

$$Error\,\% = \frac{QRS_{Db3} - QRS_n}{QRS_{Db3}} \times 100$$

The above equation calculates the different errors obtained in the different wavelet families with respect to the db3 of the different MIT-BIH Arrhythmia database.

Thus we find that the haar gives the most poor results with error percentage 11 %, Db5 gives (– 7.23) %, coiflet gives 3.98 %, symlet gives 2% and Db2 gives 1.91 % .

Table 1: Experimental results of the R-peak detection and Cardiac Arrhythmia (next page)

V. CONCLUSION

From the comparative study it can be seen that db3 wavelet helps in developing the most appropriate tool for automatic detection of cardiac arrhythmia. Since the application of WT in ECG signal analysis is a new field of research, many other techniques will be required to improve the clinical usefulness of signal processing.

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Table 1: Experimental results of the R-peak detection and Cardiac Arrhythmia

Tests	Gender	Age	Sampling Freq, 'Fs'	Wavelet Applied	Heartbeat Rate	No. of R-peaks	Cardiac Arrhythmia
Test 1	Male	64	1000	Haar	68.27	6827	Normal
				Db2	73.58	7358	Normal
				Db3	8029	8029	Normal
				Db5	87.41	8741	Normal
				Coif1	74.16	7416	Normal
				Sym3	73.58	7358	Normal
Test 2	Male	68	1000	Haar	29.39	2939	Bradycardia
				Db2	31.08	3108	Bradycardia
				Db3	32.67	3267	Bradycardia
				Db5	38.04	3804	Bradycardia
				Coif1	31.76	3176	Bradycardia
				Sym3	31.08	3108	Bradycardia
Test 3	Male	43	1000	Haar	100.28	10028	Tachycardia
				Db2	102.21	10221	Tachycardia
				Db3	104.45	10445	Tachycardia
				Db5	105.57	10557	Tachycardia
				Coif1	100.31	10031	Tachycardia
				Sym3	100.21	10021	Tachycardia
Test 4	Female	72	650	Haar	60.38	3924.7	Normal
				Db2	68.38	4444.7	Normal
				Db3	80.46	5229.9	Normal
				Db5	94.84	6164.6	Normal
				Coif1	67.35	4377.8	Normal
				Sym3	68.38	4444.7	Normal
Test 5	Female	76	650	Haar	42.22	2744.3	Bradycardia
				Db2	40.49	2629.2	Bradycardia
				Db3	39.05	2538.2	Bradycardia
				Db5	40.65	2642.2	Bradycardia
				Coif1	40.85	2655.2	Bradycardia
				Sym3	40.49	2629.2	Bradycardia
Test 6	Male	32	650	Haar	42.46	2759.9	Bradycardia
				Db2	52.76	3429.4	Bradycardia
				Db3	45.86	2980.9	Bradycardia
				Db5	50.63	3290.9	Bradycardia
				Coif1	51.86	2593	Bradycardia
				Sym2	52.76	3429.4	Bradycardia

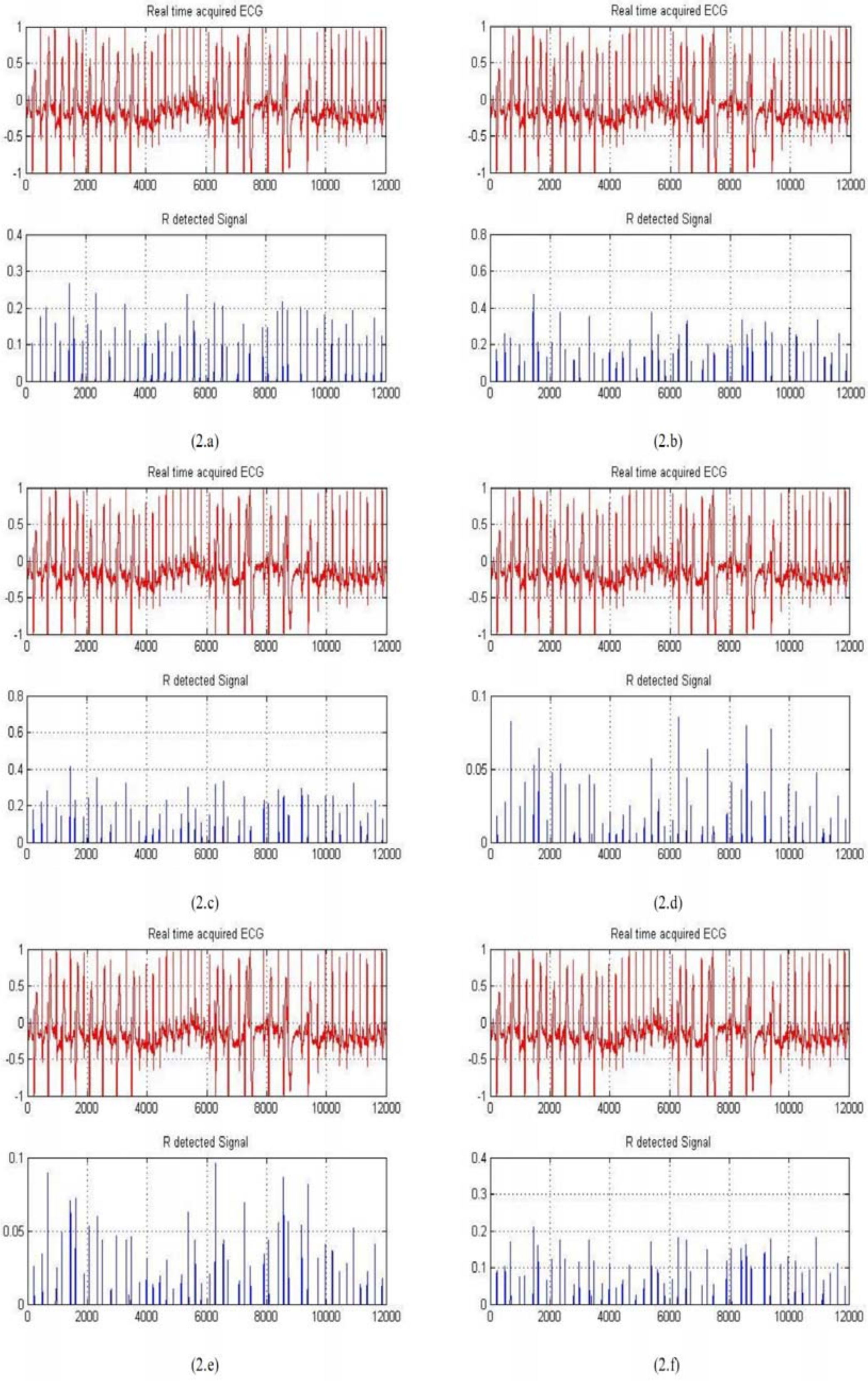


Figure 2. Results of test1 showing Normal Rhythm by using the following Wavelet Transforms (2.a)haar (2.b)db2 (2.c) db3 (2.d) db5 (2.e) coif1 (2.f) sym3

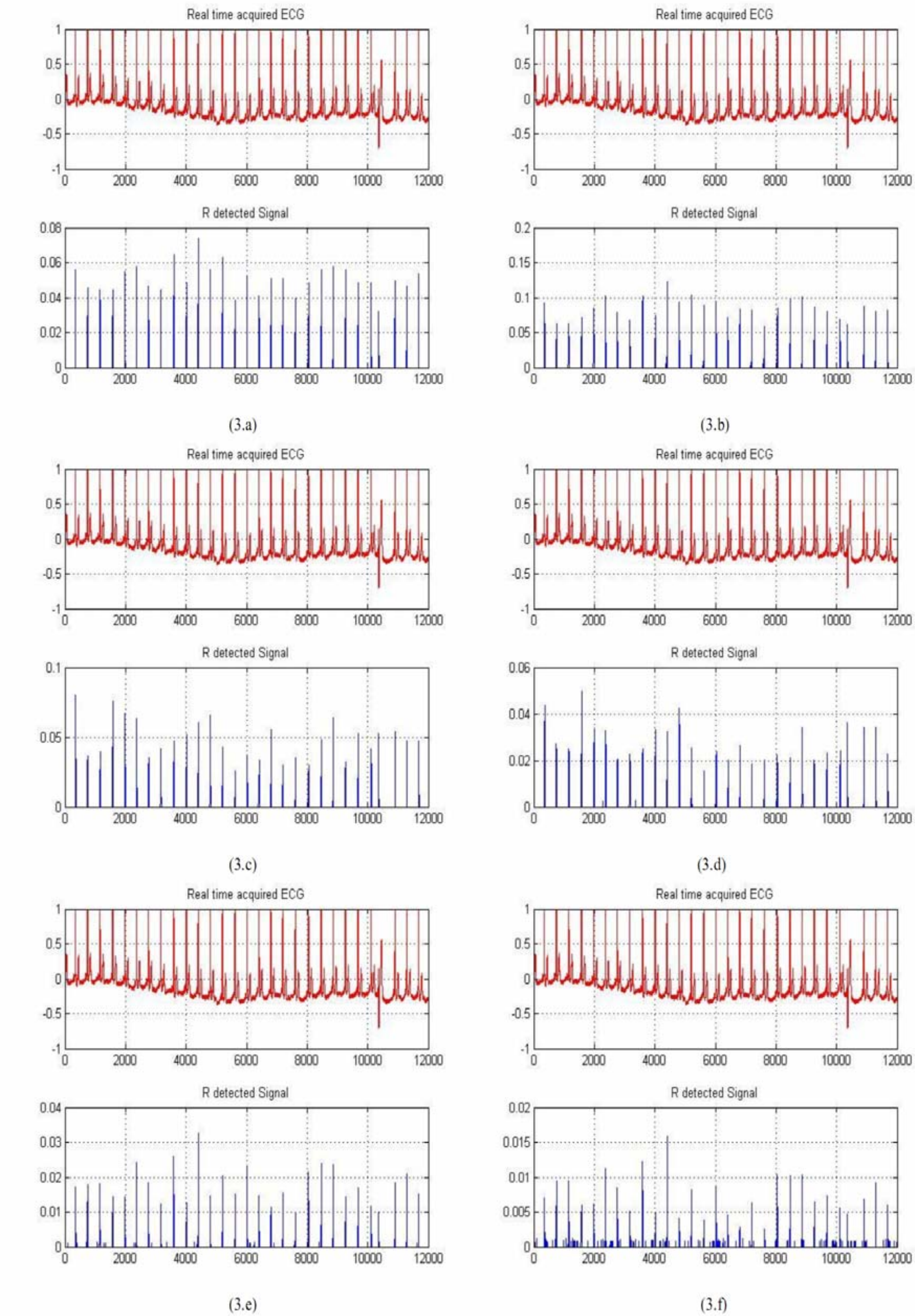
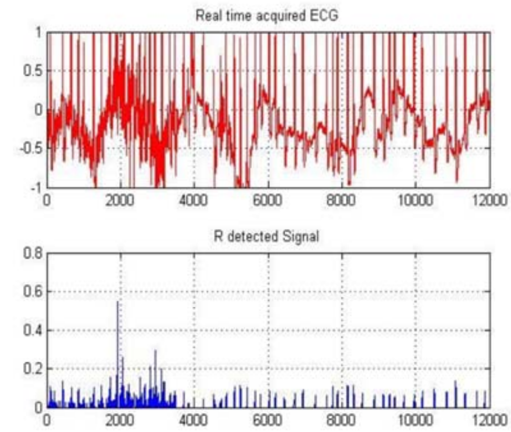
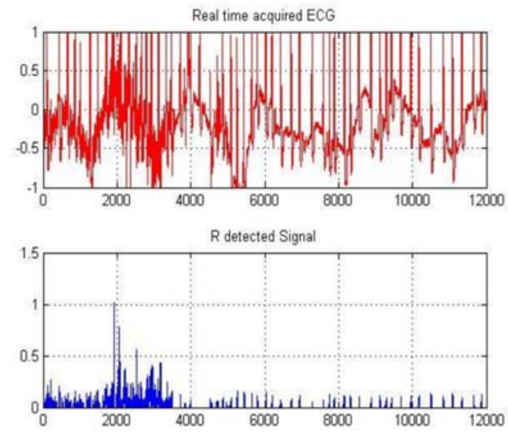


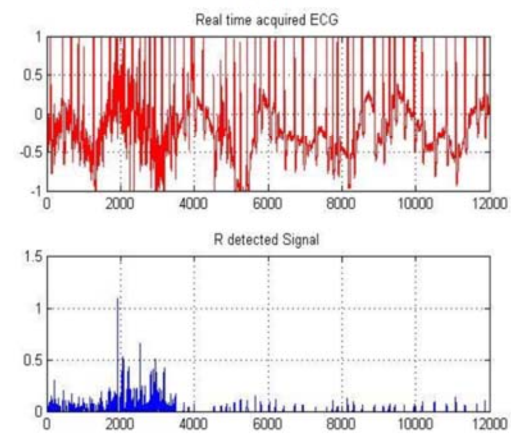
Figure 3. Results of test2 showing Sinus Bradycardia by using the following Wavelet Transforms (3.a)haar (3.b)db2 (3.c) db3 (3.d) db5 (3.e) coif1 (3.f) sym3



(4.a)



(4.b)



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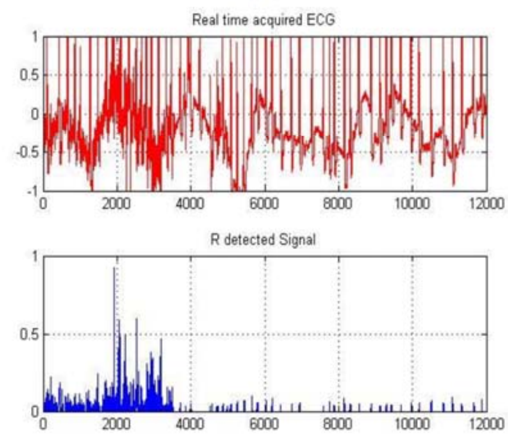

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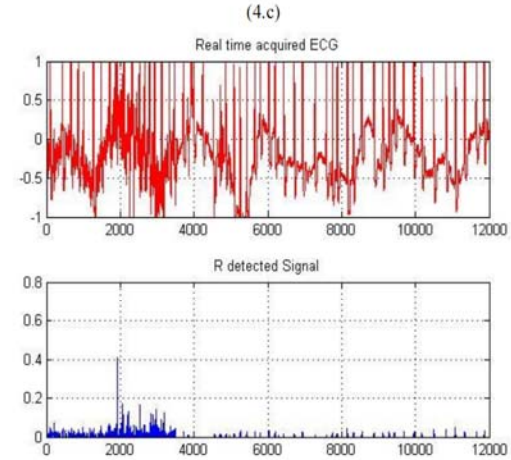
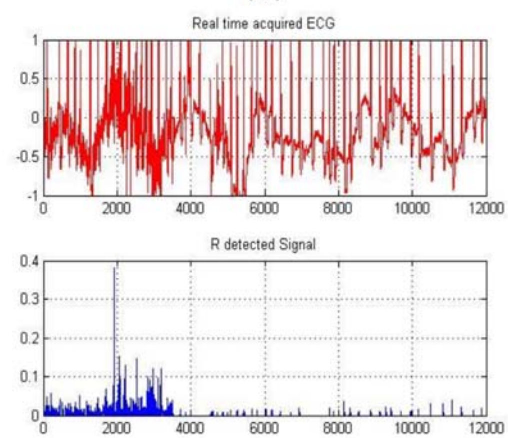


(4.e)



(4.f)

Figure 4. Results of test3 showing Sinus Tachycardia by using the following Wavelet Transforms (4.a)haar (4.b)db2 (4.c) db3 (4.d) db5 (4.e) coif1et (4.f) sym3

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