Heart Rate Calculation and R Peak Detection using Double Difference Method

Tanya kamboj[1] Ram Avtar Jaswal[2]
[1]M.Tech. Student [2]Assistant Professor
[1,2]U.I.E.T Kurukshetra

Abstract— ECG Signal is a non-stationary signal i.e. frequency components varies with time. To analyse the ECG signal various methods are used like wavelet transform, Hilbert transform etc. This paper proposes a simple and efficient algorithm for the detection of R peaks from the loaded ECG data. The double difference method is used to find the R peaks. The proposed method has three stages: filtering, thresholding of the ECG data to identify the peaks with comparison in the QRS regions, and RR interval processing to accurate detection of the peaks. After detecting the RR interval, the heart rate can be obtained by applying simple formula. The performance of the algorithm is tested on arrhythmia data taken from MIT-BIH database and then loaded signal is classified on the basis of heart rate.

Key words: ECG, Double Difference, Filtering, Thresholding

I. INTRODUCTION

The electrocardiogram (ECG) is the recording of the electrical activity of the heart and the one cycle of the heart is characterized by the sequence of P, QRS, T and a conditional U wave (fig.1). This sequence of components is obtained by the depolarization and polarization of the myocardium and these are associated with the contractions of the atria and ventricle present in the heart. ECG is recorded by using 12 lead system in which electrodes are placed on the body to get the typical waveform. ECG is the important tool to identify various cardiac diseases. The different features of the ECG like PR interval, QRS interval, QT interval, and the segments such as ST, PR, segment. These are used to extract the cardiac condition [1,2]. The different computer techniques are used to extract the features from the typical waveform. Detection of the R peaks provides the fundamental in all ECG analysis algorithm. QRS complex waveform is formed during the ventricular contraction and its shape gives much information about the state of the heart. QRS is the starting point to detect the other feature of the ECG signal like P, T waves [3, 4]. QRS detection is not only important in HRV (heart rate variability) but also to diagonise the heart diseases [2]. Many QRS detection algorithm available in literature which are classified as digital filter based, non- linear transformation based, wavelet based [5]. The double difference method which is widely used for QRS detection because of its ease of implementation and low computation [6]. In a non-linear Hilbert transform is used to detect the QRS complex to increase its detection probability [7]. The wavelet technique is also used for R peak detection by decomposition of the ECG signal [8]. These methods require mother wavelet and scale values. The Empirical mode is used to localize R peaks and to detect QRS regions. ANN or SVM is used to classify the signals after detecting QRS complex [9-10]. The R peaks which are detected are not always accurate and can have missed or false peaks. Algorithm used to increase the sensitivity by processing RR interval. The QRS detection is not an easy task because of the physiological variability of this complex and due to the presence of noises in the signal. The low frequency and high frequency noise are removed by using suitable method and area criteria method can be used to detect R peaks [11]. The squared double difference method is used to detect R peaks and QRS complex and with use of thresholding its sensitivity is increased [12, 13]. So many algorithms are used to detect R peaks and have much significance of each method.

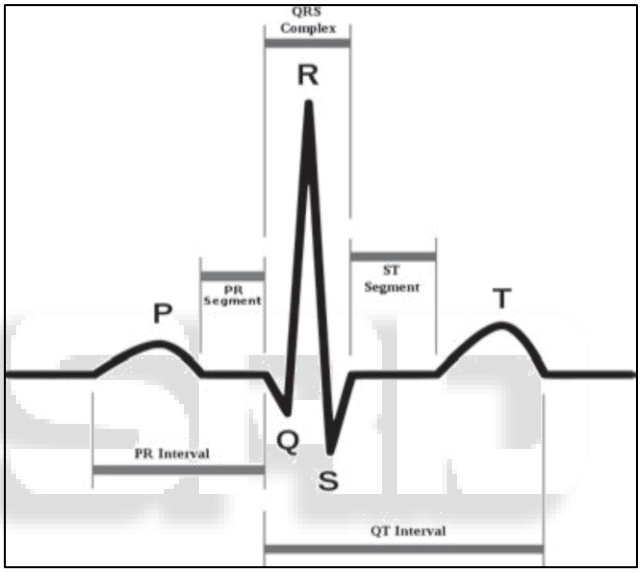

Fig. 1: Schematic representation of the ECG wave

In this paper an algorithm is derived based on double difference. The algorithm has three stages. Firstly, the FFT is taken of the signal and then filter is applied to remove lower and higher frequency components. Then the signal is sorted in an order and thresholding is done to detect the QRS regions. Secondly, the magnitude comparison is done in the QRS regions to detect R peaks. In last, the RR intervals are obtained. After obtaining RR interval the heart rate can be calculated. After having heart rate the Arrhythmia signal can be classified into tachycardia and bradycardia. The algorithm is tested on 1 min ECG data taken from MIT-BIH database [14].

II. METHODOLOGY

The algorithm is based on the derivative approach and operates on the ECG signal from a single lead. The digital ECG signal data is read as 1-d array of the time instants. This method involves four different stages for the detection of the R peaks.

A. Smoothing and Filtering of Raw Data

The signal is denoised by taking FFT of the raw signal and then low and high frequency components are removed by

the appropriate method. In this, double filtering is done to remove the noise so that all peaks can be detected.

B. Detection of QRS Region

At the high frequency components the ECG signal has higher peaks. As the sampling instants of data remains constant the amplitude difference are used to detect QRS regions. The double difference measures the magnitude of the signal in the QRS regions which led to the localization of the region. The process has following steps:

1) From the data the double difference are calculated at all the points and the difference array is created.
2) The difference array is sorted and the difference peaks are selected above a constant threshold value.
3) After thresholding, the peaks are deleted below the threshold value.

C. Detection of R peaks

The positive peaks of the QRS regions are the R peaks. By the relative magnitude comparison in each QRS regions the R peak can be detected. A search for maximum was done on the relative magnitudes for each window to remove errors due to baseline wander.

1) The maximum and minimum amplitude values of the ECG data array are calculated for each detected QRS.
2) To get the relative magnitudes the mean of the maximum and minimum values are subtracted from all data points of that window.
3) The location of the maximum of the relative magnitudes is the R point locations of the analogous QRS.

D. Processing of RR Intervals

The R peaks got may not be exact. There can be wrong detections or missed peaks. To confirm the accuracy of the detection of RR intervals are deal with according to definite criteria. It is considered that the 200ms can be the minimum difference between two successive R peaks.

1) The peaks detected between the 200ms is considered to be the noisy and removed.
2) The average RR interval is calculated and considered to be the reference for the RR interval processing.
3) All the successive RR intervals are compared with the calculated average RR interval and then proceed.

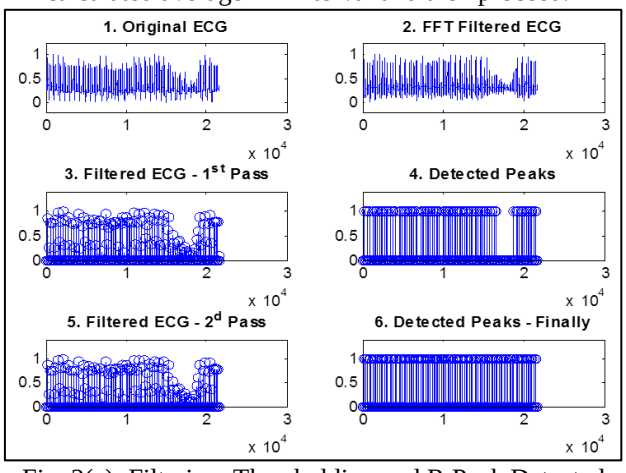

Fig. 2(a): Filtering, Thresholding and R Peak Detected

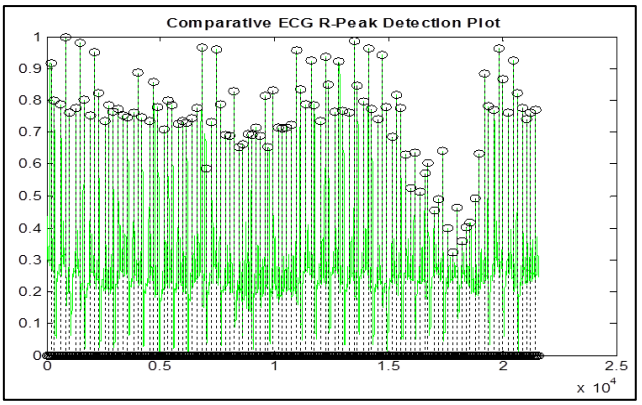

Fig. 2(b) Finally R Peak detected

III. RESULT

The arrhythmia data available at MIT-BIH database is at 360 hz is used to do the performance for the proposed algorithm. It is tested on 1 min ECG data for a single lead.

The R peak is detected is used for the calculation of the heart rate of the signal.

Heart rate = 60*sampling interval/ RR interval (1)

After calculating the heart rate, the patient data is detected as tachycardia and bradycardia.

IV. CONCLUSION

The proposed algorithm is efficient and simple with low computational overhead. The algorithm can be used to detect the cardiac diseases. This method is easy to use and gives good result in the peak detection of the signal. Conventional based methods are sensitive to high frequency components which leads to false detections, in this method false detected peaks can be eliminated by the processing of RR interval. By detecting RR interval, heart rate can be calculated of the different signals. The proposed algorithm can be detected to extract other features of the ECG.

REFERENCES

[1] Schamroth L, An Introduction to Electrocardiography. 7th ed. Oxford: Blackwell Science ltd; 1990.
[2] Chan H.L, Chou W.S., Chen S.W, Fang S.C, Liou C.S, Hwang Y.S. Continuous and online analysis of heart rate variability. J Med Eng. Technol. 2005; vol. 29(5): 227-34.
[3] Zhu Y., Thakor N.V, P-wave detection by adaptive cancellation of QRS-T complex, IEEE Ann. Conf. Eng. Med. Biol. Soc. 1986; 329–331.
[4] Gritzali F, Frangakis G, Papakonstantinou G, Detection of the P and T waves in ECG, Comp. Biomed. Res. 22; 1989, 83–91.
[5] Kohler B.U, Hennig C, Orglmeister R, The principles of software QRS detection, IEEE Eng Med. Biol. Mag. 2002, 42-57.
[6] Yun-Chi Yeh,Wen-June Wang, "QRS complexes detection for ECG signal: The Difference Operation Method", computer methods and programs in biomedicine 9 1 (2 0 0 8) 245–254.
[7] Benitez D, Gaydecki PA, Zaidi A, Fitzpatrick AP, The use of the Hilbert transform in ECG Signal analysis, Comp. in Bio. and Med. 2001, vol.31, no. 5; 399-406.

[8] Juie D. Peshave, Rajveer Shastri," Feature Extraction of ECG Signal", International Conference on Communication and Signal Processing, April 3-5, 2014, India.
[9] Suzuki Y, Self organising QRS-wave recognition in ECG using Neural Net-works, IEEE Trans. on Neural Net. 1995, vol. 6(6); pp 1469–1477.
[10] Mehta S. S, Lingayat N. S, Detection of QRS complexes in electrocardiogram using support vector machine, J. of Med. Eng. & Technol. 2008, Vol. 32, No. 3, 206 – 215
[11] Yangdong (Jack) Liao, Ru-Xin (Tony) Na, and Derek Rayside, Accurate ECG R-Peak Detection for Telemedicine', 2014 IEEE Canada International Humanitarian Technology Conference.
[12] Widjaja D, Vandeput S, Taelman J, Bracker M, Otte R.A. et. al., Accurate R peak detection and advanced preprocessing of normal ECG for heart rate variability analysis, Computers in cardiology. 2011, 533-536.
[13] Adnane M, Jiang Z, Choi S, Development of QRS detection algorithm designed for wearable cardio-respiratory system, Comp. Methods in Biomed. 2009, vol. 93, 20-31.
[14] http.// Physio.net database.

