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ECG Signal Characterization and Correlation To Heart Abnormalities

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Abstract –*ECG is one of the most important physiological parameter that gives the correct assessment regarding the functioning of the heart. One cardiac cycle in an ECG signal consists of the PQRST waves. This paper presents the collection of ECG signal from Database, filtering and processing of ECG signal, feature extraction, detection of P, Q, R, S and T values of an ECG signal and the heart rate. One of the important cardiovascular disease is arrhythmia. By calculating the heart rate the different types of arrhythmia classes including Tachycardia and Bradycardia are determined. MATLAB is used for the implementation & ECG signals were taken from MIT-BIH Database. The extracted parameters are compared with the standard morphological values of ECG signal and abnormality is classified.*

Key Words: **Peak Detection, Heart Rate Detection, Tachycardia, Bradycardia, MATLAB, MIT-BIH Arrhythmia Database**

1. INTRODUCTION

Electrocardiogram is a diagnosis tool that reported the electrical activity of heart recorded by skin electrode. It provides a huge amount of useful information and remains as an essential part of diagnosis and treatment for cardiac patients. ECG varies from person to person based on their heart conditions. A typical ECG tracing of normal heart beat consists of a P wave, Q wave, R wave, S wave, T wave and a U wave. Successive repetition of these "PQRST" is the monotony forms of ECG. The most important information about ECG signal is concentrated on the P wave, QRS complex and T wave. These data include the positions and/or magnitudes of PR interval, QRS interval, QT interval, ST interval, PR segment, and ST segment. However, a proper recognition and classification of the heart signals are essential requirement for the diagnosis of heart diseases.

The ECG signal is downloaded from MIT-BIH Arrhythmia database, since this signal contains some noise hence processing and filtering of ECG signal are performed. The amplitude and duration of each wave in ECG signal has been determined. This paper presents PQRST wave detection methods based on finding features of signal and thresholding. By calculating the Heart Rate, the ECG signal can be defined as Normal, Bradycardia and Tachycardia. Heart rate is the speed of the heartbeat measured by the number of heartbeats per unit of time usually expressed as beats per minute (Bpm). The normal heart rate for normal person is in the range of 60 to 100 beats per minute, but this may change with age and sex. The characteristics of normal heart rhythm also called Normal Sinus Rhythm (NSR) any disorder in these parameters results in a pathological condition called Arrhythmia or dysrhythmia.

ECG arrhythmia can be defined as electrical activity of the heart is irregular and can cause heartbeat to be slow or fast. When the heart rate less than 60 bpm is called Bradycardia and when the heart rate more than 100 bpm is called Tachycardia. Arrhythmia detection and classification are only based on surface Electrocardiogram analysis. MATLAB is used for the implementation of this research work to detect abnormalities present in the ECG signal.

The ECG signal consists of five waves where the horizontal axis of a wave represents the time and the vertical of a wave which includes height and depth represent the voltage. The normal ECG wave is composed of a series of positive and negative waveforms such as P wave, QRS complex, and T wave as shown in figure 1[1]. Where the P wave represents the First upward deflection and atrial depolarization. QRS complex is composed of three waves Q, R and S represents ventricular depolarization and T wave represents the Repolarization of ventricles.

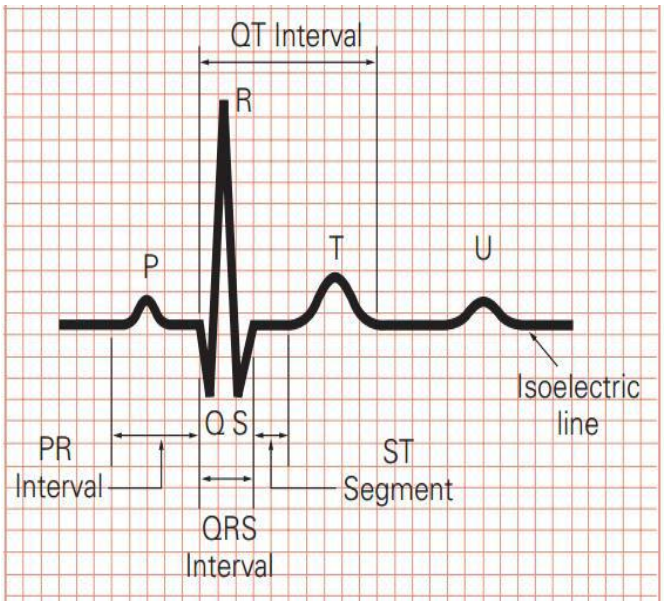

Figure 1: Normal ECG signal

The first time interval in the horizontal axis is P-R interval which represents the period from the onset of the P–wave to the beginning of the QRS complex. This interval represents the time between the beginning of atrial depolarization and the beginning of ventricular depolarization. The S–T segment following the QRS and describes the part between the end of the S wave (the J point) and the beginning of the T wave and it represents the interval between ventricular muscle depolarization and repolarization. The Q–T interval is a time period between the beginnings of the Q wave to the end of the T wave in the heart's electrical cycle. The QT interval representing the total duration of electrical activity depolarization and repolarization of the ventricles. Table 1 represents the normal amplitudes and durations of the ECG waveform [2][6].

TABLE 1. NORMAL ECG WAVE AMPLITUDES AND DURATIONS.

ECG parameter	Typical amplitude [mV] and wave duration [seconds]
P wave	0. 25 mV
R wave	1. 60 mV
Q wave	25 percent of R wave
T wave	0.1 to 0.5 mV
P-R interval	0.12 to 0.20 seconds
Q-T interval	0.35 to 0.44 seconds
S-T segment	0.05 to 0.15 seconds
QRS interval	0.09 to 0.10 seconds
Heart Rate	60-100 bpm

Description of a cardiac cycle:
P wave - Atrial Depolarization
Q wave - First negative (down ward) deflection after the P wave but before the R wave
R wave - First positive (upward) deflection following the P wave
S wave - First negative (down ward) deflection after the R wave
T wave - Indicates ventricular repolarization

2. LITERATURE SURVEY

To study and analyze more about the ECG techniques, the following literature survey has been done. In [1]. This paper presents a procedure to extract information from ECG data & determine types of Arrhythmias and also determining different intervals such as PR Interval, RR Interval, and Heart Rate.
In [2] In this proposed method they designed a graphical user Interface (GUI) by using MATLAB for detecting PQRST peaks in ECG signal. In [3], authors have presented MATLAB based GUI for arrhythmia detection using wavelet transform. They determined the different intervals such as PR Interval, RR Interval, and QRS width by comparing them with normal ECG classify arrhythmia type.
In [4] authors have determined the different arrhythmias are Atrial Fibrillation (AF), Cardiac Ischemia (CI) and Sudden Cardiac Arrest (SCA). ECG data has been obtained from the MIT-BIH arrhythmia database by using MATLAB.
In [5], authors have presented analysis of ECG signal for the detection of abnormalities present with reference to Q, R and S peaks using MATLAB.
In [6], authors have worked on different types of arrhythmia are Tachycardia, Bradycardia and Myocardial Infract (MI) are classified and Wavelet Transform is used for the detection of PQRST waves in ECG signal.
In [9] authors developed a method called study and analysis of ECG signal using MATLAB & LABVIEW as effective tools.
In [7]. This paper presents timely and accurate detection of QRS complexes present in the ECG signal. In [8]. This paper shows research issues in ECG analysis. In [10] authors focused on “Tachycardia” and “Bradycardia” to make decisions using support vector machine (SVM).They have used Dijkstra's Algorithm to send the processed ECG data from a wireless node to a remote location using a shortest path.

3. PROPOSED METHODOLOGY

The Proposed method introduces the sequence of steps as they are briefly explained below.

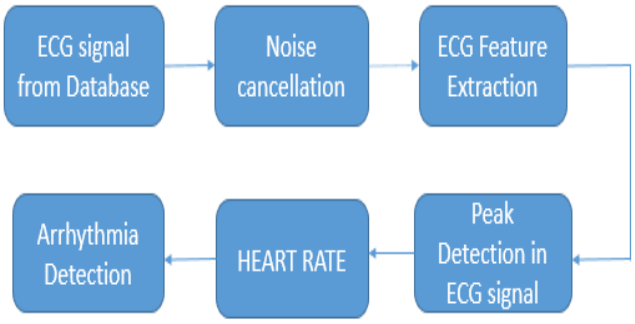

Figure 2. Block diagram of proposed method

ECG DATABASE

ECG signals were taken from MIT-BIH Arrhythmia Database. MIT-BIH Arrhythmia Database have been an enormous help for the development and evaluation of ECG classification and detection of algorithms. The analysis of ECG signals provide relevant information for Arrhythmia detection. In this work, normal ECG from the MIT-BIH

(Massachusetts Institute of Technology/Beth Israel Hospital) Normal Sinus Rhythm database is used and for abnormal ECG signals MIT-BIH arrhythmia database is used. This Database provides large collections of recorded physiological signals.

ECG SIGNAL PROCESSING

Under the processing of the input signal it is known by adjusting the properties to achieve the best result for classification of ECG signal. One of the basic types of processing of ECG signal is filtering. Savitzkey-Golay filter is used to cancel the noise in the ECG signal and removed the Baseline wandering in ECG signal. ECG signals must be processed before performing arrhythmia classification and Peak Detection.

ECG FEATURE EXTRACTION

The main objective of the ECG feature extraction process is to derive a set of parameters that best characterize the ECG signal and these parameters should contain maximum information about the ECG signal. Hence the selection of these parameters is an important criterion to be considered for proper classification. ECG feature extraction play vital role in disease identification. The Feature Extraction stage extracts diagnostic information from the ECG signal. The detection of PQRST peak is the first step of feature extraction. The extracted parameters are compared with the standard morphological values of ECG signal and abnormality is classified.

PEAK DETECTION

The most important information about ECG signal is concentrated on the P wave, Q wave, R wave S wave and T wave. To detect the Peaks and location of various ECG signal parameters such as P Q R S T waves are determined by using the MATLAB functions to find its amplitude and duration of the required parameter. Objective of this research work is to classify the ECG signal into cases of various arrhythmias.

HEART RATE CALCULATION

Heart rate is the speed of the heartbeat measured by the number of heartbeats per unit of time usually expressed as beats per minute (bpm). The detection of R-peaks provides information to measure the heart rate. This supplies the evidence for diagnosis of cardiac disease. The normal heart rate for normal person is in the range of 60 to 100 beats per minute.

HEART RATE = 60/(R-R INTERVAL)
= 60/1sec
= 60BPM

ABNORMAL ECG SIGNAL (ARRHYTHMIA)

An arrhythmia (ah-RITH-me-ah) is a problem with the rate or rhythm of the heartbeat. It can be defined as electrical activity of the heart is irregular and can cause heartbeat to be slow or fast. The normal heart rate for normal person is in the range of 60 to 100 beats per minute but this may change with age and sex.

- When a heart rate more than 100 bpm is called Tachycardia (Fast heart).
- When a heart rate less than 60 bpm is called Bradycardia (Slow heart).

4. RESULTS AND DISCUSSION

To detect the Peaks and location of various ECG signal parameters such as P Q R S T waves are determined by using the MATLAB functions to find its amplitude and duration of the required parameter. In the ECG waveform the X-axis represents the time and Y-axis indicates the amplitude of signal in mV.

The ECG signal shown in Figure 4 is taken from the company SenseSemi Technologies Pvt Ltd, Bangalore. This is a noisy signal with variable baseline. Savitzkey-Golay filter is used to cancel the noise in the ECG signal and removed the Baseline wandering in ECG signal as shown in figure 6. The ECG signal shown in figure 7 taken from MIT-BIH Normal Sinus Rhythm Database. The ECG signal shown in figure 9 and Figure 10 taken from MIT-BIH Arrhythmia Database and peak detection was done for both Normal and Abnormal ECG signals. The extracted parameters are compared with the standard values of ECG signal and abnormality is classified as shown in Table 2 and Table 3. The ECG parameters are important in finding the arrhythmia.

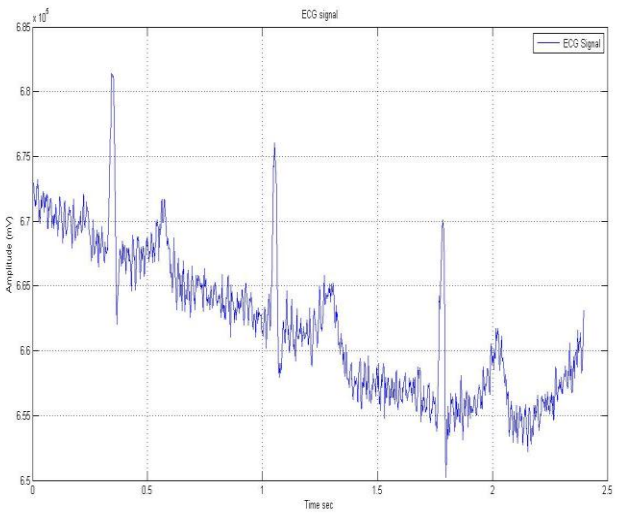

Fig 4: ECG signal with noise

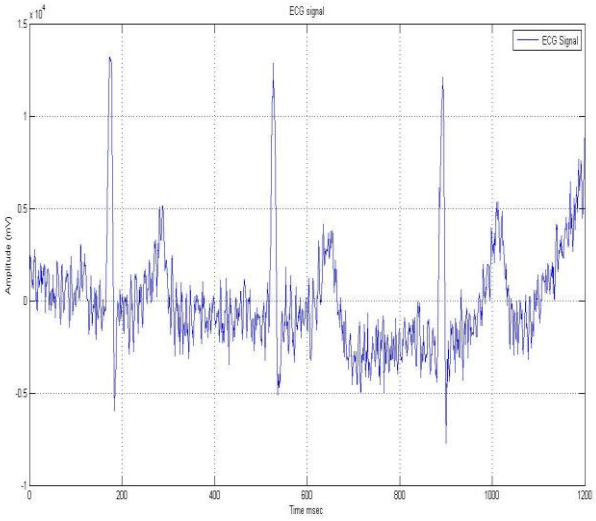

Fig 5: Baseline corrected ECG signal

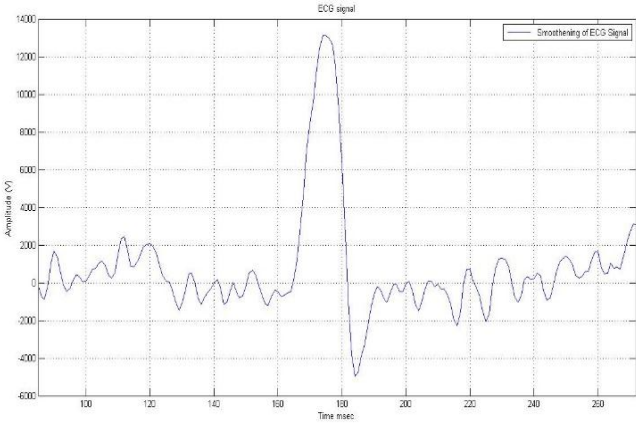

Fig 6: ECG signal after using Savitzky- Golay filter

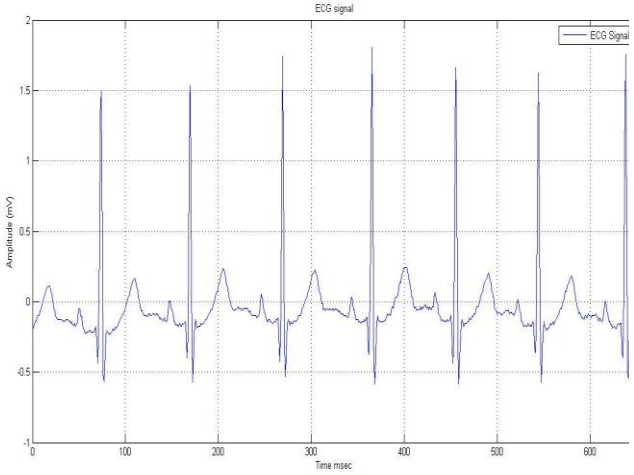

Fig 7: Normal ECG waveform in MATLAB

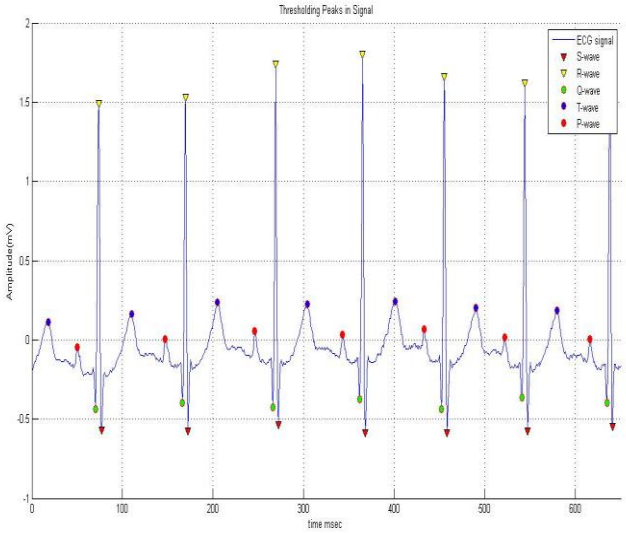

Fig 8: Representation of Normal ECG signal with Peak

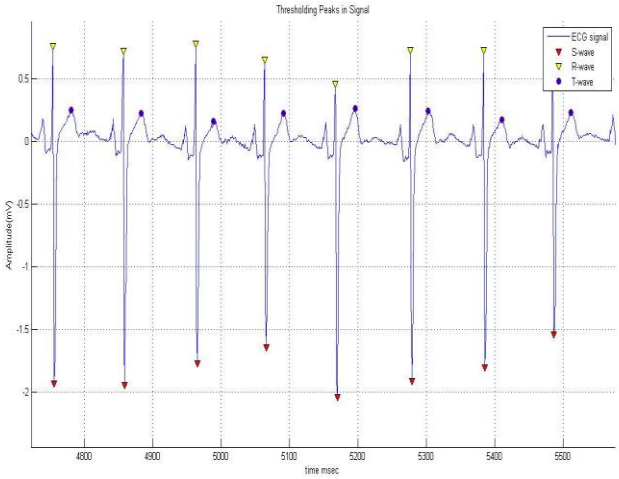

Fig 9: Representation of Abnormal ECG signal with peak

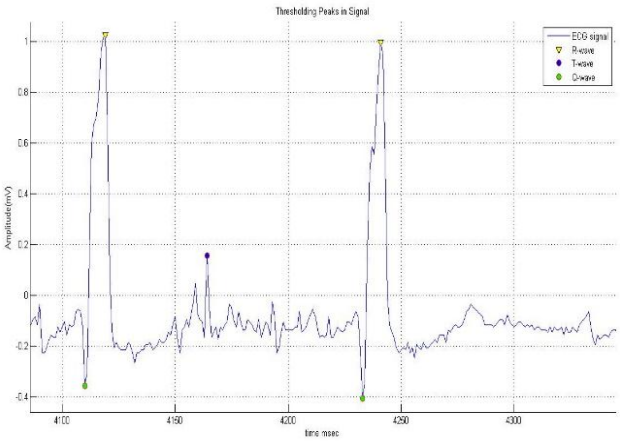

Fig 10: Representation of Abnormal ECG signal with peak

Table 2. Comparison of the values of PQRST waves and Heart Rate for Normal ECG signal.

ECG PARAMETERS	Standard values of PQRST waves	The values of PQRST waves detected as shown in fig 8
P WAVE	0.25mV	0.055mV
Q WAVE	25% of R wave	-0.435mV
R WAVE	1.60mV	1.4950 mV
T WAVE	0.1 -0.5 mV	0.115 mV
HEART RATE	60-100 bpm	78 bpm

Table 3. Comparison of the values of PQRST waves and Heart Rate for Abnormal ECG signals.

ECG PARAMETERS	Standard values of PQRST waves & Heart Rate	Detected peak values of Abnormal signal as shown in fig 9	Detected peak values of Abnormal signal as shown in fig 10
P WAVE	0.25mV	Not in Range	Not in Range
Q WAVE	25% of R wave	Not in Range	-0.355mV
R WAVE	1.60mV	0.75mV	1.025mV
T WAVE	0.1 -0.5 mV	0.24mV	0.155mV
HEART RATE	60-100 bpm	125 bpm	54 pm

5. CONCLUSION AND FUTURE SCOPE

One of the crucial steps in ECG analysis is to accurately detect the different waves namely P, Q, R, S & T forms the entire cardiac cycle. This methodology is definitely a new approach to detect the peaks with the nonstandard shapes present in the ECG signals and also calculated Heart Rate. By calculating of Heart Rate the ECG signal can be defined as Normal, Bradycardia and Tachycardia. The values of PQRST waves are displayed by using MATLAB functions and their corresponding waveforms are plotted. From the obtained results we can found that the PQRST values for the normal ECG signal is within the specified range and the simulation of ECG waveform will help to build the hardware conveniently. This proposed wok could be continued further to implement this system to find deposits of arrhythmia in the heart by using calculations of intervals between impulses of two different signals in real time.

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