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Performance Analysis of R- Peak Detection Methods on ECG Signals

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ABSTRACT: The electrocardiogram signal is the most important biological signal which is used for diagnosing people's health. The detection of R wave from signal is important part carried out in ECG signal analysis. The frequently used algorithms in detecting the R peak are Wavelet transform, Hilbert transform, Pantompkins algorithm,combination of Wavelet and Hilbert and Hilbert and Wavelet. This project deals with the comparison of the above mentioned algorithm and draws a conclusion which tells the most accurate method in detecting the R peak.

KEYWORDS: ECG signal, R peak, Wavelet transform, Hilbert transform, Pantompkins algorithms.

I.INTRODUCTION

The ECG signal is the recording of electrical activity of heart. It provides a wide range of information about cardiac disorders. The depolarization and repolarization activities of heart provides ECG. The ECG consists of repeated waves named as P,Q,R,S,T. P wave- It represents the depolarization of atria.QRS complex- It represents ventricular depolarization. T wave- It represents ventricular repolarization[1].
Detection of QRS complex is the most important work carried outin ECG signal analysis. The detection of R wave in heart signal plays a vital role in detecting life threatening diseases. And detecting R wave is easier than other portions of ECG signal due to its high amplitude and its structural form[1,2].
In this project we are detecting the R peak to identify life threatening diseases. This may result in an irregular heartbeat. This is known as arrhythmia condition.
The general ECG waveform for arrhythmia is as shown in the figure,

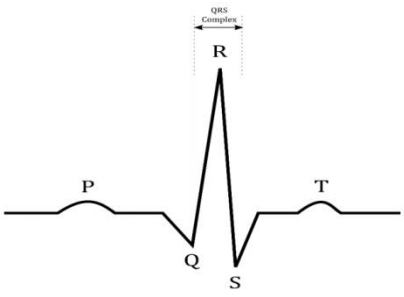

Fig: 1 GENERAL WAVEFORM

Arrhythmia refers to irregular heartbeat. During arrhythmia, the heart can beat too fast or too slow which is also referred to as tachycradia or bradycardia respectively. An arrhythmia condition occurs when the electrical impulses fail to work correctly. These impulses control the heartbeat and heart rhythm. If there is any problem in completion of a heartbeat cycle and beginning of a new cycle, it is known as arrhythmia[1]. There are different types of arrhythmia. Some of them are supraventricular, brady, sinus arrhythmia. In this project we are going to compare the accuracy of R peak obtained from the different algorithms used. The algorithms used in our project are:

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- Hilbert transform
- wavelet transform
- Hilbert and wavelet transform
- Wavelet and Hilbert transform
- Pantompkins algorithm

II.ALGORITHMS

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A. Hilbert Transform

This transform is one of the most important and common transforms used in field of signal theory. The importance of this transform is due to its property to extend real functions into analytical functions. The applications that has been considered are:

- Electrocardiography
- Modulation

The hilbert transform is defined as convolution between functions by using fourier transform. Thus this transform is defined as H[x(t)]= y(t)=$\frac{1}{\pi}\int x(\tau)/(t-\tau)d\tau$

F(t) is a linear function of f(t). Thus by applying convolution, F(t)=$1/\pi t$. f(t)

This transform extract a complex sequence with same length for a real sequence. As this transform is odd, the dominant peaks in output is formed by zero-cross points in ECG signal. Thus the output obtained are R peak which is nothing but the dominant peak obtained by this algorithm[2,3].

B. Wavelet Transform

Wavelet transforms decompose the signal into time varying frequency components. This makes the signals into reduced representations. Wavelet transform of a signal is given by $W_n(s) = \sum_{n'=0}^{N-1} x_{n'} . \varphi * (n' - n)/s . \partial t$ Where, $\varphi * (t)$is the complex conjugate of wavelet function of $\varphi(t)$ s is dilation parameter of the wavelet. And n is the location parameter of the wavelet. This transform decomposes the signal into a sparser representation of the signal. Hence it is used for processing the signal as it resembles the feature of the original signal[2,3,5].Wavelet used is daubechies wavelet.

C. Combination of Hilbert and Wavelet Algorithm

The output of the preprocessed ECG signal is given as input to Hilbert transform. This output obtained is given to Wavelet transform as input and R peak is detected.

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E. Pantompkin's Algorithm

Pantompkins algorithm is a different approach in which the signal is filtered by using bandpass filter to reduce noise. A derivative filter is also used to get slope information and to get time interval between two consecutive signals. The amplitude squaring is done and passed through moving window integrator. Finally thresholding is done to detect R peak[4].

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III. MATERIALS AND METHODOLOGY

The following method shown in the below figure has been adopted in this project to detect R peak to identify life threatening diseases and compare the algorithms. The basic block diagram is as follows,

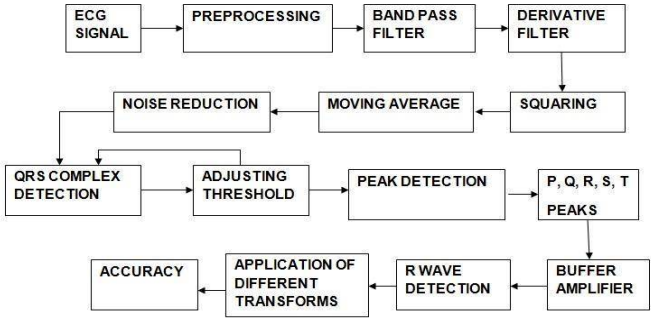

Fig: 2 BLOCK DIAGRAM

The ECG signal is selected from MIT-BIH database for preprocessing. It is referred to as raw signal (Fig 1). In preprocessing section, the noise reduction of signal is done by differentiator QRS operator and then windowing technique is used to smoothen the signal[2,3,5,6]. After preprocessing, the signal is passed through bandpass filter(Fig 2)[6]. Derivative filter is used for further noise reduction(Fig 3). Amplitude squaring is done to enhance the dominant peaks. Moving average is done to get equally space in time. QRS complex detection is done by adjusting the threshold values. These values are taken from arrhythmia ECG signals. There is a feedback for detecting QRS complex based on the signal to noise ratio[4,5,6]. Afterdetection of QRS complex, all the peaks in ECG signal is determined (i.e) P,Q,R,S,T peaks. These signals are amplified using buffer amplifier to enhance and smoothenthe signal(Fig 4). The R peak detected is processed using the above mentioned algorithms andthe finalobtained R peak accuracy of each algorithm is compared and tabulated. The R peaks obtained for hilbert and wavelet transform, hilbert transform, wavelet transform, wavelet and hilbert transform, and pantompkins algorithm is as in Fig 5.

IV. SIMULATION RESULTS

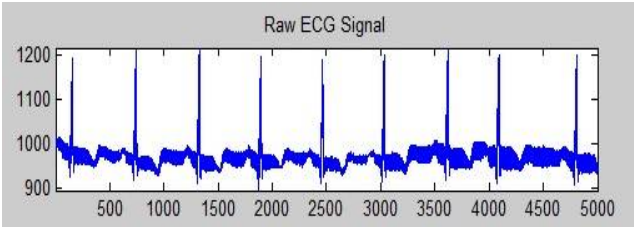

Fig:1: Raw ecg signal

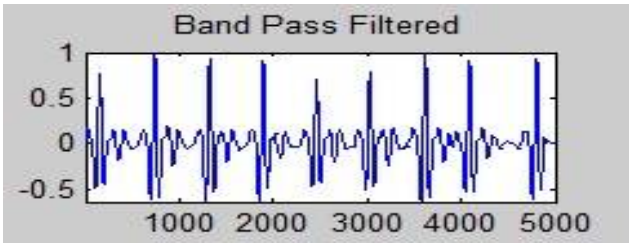

Fig 2: Band pass filtered

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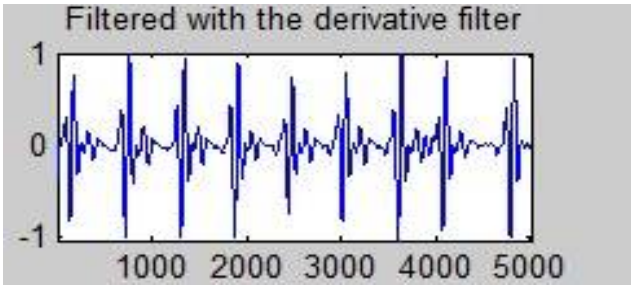

Fig 3: Filtered with the derivative filter

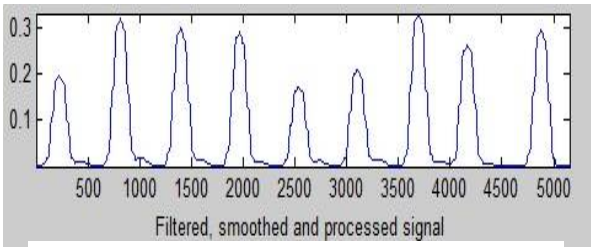

Fig 4: Filtered, smoothed and processed signal

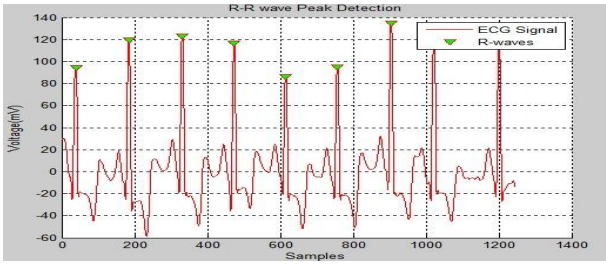

Fig 5: R-R wave peak detection

V. ACCURACY

The formula used to obtain the accuracy is accuracy =[(sum of absolute peaks)-(sum of predicted peaks)]/(sum of absolute peaks)*100
Here absolute peak refers to threshold value(5mv) and predicted value is obtained from the ECG signal taken for analysis.

VI. TABULATION

The signals that are generated with the help of ECG are processed under different algorithms, where the accuracy of each algorithm is obtained to determine the R-peak value which further indicates the presence of arrhythmia. Various signals that are carried out on the ECG and the output for each algorithm is shown in the below table.

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ECG SIGNAL	HILBERT+ WAVELET	HILBERT	WAVELET+ HILBERT	WAVELET	PANTOMPKINS
1	71.79	88.14	84.85	78.32	94.75
2	76.80	98.15	90.76	83.78	105.51
3	109.41	52.18	110.35	119.35	56.09
4	80.81	52.10	95.50	88.15	56.01
5	120.96	78.11	130.23	150.14	87.11
6	55.13	53.22	65.16	60.15	87.88
7	73.72	27.74	87.13	80.43	29.82
8	59.67	39.87	70.52	65.09	35.34
9	65.36	52.92	77.24	71.30	56.88
10	79.20	45.70	93.60	86.40	49.12
11	65.79	56.36	77.75	71.77	60.59
12	82.47	79.56	97.47	89.97	85.53
13	62.13	48.36	73.43	67.78	51.98
14	75.58	62.51	89.32	82.45	67.20
15	73.11	62.68	86.41	79.76	67.38
16	74.41	73.36	87.94	81.17	82.09
17	82.47	44.15	112.21	103.58	47.47
18	75.69	89.34	89.45	82.57	96.04
19	64.08	88.25	75.73	69.91	68.20
20	71.10	47.43	84.03	77.57	50.99

VII. CONCLUSION

This paper deals with comparison of peak detection algorithms. It is concluded that fusion of two algorithms gives a good output. That is the combination of wavelet and hilbert transform gave better accuracy compared to other algorithms. The average value of accuracy of this fusion algorithm is 98.5%. So with the accurate value of R peak, we can find the accurate arrhythmia condition of a person.

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