International Journal of Combined Research & Development (IJCRD)
eISSN: 2321-225X;pISSN:2321-2241 Volume: 4; Issue: 6; June -2015

A Novel Approach for Detection of RR Interval

Ashish Rohila
MMM University of Technology,
Gorakhpur, India

V. K. Giri
MMM University of Technology,
Gorakhpur, India

Abstract – Nowadays the ECG is recorded because of the reason that it is one of the most simple and cost effective method for diagnosing cardiovascular diseases. Various heart diseases can be diagnosed by only detecting R peak location of ECG signal. The R peak detection is the very first stage in automatic diagnosis of arrhythmia. The RR interval alone is sufficient in order to detect Heart Rate Variability (HRV) and heart rate in Beats per Minute (BPM). During last four decades different methods have been proposed and developed to detect R peak in ECG signal but a simple and accurate method is still in search. In this paper, we have proposed a threshold based algorithm to calculate RR interval and Heart rate. The performance of proposed algorithm has been compared with the traditional algorithm and it has been observed that the proposed method is more promising and give better results.

Keywords – ECG, feature extraction, heartbeat, QRS detection, RR interval.

I. INTRODUCTION

Nowadays, the number of cardiac patients is increasing with an alarming rate. As per WHO (World Health Organisation), the number of casualties from CVDs (Cardiovascular diseases) will increase to reach 23.3 million by 2030. The CVDs are projected to remain the single leading cause of death. The ECG signal has been widely used in cardiology to detect various heart diseases. Electrocardiogram is the graphical activity of heart and is used to diagnose various cardiovascular diseases. A typical ECG waveform has been shown in figure 1. An ECG signal consists of different waves such as P-wave, QRS complex, T wave and U wave. These waves are originated by nerve impulse stimulus to the heart [1]. P wave is originated by sequential activation (depolarization) of the right and left atria. The origin of QRS complex is right and left ventricular depolarization. The T wave is originated by ventricular repolarization. Origin of U wave is normally absent and it is found only in infants.

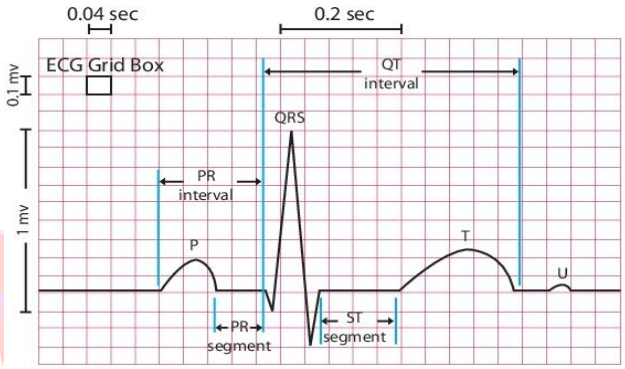

Fig.1 Waveform of an ECG Signal [13]

The R peak detection is the very first stage in automatic diagnosis of cardiovascular diseases. The RR interval alone is sufficient in order to detect Heart Rate Variability (HRV) and heart rate in Beats per Minute (BPM) [1]. The cardiovascular diseases that can be diagnosed by ECG have been given in Table 1.

Table 1 Different Category of Cardiovascular Diseases.

Sr. No.	Disease	Diagnosis
1	Arrhythmia	Irregular heart beat
2	Heart Rate variability	Variation in RR interval
3	Tachycardia	Heart Rate > 100 BPM
4	Bradycardia	Heart Rate < 60 BPM

Many R peak detection algorithms have been proposed and developed by many researchers during last four decades but an efficient an accurate algorithm to detect R peak accurately is still a problem in electrocardiography [2]. Pan J and Tompkin W J (1985) proposed a real time QRS detection algorithm [3]. Hamilton and Tompkins (1986) [4] examined QRS detection algorithms. They have developed an R-peak detection algorithm in real time in which RR interval estimator had been used. S Pal and M. Mitra (2011) [5] designed a binary coded classifier for detection of cardiac arrhythmic beats. Hilbert transform and Wavelet transform have been used by Hongqiang Li and Xiaofei

Wang (2012) [6]. Some other relevant contributions have been given in [7-12].

In this paper we have proposed a threshold based algorithm to detect R peak. The RR interval and heart rate have been calculated by R peak location. The performance of proposed algorithm has been evaluated by comparing our results with traditional QRS detection algorithm given in [3].

II. ALGORITHM FOR R PEAK DETECTION

In the present work a threshold based R peak detection algorithm has been proposed. The RR interval and heart rate have been calculated by R peak location and number of R peaks in a given time window, respectively. The flow chart of the algorithm has been given in figure 2.

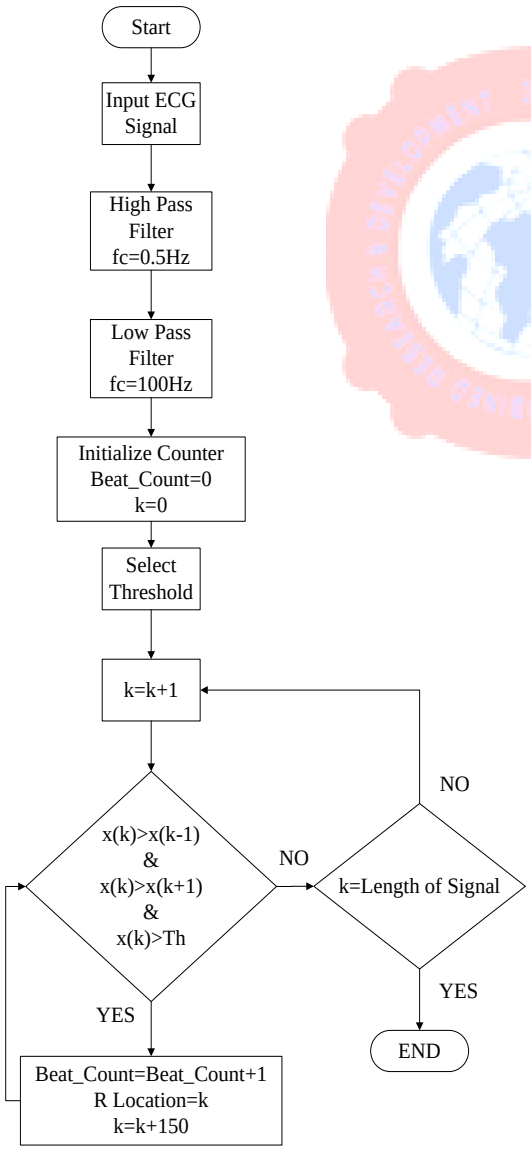

Fig.2 Flow Chart of R Peak Detection Algorithm

The flow chart of proposed algorithm has been given in figure 2. As described by the given flow chart the following steps have been included in proposed algorithm.

- ECG data has been passed through a high pass filter in order to remove baseline wander.
- ECG data has been passed through a low pass filter in order to remove muscular tremor.
- The filtered ECG signal has been squared in order to differentiate between R peak and T wave. The slope of T wave in more as compared to R peak. Therefore algorithm efficiently differentiates between T waves and R peak.
- The threshold has been defined based on empirical search. In the present algorithm an adaptive approach has been used in order to define threshold. If there is no baseline wander in the ECG signal then threshold may be chosen as half of the maximum amplitude present in the signal. Whereas in case of high baseline wander an adaptive threshold must be chosen. In this case threshold must be selected for every small interval of the signal.
- A sample x (k) has been checked for $x(k) > x(k-1), x(k) \geq x(k+1) \& x(k) > threshold$. All the three conditions must be satisfied by a sample in order to be considered as R peak. These conditions minimise the possibility of false QRS detection.
- If condition defined in previous step is false then increase the counter by one and repeat the previous step. But if condition defined in previous step is true than x(k) has been defined as R peak. In this case the counter has been increased by 300ms because next R peak can never be appearing in such a short interval. This will minimise the possibility of false R peak detection.
- Once all samples have been run through the program algorithm may be stopped.
- RR interval is than calculated by difference in sample points between two successive peaks and sampling frequency.
- Heart rate can be calculated by mean value of RR interval..
- Heart rate variability and arrhythmia may be diagnosed if there is a large variation in RR interval.
- Tachycardia and Bradycardia may be diagnosed if heart rate is greater than 100 BPM or less than 60 BPM, respectively.

Once the R peak location has been detected then one can easily calculate RR interval. If RR interval is not same for each beat then it can be diagnosed as a case of arrhythmia. The heart rate is dependent upon

this RR interval. The heart rate has been calculated as per following equation.

$$Heart\ Rate\ (BPM) = \frac{60}{RR\ Interval\ in\ Seconds} \quad (1)$$

III. TEST RESULTS AND DISCUSSIONS

The ECG signals have been recorded using Biopac DAQ Systems Model No. BSLBSC-WSS29L in measurement laboratory for 10 seconds duration with 500 Hz sampling frequency. The R peak detection algorithm has been applied to each ECG signal record in order to detect R peak and to calculate heart rate. The RR interval and the heart rate have been determined for each recorded signal. The results have been compared with the values of RR interval given by electrocardiograph for different subjects. The results of test performed have been summarized in table 2.

Table 2 RR interval and Heart Rate of Different ECG Records

Record Number	RR interval Recorded by DAQ System (seconds)	Calculated by Traditional Algorithm (seconds)	Calculated by Proposed Algorithm (seconds)	Heart Rate in BPM
Lab Record 1	0.7660	0.7750	0.7608	78
Lab Record 2	0.8100	0.8060	0.8050	78
Lab Record 3	0.8800	0.8540	0.8828	66
Lab Record 4	0.6200	0.6325	0.6220	96
Lab Record 5	0.6140	0.6140	0.6144	96
Lab Record 6	0.8700	0.8915	0.8735	72

The algorithm given in [3] provides only R peak location in ECG signal in the form of sample number whereas in the proposed algorithm calculation of RR interval and heart rate (BPM) has been included in the algorithm itself. In order to compare the performance of both algorithms we have calculated the speed of algorithms in MATLAB environment running on Pentium Dual Core Processor (1.8GHz). The algorithm given in [3] takes 0.967 seconds whereas the proposed algorithm consumes 0.368 seconds in order to detect R peaks. Therefore, it means that proposed algorithm performs faster than traditional QRS detection algorithm. The comparison of results obtained by different algorithms has been shown in figure 3.

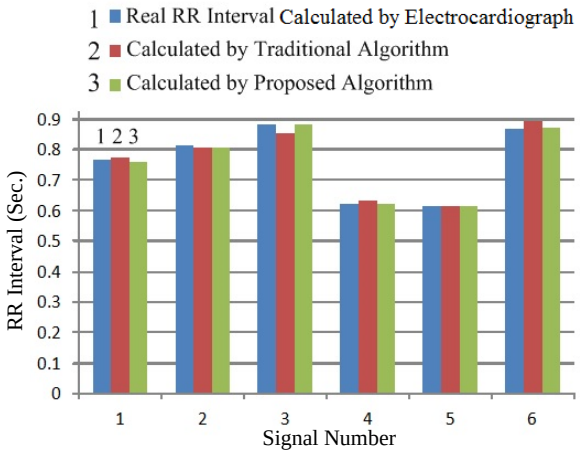

Fig.3 RR Interval obtained by two algorithms

IV. CONCLUSIONS

In the present work a threshold base QRS detection algorithm has been proposed. The performance of proposed algorithm has been compared with performance of Pan Tompkin's heart beat detection algorithm and it has been found that proposed algorithm performs almost similar to Pan Tompkin's algorithm with faster calculation of RR interval and heart beat. Hence, we can conclude that the performance of proposed algorithm is better than the previous one in terms of speed of calculations.

I. ACKNOWLEDGMENTS

This work is supported by University Grant Commission (UGC), New Delhi, India under Major Research Project (MRP) scheme. This work has been carried out in Electrical Engineering Department of MMM University of Technology, Gorakhpur, India.

References

[1] G S Sawhney, Fundamentals of Biomedical Engineering, New Age International Publishers, ISBN (13): 978-81-224-2549-9, 2007.

[2] S.Karpagachelvi, M.Arthanari and M.Sivakumar, "ECG Feature Extraction Techniques - A Survey Approach". International Journal of Computer Science and Information Security, Vol. 8, No. 1, 2010, pp 76-80.

[3] Pan J, Tompkins W. J. "A Real QRS Detection Algorithm", IEEE Transactions on Biomedical Engineering Vol. 32, No. 3, 1985, pp 230-236.

[4] Hamilton, P.S. and Tompkins, W.J. , Quantitative Investigation of QRS detection rules using the MIT/BIH Arrhythmia Database,

IEEE Trans on Biomedical Engineering, Vol. BME-33, Issue 12, 1986 pp 1157 - 1165.

[5] S. Pal and M. Mitra, "Detection of cardiac arrhythmic beats by logical classifier using binary coding". IET Science, Measurement and Technology, Vol.6 Issue 6, 2011, pp 449-455.

[6] Hongqiang Li and Xiaofei Wang, "Detection of electrocardiogram characteristic points using lifting wavelet transform and Hilbert transform", Transactions of the Institute of Measurement and Control, Vol. 35 Issue 5, 2012, pp 574-582.

[7] Sautami Basu and Yusuf U Khan, "RR Interval Time Series Formulation in ECG Signals". i-manager's Journal on Future Engineering & Technology, Vol. 9 , No. 2, 2003, pp 22-26.

[8] A. K. M. Fazlul Haque, Md. Hanif Ali, M. Adnan Kiber and Md. Tanvir Hasan, "Detection of Small Variations of ECG Features using Wavelet". ARPN Journal of Engineering and Applied Sciences. Vol. 4, No. 6, 2009, pp 27-30.

[9] José García*, Magnus Åström, Javier Mendive, Pablo Laguna, and Leif Sörnmo, "ECG-Based Detection of Body Position Changes in Ischemia Monitoring". IEEE Transactions on Biomedical Engineering, VOL. 50, NO. 6, 2003, pp 677-685.

[10] Mohammadreza Ravanfar, Leila Azinfar, Riadh Arefin, Reza Fazel-Rezai, "Electrocardiogram Baseline wander Removal based on Empirical Mode Decomposition". Vol. 41, 2014, pp.45-48.

[11] Nitish V. Thakor, and Yi-Sheng Zhu, "Applications of Adaptive Filtering to ECG Analysis : Noise Cancellation and Arrhythmia Detection", IEEE Transactions on Biomedical Engineering. Vol. 38. No. 8, 1991, pp. 785-794.

[12] L Chmelka, J Kozumplık, "Wavelet-Based Wiener Filter for Electrocardiogram Signal Denoising", Computing in Cardiology. Vol 32. 2005, Pp 771-774.

[13] www.research.chop.edu/programs/lqts/ecg.php

Ashish Rohila obtained his B.Tech. (Electronics & Instrumentation) Degree from Radha Govind Engineering College, Meerut (Affiliated to Gautam Buddh Technical University) Lucknow (UP) in 2011. Presently, He is M.Tech (Control & Instrumentation) student in Electrical Engineering Department of M.M.M. University of Technology, Gorakhpur (UP). He has presented three research papers in National Conferences and published one research paper in international journal. His research interests include Digital Signal Processing, Measurement and Instrumentation, Biomedical Instrumentation, ECG and Control Systems.

V.K.Giri obtained his B.E. (Electrical) Degree from SVNIT (erstwhile, SVRCET), Surat (Gujrat) in 1988, M.E. (Measurement and Instrumentation) Hons. degree from University of Roorkee, Roorkee in 1997 and Ph.D. degree from Indian Institute of Technology Roorkee, Roorkee in 2003. He joined the Electrical Engineering Department of M.M.M University of Technology, Gorakhpur (UP) in 1989 as lecturer. Presently, he holds the position of Professor in the same department since, 2008. He has published more than 60 research papers, guided 14 PG students; and supervising 6 Ph.D. theses. He has received many awards including the best paper awards of the Institution of Engineers (India) in 23rd Indian Engineering Congress in year 2008. He was elected as Fellow of the Institution of Engineers (IE), Institution of Electronics and telecommunication Engineers, and is a member of many professional bodies such as life member ISTE, member IEE and member CSI. He has also undertaken large number of consultancy, testing & sponsored projects from UGC, industries and other government departments. His research interests include Digital Signal Processing, Condition Monitoring of Machines, Control and Instrumentation, Biomedical Instrumentation, ECG, Data Compression and Telemedicine.