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Wavelet Based R Peak Detection in ECG Signals Using Matlab

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Abstract: ***In present study, an electrocardiogram (ECG) R peak detection system based on Discrete wavelet transform was developed & evaluated. Different ECG signals samples from MIT/BIH Arrhythmia database (ML II lead) was used to verify the algorithm using MATLAB software. First of all algorithm on MIT/BIH database was verified and then same algorithm was applied on Indian patient's ECG records. The classification rate of R peak by this program for MIT/BIH Database was 96.28%.***

1. INTRODUCTION

ECG is the electrical activity of the heart. It provides information about heart rate, rhythm & morphology. ECG varies from person to person due to various parameters including age, weight & habitat. Electrical activity of heart is characterized by five separate wave of deflection designated by P, Q, R, S, T. Detection of PQRS especially peak of QRS complex or R peak is difficult because ECG is time varying characteristics subject to physiology variation due to patient & to corruption due to noise. Accurate measurement of ECG parameters is an important requirement of quantitative ECG analysis, particularly if the result of ECG is used for medicinal and clinical purpose. The accuracy depends on accuracy of algorithm.

In last few decades various approaches to detect the peak has been proposed, involving artificial neural network, real time approach, genetics algorithm, heuristic algorithm based on nonlinear transform and filter banks. Recently wavelet transform has been proven to be useful tool for non stationary signal analysis. In present study Discrete wavelet transform based on dyadic scale selection was used for analysis.

2. WAVELET TRANSFORM

Wavelet transform is a linear distribution. The continuous wavelet transform (CWT) is defined as the sum of the signal over all the time multiplied by scaled, shifted versions of the wavelet function Ψ [1]:

$$C(Scale, Position) = \int f(t)\, \Psi(Scale, Position)\, dt$$

The result of CWT is wavelet coefficients C, which are a function of scale and position. Multiplying each coefficients by the appropriately scaled and shifted wavelet yields the constitute wavelets of the original signal $f(t)$.

Discrete wavelet transform is same as CWT but it is based on choice of scale and position, if they are power of 2 or we say dyadic scale and position then DWT can be employed. DWT can be efficiently developed by using filter developed by Mallet in 1988. The following scheme (Figure1) was employed using filter in following way:

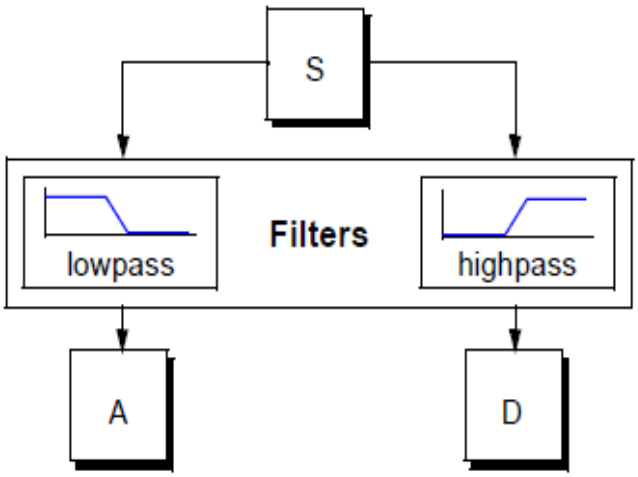

Fig. 1

2.1 Wavelet Selection

The Daubechies wavelet which also known as Db family of DWT wavelet family was used because the shape of the signal on which we are working and that of the Db5 (with 8 level decomposition) is same. The performance analysis can also be carried out on other wavelet family. But, accuracy was much higher with above family in comparison to any other family.

3. METHODOLOGY

To point R peak in ECG signal we first extract its time amplitude text form or signal form easily available from MIT/BIH arrhythmia database (used for verification of programming module). The approximation and detail coefficient was estimated by wavelet calculations. These were used for further denoising of signals. The coefficients were calculated based on mean value for peak detection.

The simplest way is depicted in Figure 2 to detect R peak.

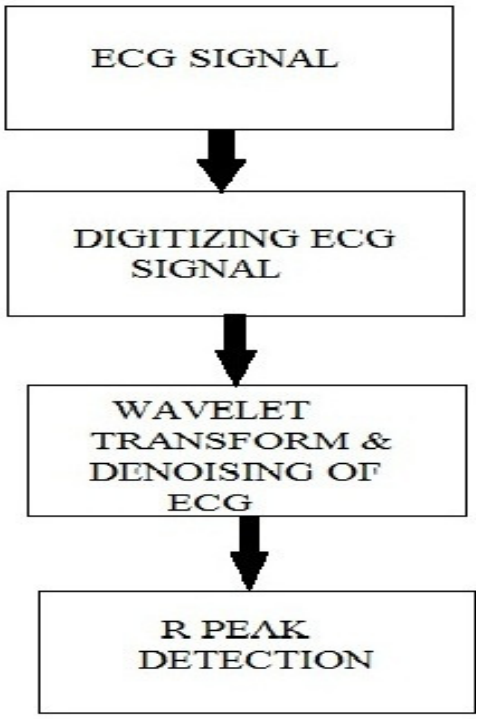

Fig. 2 Methodology to detect R peak

4. ALGORITHM

The algorithm can be explained with the help of following steps:

4.1 Step1: Digitizing ECG Waveform

First of all ECG signals were scanned: (The 50 year patient signal was used which are shown in figures).The ECG signals is scaled such that on y- axis it is 10mm/mV and on x-axis 25mm/s .The paper speed was 25mm/s. The Laser Jet 3020 scanner was used for scanning signals. The 300 DPI was used so as to satisfy sampling frequency use by MIT/BIH .The signals were digitized in V-I text form by using various algorithm. The obtained recorded signals were noisy (Figure 3).

The ECG waveform was extracted by using image thresholding technique. The scanned ECG paper was firstly converted into intensity image. After that a threshold level was selected in the form of gray scale level to distinguish the trace of interest. ECG signal can be extracted easily from the threshold image. The image after background subtracted is filtered with a contrast enhancement filter. The pixel locations are denoted on X and y axis of Cartesian coordinate system. After, setting x- axis reference as one dot corresponds to 3 ms and 7.5μV for y axis (time and voltage axis respectively [2]. These references were decided on the basis of pattern of MIT/BIH Arrhythmia Database.

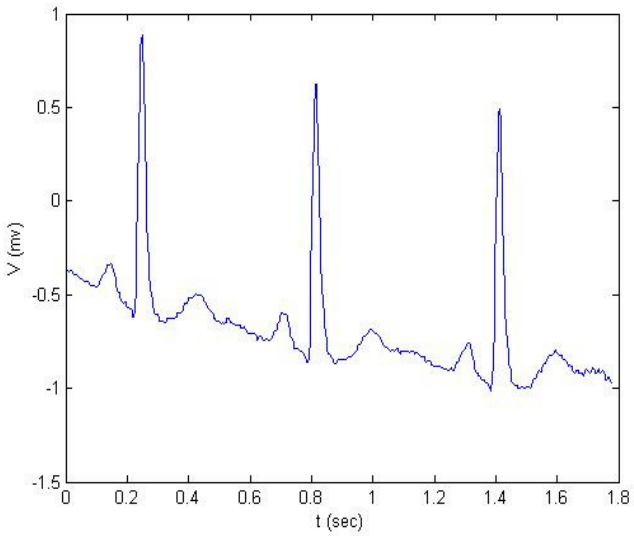

Fig. 3 Noisy ECG signal

4.2 Step 2: Wavelet transform and denoising of ECG signal

ECG signal contains different noises like baseline drift, electrode potential, frequency interference, polarization noise, muscle noise, the internal amplifier noise and motor artifacts. Out of this baseline drift is of main concern during peak detection or beak calculation. Wavelet transform remove this baseline drift [3]. DWT decompose and compose the ECG signal which in turn removes this baseline drift. We use 150 samples in one turn to remove and perform smoothening operation. After this operation we got signals which are shown in figure:

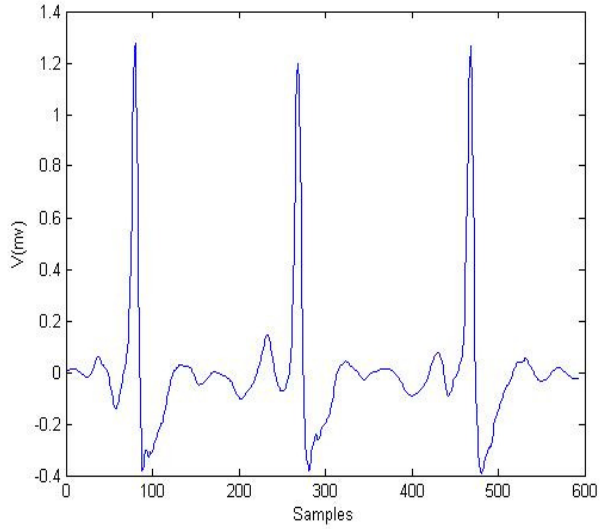

Fig. 4 Denoised ECG signal

4.3 Step 3: R Peak detection

In order to detect the peaks, specific details of signal are selected. The detection of R peak is the first step of feature extraction. The R peak in the ECG signal has the largest amplitude .The QRS complex verification consists of determining the R point of the heartbeat, which is in general the point where the heartbeat has highest amplitude. Most of the energy of the QRS complex lies between 3Hz and 40 Hz [4] [5]

The 3-dB frequency of Wavelet indicates that most of the energy of the QRS complex lies between 2^3 to 2^4 scales value. The motion of artifacts and baseline wander (noise) increases after 2^5 scales. The several detail coefficients lying between 2^3 to 2^5 were used to detect R peak [6].

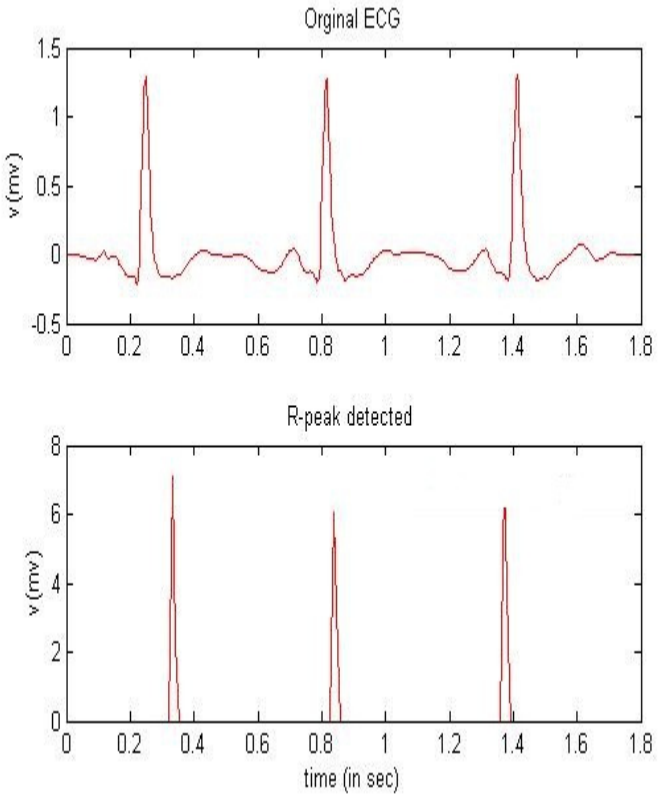

Fig. 5 R Peak Detected

Table 1 shows correlation observed between the R peak detected in database and above algorithm. This is clear from results that the above algorithm is correct and can be used efficiently to detect R peak from any ECG signal.

Table. 1 Correlation between R peak and algorithm

Patient No.	*Type*	*Correlation*
100	Arrhythmia	95.11
108	Arrhythmia	98.23

5. CONCLUSION

An algorithm for the R peak detection using Wavelet Transform has been developed. The work is different from earlier works on same subject because of the Indian Patients Database (normal as some arrhythmias data's) was used for analysis. These results can be used for the calculation of heart rate. It can also be used as an input for various cardiac diagnosis systems. The overall sensitivity of detector is improved. This algorithm consumed less time and it also has some social relevance.

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