Conference Paper

Premature Ventricular Contraction (PVC) Detection Using R Signals

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Abstract

Arrhythmia is an abnormal heart rhythm caused by any changes in the normal sequence of electrical impulses. Changing of electrical impulse sequence can occur too fast or too slow. When the heart does not beat properly, it cannot pump blood effectively. Arrhythmia can further cause more complicated disease, such as sudden cardiac arrest and stroke. Premature Ventricular Contraction (PVC) is one type of arrhythmia. It occurs when extra heartbeat comes sooner than normal followed by a pause that causes the next beat to be more forceful. In this research, PVC's characteristics are used as a feature for detecting PVC. Arrhythmia data from the MIT-BIH database consisting of 105 records are used as data test. The data are separated into 30 pieces every 1 min. Every one-minute data is processed by the proposed method. The proposed method consists of PVC detection to identify peak or R signals. This method detects every peak of data record 105 to find time difference. The system was evaluated using three assessments; there are accuracy, sensitivity, and specificity. Results show that PVC can be successfully detected by the proposed method with an accuracy of 99.51 %, sensitivity of 87.5 % and specificity of 99.60 %. The proposed method can correctly identify those who have PVCs from all data as high as to correctly identify those who do not suffer from PVCs.

Keywords: Arrhythmia, ECG, Heart, Peak detection, Premature Ventricular Contraction.

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1. Introduction

Arrhythmia is one of the heart disorders that is indicated by abnormal heartbeat, so that changes the normal sequence of electrical impulses. Electrical Impulses sequence changes if it occurs too fast, too slow, or erratic [1–5]. When the heartbeat is not ticking properly, the heart cannot pump the blood to all organs of the body effectively. Thus, it can impact on the performance of the body's organs and cannot work properly.

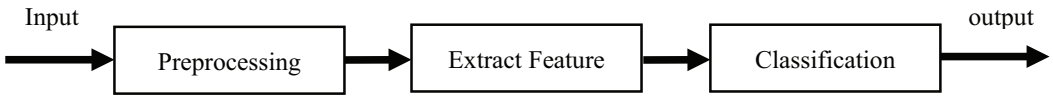

Figure 1: Research flow.

Detection of arrhythmia is very important. Arrhythmia can be used for heart disease detection especially heart attack and stroke. Several previous studies have been conducted to detect arrhythmia with various methods. Mane et al. used electrocardiograph (ECG) record to find Premature Ventricular Contraction (PVC), Right Bundle Branch Block (RBBB) and Left Bundle Branch Block (LBBB) [6]. PVC, RBBB, and LBBB have their characteristic. Mane et al. are utilizing three characteristics to obtain symptoms of arrhythmia. The symptoms of arrhythmia can be detected through R signal on ECG waveform. R signals detection algorithm can be combined with Teager Energy Operator (TEO). TEO is used to trace fast changing in ECG waveform [7, 8]. Another method that is used for arrhythmia detection is utilizing features of morphology and signal dynamic of ECG. The features are obtained from signal processing using Wavelet Transform (WT) [5, 9] method and Independent Component Analysis (ICA) [4]. Those methods are used to separate heartbeat to be changed coefficient value that is compatible with heartbeat. Coefficient value is called a morphological feature, and the dynamic feature can be found by R-R interval information [4].

The proposed research is arrhythmia detection using PVC characteristic through peak detection and R-R interval. Peak detection is used for determining the highest point on ECG signals then the highest point is used for determining R-R interval. The R-R interval is a time difference between peak to peak from the ECG signal and uses it for PVC detection.

2. Materials and Methods

The study of PVC detection is conducted using data that are taken from MIT-BIH database number 105 [10]. The data record is taken with a duration of 30 min to 60 min. The data record is separated into 30 data which have a duration of 1 min per data. The first minute of the data are used as training and rest of the data are used as testing. The data that are obtained will be analyzed to detect PVC using MATLAB software.

The data are taken from the MIT-BIH database, and research flow is shown in Figure 1. The initial stage of research shown in Figure 1, ECG record from MIT-BIH is used as input for preprocessing. This stage separates ECG record dataset to 30 parts where each

part has 1 min duration. The first minute is used as training data and the next minutes to 30 min of data are used as testing data. The training data is data that is used to create a model for detecting PVC, and the testing data have to function for performance assessment of the system in detecting PVC.

Preprocessing is a stage to prepare the data that will be used for feature extraction and classification process. After the data have been prepared, the next step was feature extraction. Feature extraction was used for showing arrhythmia, especially PVC. QRS morphology analysis which R signal is peak point of heart signal [3] as shown in Figure 2 is used for the feature.

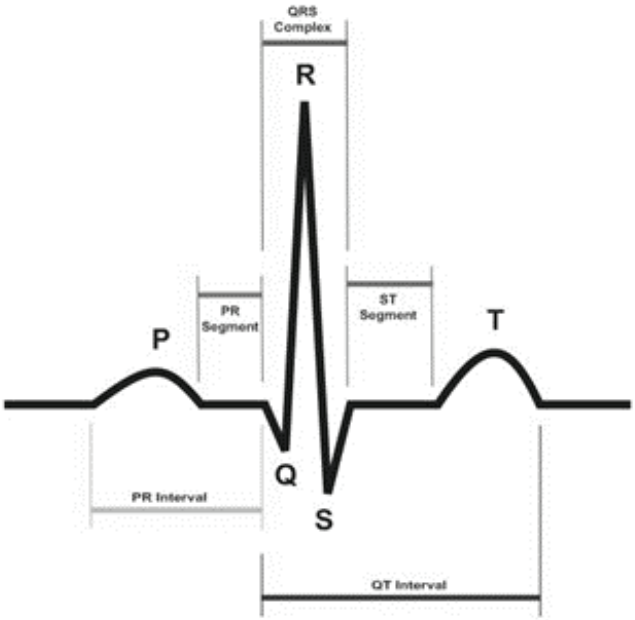

Figure 2: ECG Signal.

The R signal detection is done by tracking all data record of ECG signal based on the threshold value. If a data record has amplitude bigger than the threshold value, then the amplitude will be marked as R signal of the ECG signal.

PVC has characteristic that is ticking faster than normal heartbeat. Thus, it will occur a long time interlude on the next heartbeat. After R signals found and characteristic PVC knew, classification is done on the ECG signals for showing PVC points

PVC can be known by R-R interval. R-R interval is a time difference between R signals as shown in Figure 3.

Time of R signal can be known when R signal is marked. So, the time difference can be determined by subtracting between the current and earlier R signal's time. If time difference has a lower value than the threshold, hence those will be detected as PVC, and the output of this research is performance assessment of the system.

TABLE 1: Performance system to detect PVC.

No	Minute (s)			PVC (Ground Truth)	PVC (System)	Percentage (%)
1	0	-	1	4	4	100
2	1	-	2	2	1	50
3	2	-	3	2	1	50
4	3	-	4	3	3	100
5	4	-	5	1	1	100
6	5	-	6	3	2	67
7	6	-	7	1	1	100
8	7	-	8	3	2	67
9	8	-	9	1	0	0
10	9	-	10	1	0	0
11	10	-	11	1	0	0
12	11	-	12	3	3	100
13	12	-	13	1	1	100
14	13	-	14	1	0	0
15	14	-	15	1	3	33
16	15	-	16	0	0	100
17	16	-	17	0	0	100
18	17	-	18	1	1	100
19	18	-	19	0	0	100
20	19	-	20	1	1	100
21	20	-	21	1	4	25
22	21	-	22	2	3	67
23	22	-	23	2	2	100
24	23	-	24	0	1	50
25	24	-	25	1	1	100
26	25	-	26	0	0	100
27	26	-	27	2	1	50
28	27	-	28	0	1	50
29	28	-	29	3	2	67
30	29	-	30	0	0	100
Average						95

3. Results

Table 1 shows a comparison result between ground truth with system performance. The result shows that the performance system is good for detecting PVC with 95 % to detect

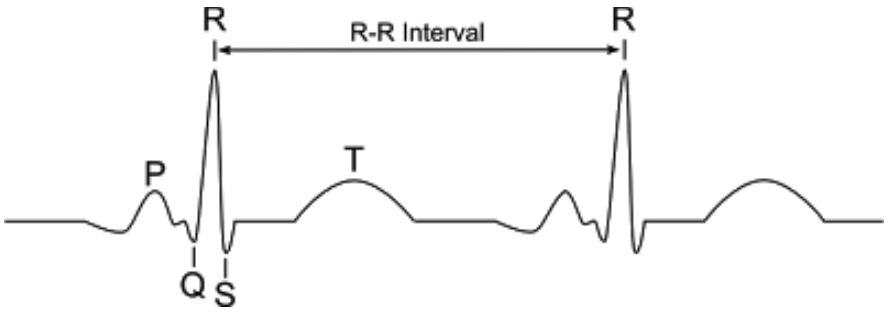

Figure 3: R-R interval [3].

PVC. The performance of the system is also evaluated for accuracy, sensitivity, and specificity that the equation following on Eq. 1, Eq. 2, and Eq. 3.

$$accuracy = \frac{TP + TN}{TP + TN + FP + FN} \tag{1}$$

$$sensitivity = \frac{TP}{TP + FN} \tag{2}$$

$$specificity = \frac{TN}{TN + FP} \tag{3}$$

Where TP (True Positive) shows, the system can detect PVC. TN (True Negative) shows the system can detect non-PVC. FP (False Positive) detects non-PVC, but that is PVC, and FN (False Negative) detects PVC, but actually, that is not PVC.

Accuracy is used for detecting all symptoms in the MIT-BIH database. Measuring of accuracy in detecting PVC is calculated using sensitivity while specificity is used for assessment of performance in rejecting normal beats as non-PVC.

TABLE 2: Performance assessment.

Accuracy	Sensitivity	Specificity
99.51 %	87.50 %	99.60 %

Table 2 shows that the system has an excellent performance for accuracy and specificity, but still lacks performance for sensitivity. It is caused by performance system has FN value is higher than TP value.

4. Discussion

In previous work, several methods have been proposed to detect PVC. R-R interval and R-signals analysis is a general method that uses for detecting PVC. Mane et al. use those methods for detecting PVC. The premature occurrence is PVC's main characteristic. So, R-R interval can be used as feature and parameter that is used to measure the PVC [6].

R-R interval and energy analysis of the ECG signal to detect PVC are proposed by Mane et al. the performance system evaluated using specificity and sensitivity. The final result is obtained specificity of 92.59 % and sensitivity of 96.15 %. If those results are compared with a proposed method that is used in this work, the proposed method has a weakness on the system to measures the accuracy in detecting PVC. However, the proposed method offers an excellent to rejecting normal beats as non-PVC beats. In addition, the proposed method offers a simple algorithm that is used for detecting PVC.

5. Conclusions

The authors conclude that the proposed method can detect PVC with good performance and offers a simple algorithm, however, the algorithm of the system still have a lack of sensitivity. Thereby, the system needs to be improved in the future.

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