Diagnosis of Cardiac Ischemia by Analysing Stress ECG

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Abstract – Stress ECG has been effectively used for analysis of the myocardial ischemia than normal ECG because of the reason that ischemic conditions will be dominated in stress conditions. According to the clinically proven facts, after taking a series of exercise, the chance of finding ischemia can rise up to 80%-90%. In ECG, the ST segment detection has close relationship with myocardial ischemia and myocardial infarction. Denoising of the stress ECG has done using filters. The key points of ECG signal like Q, R, S are found out using Pan Tompkins algorithm. Other key points like P, T, Ton, Toff, J, ISO are also found using window method. The feature of interest is ST segment. Based on R-R interval, heart rate was found out. By considering the age of the individual sub-maximal heart rate is fixed and let the patient to do exercise stress test which lasts until sub-maximal heart rate was reached. The ST segment was analyzed on and after the sub-maximal heart rate. According to the clinically proven facts, for a person having ischemia the ST level shows a depression for about two minutes or more during relaxing stage. ECG signals from MIT-BIH ST Change Database had been used to verify the algorithm in MATLAB software.

Keywords—Myocardial ischemia, ECG, ST segment, Sub-maximal heart rate, Exercise stress test.

I. INTRODUCTION

Myocardial ischemia is one of the most common heart diseases. The main reason is coronary atherosclerosis decreased blood flow to the heart, that make oxygen supply decrease and myocardial metabolism appears abnormal, in this condition the heart cannot work normally. If this continues, it means the patient get myocardial ischemia. The immediate reason for myocardial infarction is coronary artery disease which makes blood fell sharply or interrupted. Thus heart will appears serious and sustainability of ischemia and cause infarction.

The detection of Coronary Artery Disease can be done using various techniques like stress ECG analysis, coronary angiography and echocardiogram. The main advantages of stress ECG analysis over other methods are the cost effectiveness and noninvasiveness. Normal ECG is not capable of detecting early onset of ischemic conditions. The clinical principle behind this stress ECG method is that coronary artery problems will be dominated in stress conditions, because exercise related ischemia is limited to sub endocardium and it is proportional to the increase in myocardial oxygen demand.

Because ST segment will show in various form for different kinds heart disease attack, so that the change of ST segment is a significant indicator of various heart disease in ECG clinical care.

Liu[1] used neural network technique for the prediction of the ST type. But it requires a lot of data for the training and it cannot predict new patterns. Shi.[2] used a new wavelet method for finding characteristic points of ECG. But accuracy of detection was least. Narayana [3] implemented the Pan Tompkins algorithm successfully for ECG key point detection.

In this paper, for finding QRS complex Pan Tompkins algorithm was used. Using that we are finding the heart rate of the person. Then other key points of the ECG are finding out. Features of the ECG signal are extracted and then analyzed for deciding whether the person had Ischemic condition or not. The approach was tested by using ECG signal from MIT-BIH ST Change Database.
II. METHODOLOGY

![Block diagram](image)

A. Data collection

The ECG signals are retrieved from ECG database called MIT-BIH ST Change Database. Each dataset contains two signals, V4 and V5. Signals of half an hour duration had been retrieved. The retrieval was done in MATLAB itself by using a specialized toolbox called WFDB which had been installed manually.

B. Denoising

It was necessary to suppress noise before precisely extracting the features of ECG signal. The main noises present in the ECG signal are Power line interferences and Baseline wandering noises. Power line interference is located around the frequency of 50 Hz. By designing a 50 Hz notch filter we can easily remove that noise. Baseline wandering has a lower frequency and is located below .05 Hz, whose frequency component was approximate to that of ST-T segment. For removing that noise, a high pass filter having cut off frequency of .05 Hz was used. DC line shifting was also cancelled and the signal is normalized to one.

![Figure 2. Key points of ECG](image)

C. ECG Key points detection

In this project, we used the Pan Tompkins algorithm for finding QRS peaks of the ECG.

The algorithm includes a series of filters and operators that perform operations like derivative, squaring, integration, and adaptive thresholding and search procedures.

![Figure 3. Pan Tompkins algorithm](image)
Taking R peak as the reference point T wave peak, ISO point, J points were found out. Point J is the ending point of QRS wave. A window of [Rpeak+20ms, Rpeak+100ms] is used as the interval for finding point J. ISO (Isoelectric) point is used as the reference point for the entire ECG waveform. A window of [Rpeak-100ms, Rpeak-20ms] is used for finding ISO point. These two points are found based on the slope change detection. T-on point is the end point of the ST segment and starting point of the T wave.

D. Stress test

MIT-BIH ST Change Database is a Stress ECG database, which follows Bruce protocol. Stress test protocol should be consistent with the patient’s physical capacity. In this protocol, the patient will be allowed to do the exercise until the sub-maximal heart rate is reached which is also called target heart rate. Target heart rate is age dependent which is given below in formula 1

Target HR= 214–(.8*age) for men

Target HR= 209–(.9*age) for woman (1)

As the Target heart rate is reached, exercise will be stopped and let the patient to relax. During the test, if the patient does not feel comfortable, the exercise will be stopped at sudden and asks the patient to relax. The relaxing stage is the perfect time for diagnosis, because during that time ST segment deviation will be dominant for the ischemic conditions [4].

E. ST level analysis

Analysis of the ST segment was done at J+x point. J+x point is the point which is x milliseconds after the point J.

x depends on the heart rate which is given below in formula 2

\[
x = \begin{cases} 
80 \text{ ms}, & \text{if HR}<100 \text{ bpm} \\
72 \text{ ms}, & \text{if 100<HR<110 \text{ bpm}} \\
64 \text{ ms}, & \text{if 110<HR<120 \text{ bpm}} \\
60 \text{ ms}, & \text{if HR}>120 \text{ bpm}
\end{cases}
\] (2)

At first finding the target heart rate of the patient; then analyze the ECG signal on and after achieving the target heart rate. Then check for whether the ST segment has any variation at J+x point. According to clinically proven facts, during resting stage of stress test, if the ST segment has a depression of about .01 mv than at the exercise stage and if it prolonged more than two minutes, then we can say that the patient is having ischemia. The duration of that depression will tell about the severity of the disease.

III. RESULT

From the MIT-BIH ST Change Database, stress ECG signals have been studied. From the stress test procedure it is observed that ST segment depression had significance in finding ischemic conditions. The results are shown below.

![Figure 4. Heart rate variation for signal 1](image)

![Figure 5. Heart rate variation for signal 2](image)

<table>
<thead>
<tr>
<th>Table 1: ECG signal 1 from MIT-BIH ST database</th>
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<tbody>
<tr>
<td>Time (minute)</td>
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Table 2: ECG signal 2 from MIT-BIH ST database

Figure (4) shows the signal 1, it is found that sub-maximal heart rate reached at fourth minute and after that the patient will be in relaxing state. From the table (1), it is clear that during relaxing period ST segment shows considerable depression which lasts up to ninth minute and after that it starts to recover. As the depression lasts for more than five 5 minutes, the patient is having severe ischemia.

Figure (5) shows the signal 2, sub-maximal heart rate is achieved at seventeenth minute and from the table (2), it is clear that there was no further depression in the ST segment during the resting stage. So the person is a normal

IV. CONCLUSION

ST segment feature under stress condition has a significant effect in diagnosing ischemic condition of the patients and it shows perfect discrimination of the normal and abnormal ECG signals.

V. REFERENCES


