ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 5, May 2015

# A Novel Technique of R-Peak Detection for ECG Signal Analysis: Variable Threshold Method

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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. For which 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 uses the variable threshold for detection of R-peaks this method increases accuracy of R-peak detection and reduces false peak detection.**

***Index Terms*— QRS complex, R-peak detection, sampling frequency, Thresholding, windowing.**

## I. INTRODUCTION

For accurate and efficient analysis of the ECG signal for diagnosing the several heart abnormalities it is most important to find out R-peaks correctly of the QRS complex. This will play an important role in finding out heart rate and variations in it. For detection of R-peaks variable threshold method is used which uses windowing technique and for each window a threshold value is set from the maximum value in the particular window and thus it is different for each window and it is termed as variable threshold method this method has very high efficiency than many other methods. This algorithm is very much efficient for detecting R-peaks correctly and increases the accuracy in analysis of the ECG signal

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ECG WAVE REPRESENTATION

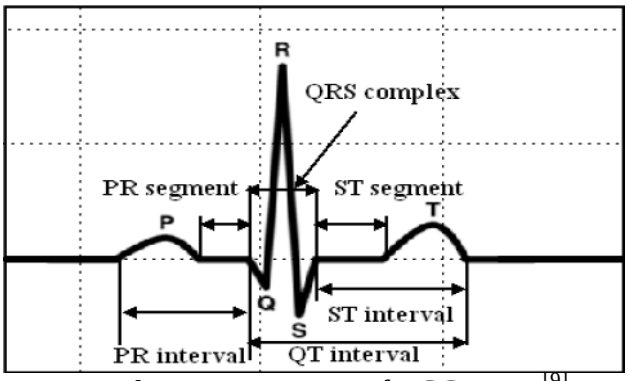


Figure1: The representation of ECG wave [9]

**P** wave indicates atrial contraction, represent contraction of the left and right atria and has low amplitude (approx. 1mV).

**PR**[3] Interval gives time during which depolarization wave reaches to the ventricles.

**QRS**[6] Interval is three peak points Q, R, S. Q wave is the first negative peak just after P whereas R wave is the first positive peak just after Q. S wave is the first negative peak just after R-peak wave. This QRS wave represents which means ventricular depolarization (and contraction)

**ST** Segment gives the difference in time between ventricular depolarization and start of polarization.

**T** wave represents ventricular polarization.

**QT** Interval represents whole ventricular activity.

**Table No. 1**: Amplitude and time duration of ECG wave points [9]

| Sl. no. | Parameter Points | Amplitude (mV) | Time duration(msec) |
|---|---|---|---|
| 1 | P wave | 0.1-0.2 | 60-80 |
| 2 | PR-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

There are several methods were developed to detect the R-peak and QRS complex like Hilbert Transform method, Hybrid Wavelet Transform method[4], neural network method ,polynomial curve fitting[2] method and various others. Combination of approaches of thresholding and derivative method applied under a particular span of sample window is used. Here the threshold used is the variable threshold which depends on the maximum value of samples in a particular span.

*A. Block Diagram*

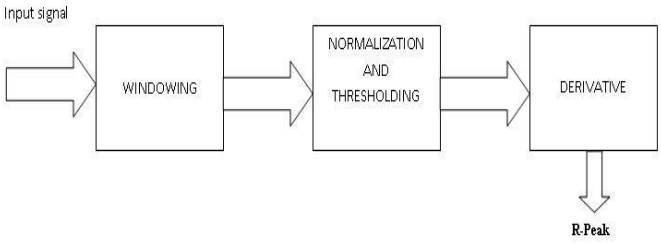


Figure 2: R-peak detection

WINDOWING

In this whole signal is divided into the span window[9] of samples which is equal to twice of the sampling frequency of the signal i.e. '2fs'. The span window is taken to be '2fs' because if we take span length of 'fs' there may be possibility that no R-peak appear in the particular span then there may be chance of detecting the false peak but on the other hand at least one R-peak is present in the span if we take it of length '2fs'. This is the reason why the span length 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

Concept of variable thresholding is used which means first find out the maximum value from samples in the particular span then all the samples present in the particular span are divided by the maximum value to bring the values which are greater than 0 in between 0 and 1. Then a threshold is set the peak above the threshold is called as R-peak. The reason behind calling it as variable threshold is that the maximum value varies from span to span the threshold value in one span is different because maximum value in that span is different from the other span. For example suppose the maximum value of the whole signal is 1.5 and the maximum value of one span is 0.8 and second span is 0.6 then if we have used the threshold by taking the maximum value of the signal i.e. 1.5 and if threshold value is 0.6 then the value 0.8 will be 0.53 and 0.6 will be 0.4 then the peaks of amplitude 0.8 and 0.6 will not be detected. On the other hand by taking the maximum value in the span having maximum value 0.8 then dividing the all the samples in that particular span by 0.8 we get all the sample values which are greater than 0 in between 0 and 1. And if there are two R-peaks having values 0.6 and 0.8 and threshold is set to 0.6 and by dividing the 0.6 and 0.8 by the maximum value 0.8 we get 0.75 and 1, therefore the peak which were not detected are detected by this variable threshold values.

To convert all values in the span between 0 and 1

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

PEAK DETECTION

For detection of peak the method of differentiation is used i.e. difference of the value of the samples next to previous is done, if the difference is positive then it goes on calculating difference as it gets the first difference to be negative this means the previous sample is the peak point then it calculates its amplitude value and compare it with the threshold and if it is greater than the threshold then it is the R-peak. There may be possibility that there may be multiple peaks in the single R wave due to presence of noise and they are above the threshold then to avoid detection of the false peak any peak which is in distance less than '0.35fs' of the first peak and its value is less than last peak than that peak is discarded and if the next peak is within '0.35fs' of last peak and its value is greater than last peak than last peak was discarded and the peak which is greater is the new peak and hence the greatest peak is the R-peak and all peaks within '0.35fs' are discarded and hence the chance of getting the false peak is reduced to very much extent.

**ΔW(n)=W(n+1) - W(n)**
**P(m)=W(n) and D(m)= n when ΔW(n)<0 and W(n)≥Th**
**P(m) ≠W(n) when ΔW(n)>0 or W(n)<Th**

Where **P** holds Number of peaks in particular span
And **D** holds position of peaks in the span

**R(n) = P(m)** when D(m)-D(m-1) ≥ 0.35fs
**R(n)≠ P(m)** when D(m)-D(m-1)<0.35fs

Where n= 1,2.3……m
Where R(m) is detected R-peaks and Th is threshold value of particular span.

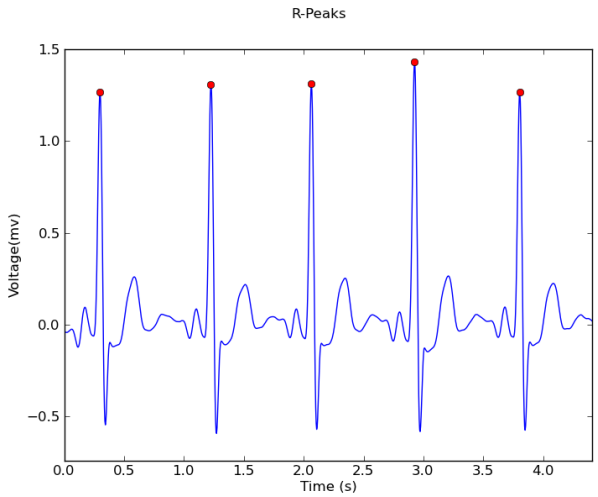


Figure3: Detected R-peaks

## CONCLUSION

ECG signal analysis is very important for diagnosing heart related diseases, and for the analysis of the problems of heart the computation of the parameters of the ECG is very important. And for analysis of the ECG signal R peak detection efficiently is very important which helps in computing the parameters from ECG signal. To detect R-peaks efficiently the noises present in the signal has to be removed which causes difficulty in the analysis. Varying threshold scheme has increased efficiency of R-peak detection.

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