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R-Peak Detection for ECG Signal Analysis using Steepest Ascent Hill Climbing Algorithm

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Abstract – ECG is considered to be the primary tool for detection of cardiac problems. An ECG signal has all the necessary information pertaining to the electrical activities of heart and about normal and abnormal activities to detect diseases and changes that occurs due to several abnormalities.Detection of R-peaks in QRS complex correctly and efficiently is very important, here we are proposing a new technique for R-peak detection which is steepest ascent hill climbing algorithm for detection of R-peaks. This method increases accuracy of R-peak detection and reduces false peak detection.

Keywords QRS complex, R-peak detection, sampling frequency, Thresholding, windowing.

I Introduction

ECG is the primary method for cardiac functions and identifying possible irregularities therein. This project aims to provide a user-interface along with the background processes to perform such analyses on incoming ECG dataset(s) and assist the medical professionals in clinical evaluations. ECG shows the electrical changes during each cardiac cycle - whose analysis helps to detect various types of heart diseases. ECG is a non-stationary signal, and has several irregularities which may or not be periodic and appear differently and at irregular intervals. To observe it clinically takes very long time and it is very tough. So here comes the need of computer based techniques for analysis of it. Sufficient research has been done in analysis of ECG for computation of heart related morphologies. Our objective is to design a simple tool which computes the parameters efficiently and possibly in real time as well.

ECG wave representation

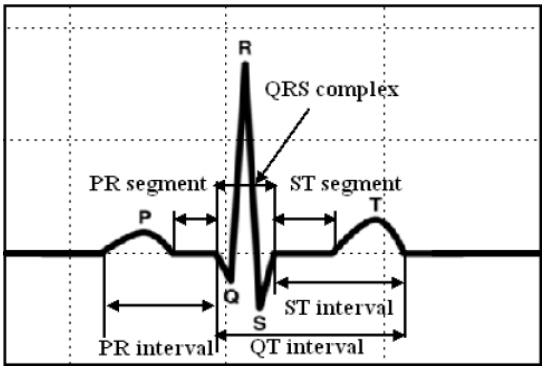

Figure 1 – ECG Wave Representation[5]

P wave gives indication of left and right atrial contraction having very low amplitude (approx. 1mV).

PR Interval gives time duration when depolarization wave reaches to the ventricles.

QRS Interval is duration between peak points Q, R, S. Q wave is first down peak just after P whereas R wave is first up peak just after Q. S wave is first down peak just after R-peak wave. This QRS wave is whole ventricular contraction

ST Segment indicates the time between ventricular depolarization and start of polarization.

T wave indicates ventricular polarization.

QT Interval shows the whole ventricular activity.

The QRS complex is change in potential difference of approx. 10–20 mV but it may vary. The amplitude of QRS complex also gives information about the heart related diseases. Duration of the QRS gives the time for the ventricles to depolarize and gives information about problem in the ventricles.

Table No. 1: Amplitude and time duration of ECG wave points [5]

s.no	Parameter Points	Amplitude (mV)	Time duration(ms)
1	P– wave	0.1–0.2	60–80
2	P R– segment	–	50–120
3	P–R	–	120–200
4	QRS	–	80–120
5	ST –segment	–	100–120
6	T –wave	0.1–0.3	120–160
7	S–T	–	320
8	R– R	–	400–1200

II Procedure

Various methods are developed for detecting the R-peak and QRS complex like polynomial curve fitting method, Wavelet Transform method, Hilbert Transform method, neural network method , and various others. Combination of approaches of thresholding and steepest ascent

hill climbing method applied under a particular span of sample window is used. Here variable threshold technique which uses maximum value of samples coming in a particular span.

Block Diagram

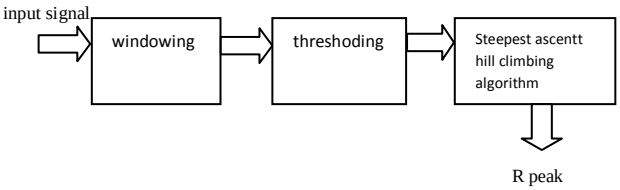

Figure 2 - R peak detection

WINDOWING

Here full signal is divided into window having samples equal to twice of the sampling frequency i.e. '2fs'. The window size is taken to be '2fs' to prevent possibility of appearing no R-peak in the particular window span. By taking this window size of '2fs' at least one R-peak is present. That is why the window span is of '2fs'.

W[1,2,….n]=x[1,2,…..n]

Where fs<n<2fs and n, fs is window size and sampling frequency

THRESHOLDING

Here variable thresholding is used which meant that first extracts maximum value sample from samples in the particular window span then all the samples of the perticular window span are divided by the maximum sample value to bring sample values greater than 1 in range of 0 and 1. Then a threshold value is set, the peak coming greater than the threshold value is called as R-peak. It is called variable threshold because the maximum value varies from window span to window span the threshold value in one window span is variable because maximum value in that window span is not same as value from the other span. For example, Let the maximum sample value of the overall signal is 1.5 and the maximum sample value of one window span is 0.8 and second window span is 0.6 then if we use the threshold value by taking the maximum sample value of the signal which is 1.5 and threshold value is 0.6 then the sample value 0.8 will be 0.53 and sample value 0.6 will be 0.4 then the peaks having 0.8 amplitude and 0.6 amplitude will not be detected. Whereas by taking the maximum sample value of the window span having maximum sample value of 0.8 then dividing the all the samples of particular window span by 0.8 will get all the sample values having values greater than 0 in range of 0 to 1. If there are two peaks having sample values 0.6 , 0.8 and threshold value is 0.6 then on dividing 0.6 and 0.8 by the maximum value 0.8 it will obtain 0.75 and 1, therefore undetectable peaks get detected by this variable threshold values.

To convert all values in the span between 0 and 1

$$\mathbf{W(n)=\frac{W(n)}{max(W)}\ for\ all\ W(n)\geq 0}$$

PEAK DETECTION

STEEPEST ASCENT HILL CLIMBING METHOD:

1. Evaluate the initial state, if goal then return and quit, else continues initial state as current state.
2. Repeat until solution is found or until a complete iteration produces no change to current state.
   a. Let S be the state such that any possible successor is better than S.
   b. For each operation for current state
      i. Apply operator and generate new state
      ii. Evaluate new state, if goal then return and quit, if not compare it to S if better, than set S to this state, if not leave S to its previous state.
   c. If S is better than current state, then set current state to S.

III Result

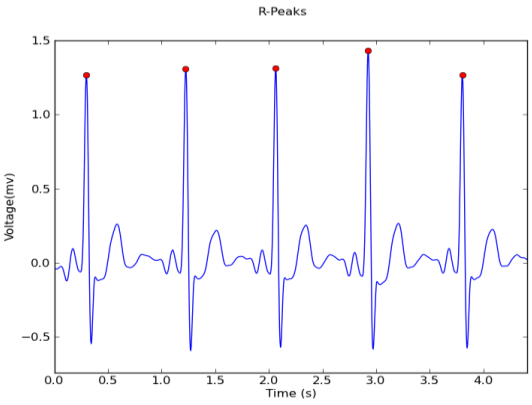

Figure 3 - Detected R-peaks

CONCLUSION

ECG analysis is very essential for diagnosing any disease related to heart. For ECG analysis, R-peak detection is done then after parameters are detected for abnormality detection. For efficient detection noise is removed with the help of moving average filter and steepest ascent hill climbing algorithm is used for R-Peak detection. The overall efficiency has also increased. The tool developed for detection also analyzes heart rate, heart rate variability, QRS variability, ST elevation. Using heart rate, tachycardia and bachycardia type of disease is detected with the help of the tool and this tool can further extended to be used for studying cardiac parameters of people of different age groups and detected other diseases related to heart.

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