ECG Analyzing program for Arrhythmia detection

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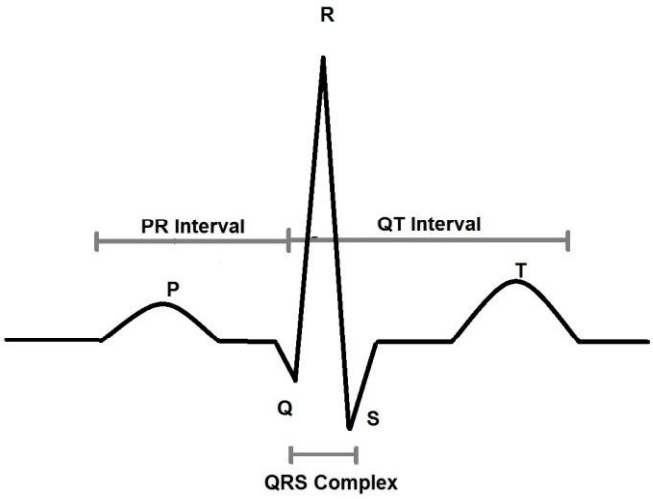
***Abstract*— The ECG analysis program can provide much information about cardiac disorder. Comparison with visual analysis, require specialist which are not available in many occasion. Therefore, computer-based technique that develops for ECG analysis can used to training inexperience staff and pre-diagnostic the ECG data. In this work, the ECG analyzing algorithm for arrhythmia detection was applied using MATLAB. Parameters that used in this analysis were peak of P wave, QRS Complex and T wave. The detection of the RR interval, PR interval, QRS complex, QT interval and conversion of the RR interval to heart rate (beat per minute) were developed. ECG analyzing program is easy to use by simply load the ECG data to analyze both the necessary value for arrhythmia detection and type of arrhythmia. In conclusion, the ECG analysis program using as a pre-screen test for ruler area and also use as a training system for medical staff was developed.**

Keywords*— *Electrocardiogram, Arrhythmia, MATLAB

I. INTRODUCTION

The Electrocardiogram (ECG) is measurement of the electrical activity of the heart. By positioning electric sensing device on body in the standard location, then sense electrical activity generated by polarization and depolarization of cardiac tissue and transfer to the characteristic pattern of ECG signal [1]. The electrical activation of the heart starts at the sino-atrial node(SA node) which call the pacemaker cell. Then the electrical is conducted across the atrium to the atrioventricular node (AV node). There is some delay at AV node before the electrical is propagated to the ventricular through the Bundle of His and Purkinje fiber [2]. After that the cardiac cycle is repeated. This activities are control the contraction of heart that pumps blood to the circulatory system. Abnormal electrical conduction result in inappropriate heart function that changes the characteristic of ECG.

The normal ECG is consist of P wave with normal amplitude about 0.25 millivolts. The PR Interval measured from the beginning of the P wave to the beginning of QRS complex. This PR interval duration is about 120 to 200 milliseconds. QRS complex is the clearly part to see. The peak of Q wave and S wave are negative value but R wave is positive value. The normal duration of QRS complex is less than 120 milliseconds. T wave is the last wave. The amplitude of T wave is about 0.3 millivolts. QT Interval is change inversely with heart rate. The RR Interval is measured from R wave to the next R wave and converse to heart rate [3].



Parameter	Normal Range (ms)
PR Interval	120-200
QRS Complex	< 120
QT Interval	< 400
RR Interval	600-1500

Fig. 1. The normal characteristic of ECG. And the normal range of each duration.[3]

Cardiac arrhythmia is a term of cardiac rhythm with an abnormal sinus rhythm, a disturbance in activation of pacemaker cell, or electrical conduction, or both activation of pacemaker cell and electrical conduction. The rhythm can be regular or irregular such as heart rate can be fast, slow or normal [4]. Arrhythmia's patient sometime have symptom but they did not know what they are. Their quality of life were reduced and could be fatal if the patient have not treated appropriately [5]. Before the medical staff prepare treatment plan, knowing the type of cardiac arrhythmia is very important. Arrhythmia can be detected by cardiac specialist using ECG strip but ECG analysis is too hard for the beginner or inexperience staff. To support arrhythmia detection, the computer-based technique is necessary. The parameters for detection and classification of arrhythmia are both peaks and interval of ECG [6].

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II. Material and Method

A. Noise Removal

Most of ECG data have some noise and interference signal.[6] Separating the ECG signal from the mix signal is required. The signal processing as FIR bandpass filter, adaptive filter and linear interpolation were applied to pick up the desired signal [7, 8].

B. Detection parameter

Peak detection finding the location and duration of the peak signal

- Detection of R wave was the first step. The R wave peak was detect by finding the point greater than the point previous and next with the threshold greater than 0.4 millivolts for ensure that it is not P wave or T wave. The point on x-axis that is R wave peak location was stored in 'R variable' in MATLAB for calculating RR Interval with the next R wave peak [7, 9].
- The midpoint between two R wave was used to be the reference.
- The Q wave was define as a lowest point between the R wave and the reference point before that R wave.
- The S wave was define as a lowest point between the R wave and the reference point after that R wave.
- P wave was detect like detection of R wave. Finding the point greater than the point previous and next but that point have to between the reference point and Q wave.
- T wave is the highest point between the S wave and the next midpoint.

When all necessary parameter were detect the program compute the interval and collect all parameter for the classifying of arrhythmia.

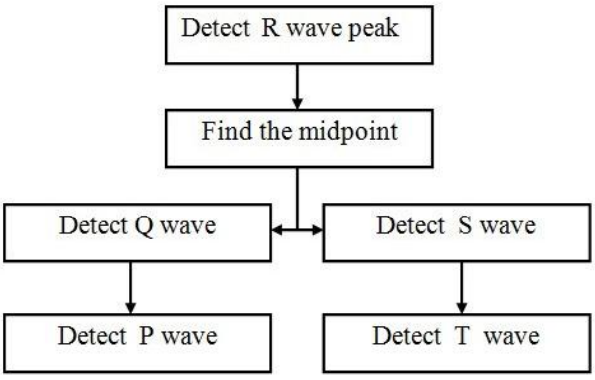

Fig. 2. Block Diagram of detection all peaks

C. Classifying of Arrhythmia

The five basic steps for classify arrhythmia were applied with MATLAB [3, 4].

- Rhythm: Regular rhythm or irregular rhythm was determine by the difference between maximum RR interval and minimum RR interval.
- Heart Rate: The normal range of heart rate is about 60 - 100 beats per minute. If the heart rate is less than 60 minute, it is called bradycardia. If the heart rate is more than 100 beats per minute, it is tachycardia.
- P wave: Considered of the amount of P wave per a QRS complex.
- PR Interval: Considered whether PR Interval is in normal range.
- QRS complex: The characteristic and duration of QRS complex is considered. It is in normal range or too broad.

Arrhythmia	Rhythm	HR (bpm)	P	PR (ms)	QRS (ms)
Normal Sinus Rhythm	Regular	60-100	1	120-200	<120
Sinus Bradycardia	Regular	<60	1	120-200	<120
Sinus Tachycardia	Regular	>100	1	120-200	<120
Sinus Arrhythmia	Irregular	60-100	1	120-200	<120
Atrial Flutter	Regular	any	>1	no	<120
Atrial Fibrillation	Irregular	any	>1	no	<120
Ventricular Tachycardia	Regular	>100	no	no	>120
Ventricular Fibrillation	Irregular	>250	no	no	>120
1st Degree AV Block	Regular	any	1	>200	<120

Fig. 3. Type of Arrhythmia with five basic steps for classification of arrhythmia.

D. Graphical User Interface

The Graphical User Interface was applied to make the ECG analysis program. The program was created under the user friendly concept.

- The axes icon was use to show the graph of ECG.
- The edit text boxes were use show all of parameters and type of arrhythmia.
- The three push buttons were applied in difference function. First is loading data and store in array with the first column is x variable. The x variable is represent the duration. The second column of array is y variable representing the voltage. The analyze button use to do all process both detection parameter and classification of arrhythmia. By the detection algorithm of finding peaks and five steps for classification of arrhythmia. The clear button is function like a reset button to clear all data that store in variable before [10].

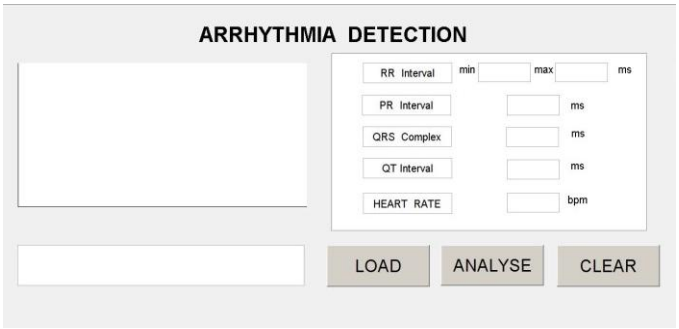

Fig. 4. ECG analysis program user interface.

E. Testing the program

The raw data that known the type of arrhythmia was used for test the efficient of ECG analysis program. The data obtain from standard MIT/BIH Arrhythmia Database. Testing was used the program like a real user and checked the result of both detection and classifying with the database [11].

III. RESULT AND DISCUSSION

The program shows detection of all peak in ECG graph. It shows necessary parameter on the right side of the screen. The RR Intervals show both of maximum value and minimum value for determine rhythm. The other parameters are show in average. The result of data analysis shows type of arrhythmia or normal sinus rhythm. The clear bottom is use to reset all data to the beginning for new analysis. As a training system the parameter in the right is useful for analysis the type of arrhythmia.

The program will show the graph with peak detection. Figure 5. The difference colors of each circle are at the difference peaks. It is easy for user to observe the graph with five basics step and use the information in the right for training and develop the visual analysis skill. As pre-screen test the staff can record all parameter and the diagnostic type of arrhythmia.

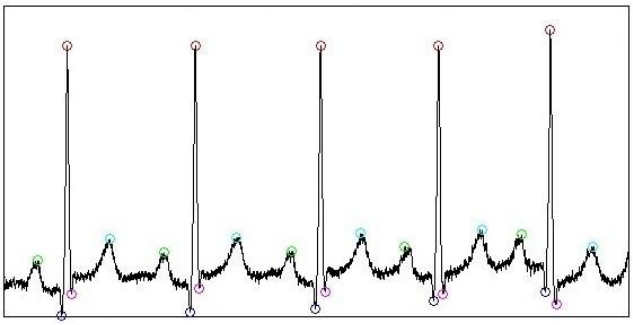

Fig. 5. ECG graph on the ECG analysis program. The green circles are represent P wave. The blue circles are represent Q wave. The red circles are represent R wave as the highest points. The purple circles are represent S wave. And the sky circles are represent T wave.

For the example in Figure 6. the program show the parameter value that all of them were in normal range but the program diagnose the Sinus arrhythmia. The sinus arrhythmia is normal heart rate, one P wave per a QRS complex, PR interval and QRS complex is in normal range as parameter on the right of the screen. However, the sinus arrhythmia is irregular rhythm. The difference between maximum RR interval and minimum RR interval is 127 milliseconds but the difference of regular rhythm have to less than 120 milliseconds.

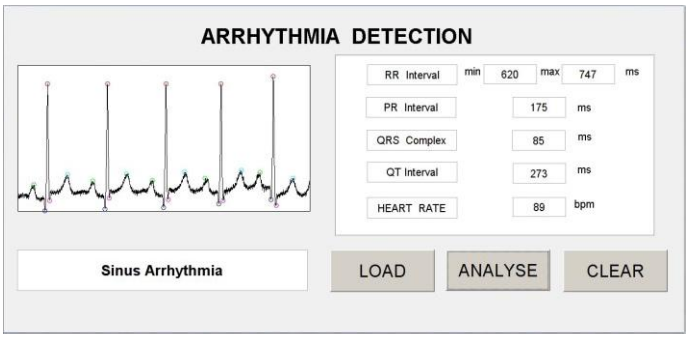

Fig. 6. Diagnose as Sinus Arrhythmia

Analysis as First degree AV block is shown in Figure 7. The PR interval is 206 milliseconds. It is more than the normal range. Other parameter is in normal range. Considered the graph in the left, The prolong PR interval can be notice before the first and the second R wave. Although the other PR interval is shorter, the PR interval value shown in the left is out of normal range. It is averaged.

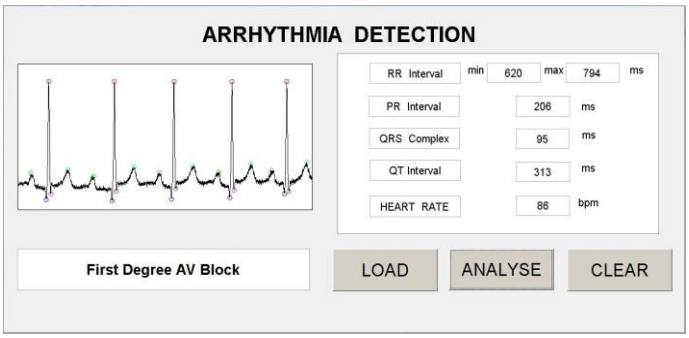

Fig. 7. Diagnose as First Degree AV Block. The PR interval calculated by the program is 206 millisecond. It is more than normal range.

Heart rate can be measured in high accuracy. All of R wave can be detected with the sensitivity of 0.4 millivolts. However the ECG analysis program is the most effective only when classify arrhythmia with P wave. Because this detection algorithm is use R wave peak to be main. All of another peak detect around the main peak. If sometimes have no R wave such as the second degree AV block (Mobitz type I) or complete heart block, this program will not possible to detect. This program can analyze with ECG lead II because the characteristic template such as P wave, R wave and T wave are upward while the Q and S wave is deflection like ECG lead II pattern.

IV. Conclusion

All of process for the ECG analysis program as signal processing, peak detection and creation of Graphical User Interface was applied by using MATLAB. This program provides much information about the ECG parameter and cardiac arrhythmias. Compare this program with visual analysis by inexperience staff, this program has been as an alternative diagnostic tool to assist and training medical staff in cardiac disease analyzing. However in generally, the result of this program never has 100 percent accuracy in classifying arrhythmia. But the parameter values can computation in high accuracy and can analyze most of arrhythmia. The future work will process the statistical analysis of accuracy of arrhythmia classification.

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