



# Identification of QRS Complexes in ECG Signal Using Hierarchical Clustering Algorithm

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**ABSTRACT:** This paper implements a fast potential based Hierarchical clustering algorithm for the detection of QRS complexes in ECG signal. QRS Complex is the most striking waveform within electrocardiogram (ECG), which provide much information about the current state of the heart function. This paper proposes a novel QRS complex and non QRS Complexes detection using Hierarchical algorithm. The performance of the algorithm is validated using MIT-BIH Database. The efficiency of QRS detection is evaluated based on two parameters namely sensitivity, detection rate and specificity.

**KEYWORDS:** ECG, MIT-BIH database, Hierarchical algorithm, QRS detection, Butterworth;

## I. INTRODUCTION

The Electrocardiogram signal is generated by polarization and depolarization of the heart that occurs when pumping blood throughout the human body, and it can be recorded by contacting electrodes to the skin at specific locations on the body. It provides the valuable information regarding the cardiovascular diseases. Any abnormality in rhythm can provide useful information about the type of disease. In ECG QRS complex is a dominant of electrocardiographic signal, Fig. 1. Its amplitude and time analysis, shape and appearance time of adjacent rhythms estimation can be used to diagnose a wide range of heart diseases. QRS complex is necessary for the determination of the heart rate, and as reference for beat alignment. Thus, the obvious problem is the precise definition of the occurrence time and other various parameters of QRS-complex.

Various methods for classification of arrhythmias have been developed by researchers and clustering technique is one of them. Although it is an unsupervised type of technique, it is advisable technique for analysis and interpretation of long term ECG Holter records. In this paper, Ascending Hierarchical clustering has been used for analysis. Different types of linkages have been used for analysis.

The MITBIH arrhythmia data base has been used and on the proposed approach data is classified into five arrhythmia beats type i.e. Normal(N), Premature ventricular contraction (PVC), Paced beats(P), Left Bundle Branch Block(LBBB) and Right Bundle Branch Block. The data is preclustered and then analysis is done using different linkages. It has been seen that 'ward' linkage has got maximum success rate for arrhythmia classification.

# International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 2, February 2016

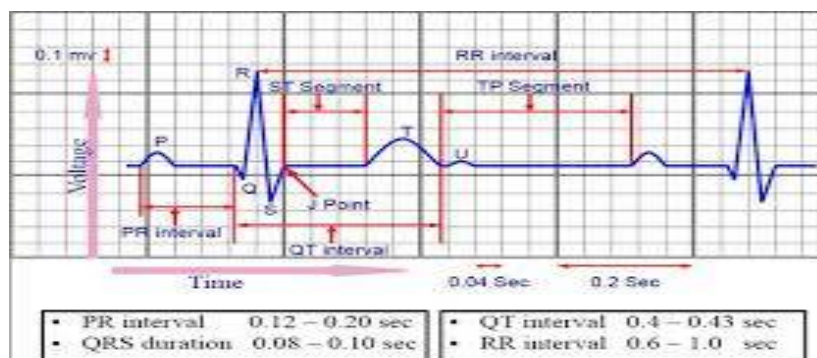


Figure 1: An ECG Signal with intervals

## II. PRE PROCESSING OF ECG SIGNAL

The major drawback of processing long-term Holter ECG signals is the presence of a high level of noise with multiple manifestations baseline wandering, power line interference or electro myographic activity, so an initial filtering stage needs to be performed. The efforts have been focused on filtering the baseline wandering, as this is the most relevant source affecting the reliability of the clustering algorithm because of the distortion it can cause on the QRS morphology. In this paper we are implementing the IIR Butterworth filter along with notch filter for pre processing.

## III. HIERARCHICAL ALGORITHM

In this paper, the Fast potential based Hierarchical Clustering algorithm [PHA] is implemented on ECG data set, which is an algorithm for an incremental clustering on streaming time sequence. It builds a hierarchical tree-shaped structure of clusters from the agglomerative hierarchical cluster tree,  $Z$ , as generated by the linkage function. Agglomerative in this top to bottom strategy follows. The leaves are the resulting clusters, with each leaf grouping a set of variables. The system contains an incremental distance measure and executes procedures for expansion and aggregation of the tree based structure. The system will consider the flow of continuous time series data by monitoring. Then time interval will be fixed. Within the specific time interval the data points will be partitioned into groups. In a partition the distance matrix is calculated is nothing but the between two objects. Each and every data point of the partition will be compare with the dMatrix value. If the data point is greater than the diameter value then the split process will be executing otherwise the Aggregate (Merge) process will be performed. Based on the above criteria the hierarchical tree will be growing. Here we have to observe the splitting process, because the splitting will decide the growth of clusters.

## IV. IMPLEMENTATION OF HIERARCHICAL ALGORITHM

Step 1: Load the MIT-BIH ECG Database

Step 2: Applied the IIR Butterworth filter along with notch filter on ECG Database

Step 3: The absolute slope i.e. absolute value of the difference between two consecutive samples is calculated to enhance the signal in the region of QRS-complex. The absolute value of slope of the ECG signal is used as an important discriminating feature because absolute slope of the signal is much more in the QRS-region than in the rest of the region. Fig.2 shows the absolute slope of the filtered ECG signal. To enhance this absolute slope this paper uses moving average criteria. Due to this it is observed that the smoother version of QRS complex is obtained, which is shown in Fig. These absolute slope values are then normalized to reduce the burden of the classifier to form the complicated decision boundary

Step 4: The various steps of Hierarchal algorithm as described in section 3 are followed in order to find the two cluster centers namely the QRS-cluster center and the non QRS-cluster center.

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Step 5: After finding two cluster centers using Hierarchical algorithm, the slope curve shown in Fig. 2(c) is scanned. The membership of slope, at a given sampling instant, is found. An output is 1 if a sample belongs to a QRS-cluster and output is 0 if it belongs to a non-QRS-cluster. Thus, a continuous train of 1's is obtained in the QRS-region and 0's is obtained in the non-QRS region.

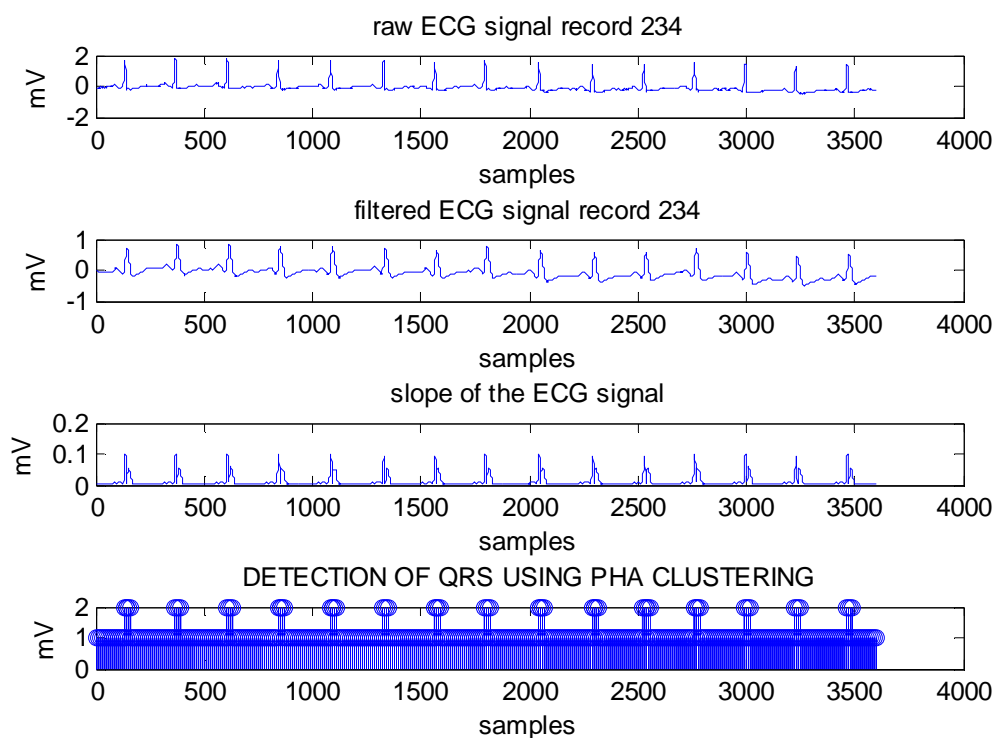


Figure 2: An Implementation of Hierarchical Clustering (a) Raw ECG Signal, (b) Filtered ECG Signal, (c) Slope of the ECG Signal, (d) Hierarchical Clustered Signal

## V. SIMULATION RESULTS

Hierarchical algorithms not only detect the QRS complexes of ECG, but also delineate them accurately. Detection is said to be true positive (TP) if the algorithm correctly discerns the QRS-complex and it is said to be false negative (FN) if the algorithm fails to detect the QRS complex. False positive (FP) detections are obtained if non-QRS-wave is detected as a QRS-complex. The ECG signals used for analysis and detection in this work are a part of MIT-BIH Arrhythmia Database given on the website of MIT-BIH.

The said algorithm is applied on total of 48 records from database. It is observed that, in the case of normal beats (i. e. for record number 100, 101, 102, 104, 105, 106, 107, 112, 113, 115, 117, 119, 121, 122, 123, 201, 202, 209, 212, 213, 215, 217, 219, 220, 221, 222, 223, 228, 230, 231, 232, 234) and right bundle branch block (i.e. for record numbers 118, 124), the results are encouraging and almost all the beats were detected successfully. Similarly, in the case of left bundle branch block also (i.e. for record numbers 111, 207, 214), the total number of complexes detected are accurate and percentage range of  $Se$  and  $P+$  is satisfactory.

As the algorithm has been implemented in MATLAB working environment, therefore the part of the whole signal of each data set has been operated. In order to evaluate the accuracy of detection of QRS complex, three essential parameters: sensitivity  $Se$  and the positive predictivity  $P+$  (detection rate), specificity are used as listed in Table 1. These parameters describe the overall performance of the detector and their values are calculated as follows

$$\text{Sensitivity} = TP / (TP + FN)$$

$$\text{Predictivity} = TP / (TP + FP)$$



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$$\text{Specificity} = \frac{TN}{(TN+FP)}$$

Using the above formula, Table.1 clearly shows the result as the average detection rate is 98.39% along with 100% sensitivity and specificity is obtained for all 48 MIT-BIH Records. Also the percentage of false positive detection and false negative detection for all records are very less.

S NO	RECORD NO	TOTAL BEATS	TRUE +VE	TRUE -VE	FALSE +VE	FALSE -VE	SENSITIVITY	PREDICTIVITY	SPECIFICITY
1	100	13	13	0	0	0	100	100%	100%
2	101	11	11	0	0	0	100	100%	100%
3	102	12	12	0	0	0	100	100%	100%
4	103	11	11	0	0	0	100	100%	100%
5	104	13	13	0	0	0	100	100%	100%
6	105	14	14	0	0	0	100	100%	100%
7	106	10	10	0	0	0	100	100%	100%
8	107	11	11	0	0	0	100	100%	100%
9	108	11	11	0	0	0	100	100%	100%
10	109	16	16	0	0	0	100	100%	100%
11	111	12	12	0	0	0	100	100%	100%
12	112	15	15	0	0	0	100	100%	100%
13	113	9	9	0	9	0	100	50%	100%
14	114	9	9	0	0	0	100	100%	100%
15	115	10	10	0	0	0	100	100%	100%
16	116	14	12	0	2	0	100	85%	100%
17	117	9	9	0	0	0	100	100%	100%
18	118	12	12	0	0	0	100	100%	100%
19	119	10	10	0	0	0	100	100%	100%
20	121	11	11	0	0	0	100	100%	100%
21	122	15	15	1	0	0	100	100%	100%
22	123	8	8	0	0	0	100	100%	100%
23	124	8	8	0	1	0	100	88%	100%
24	200	16	7	9	0	0	100	100%	100%
25	201	14	14	0	0	0	100	100%	100%
26	202	9	9	0	0	0	100	100%	100%
27	203	20	13	7	0	0	100	100%	100%
28	205	15	15	0	0	0	100	100%	100%
29	207	10	10	0	0	0	100	100%	100%
30	208	16	16	0	0	0	100	100%	100%
31	209	15	15	0	0	0	100	100%	100%
32	210	16	16	0	0	0	100	100%	100%
33	212	15	15	0	0	0	100	100%	100%
34	213	18	18	0	0	0	100	100%	100%



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35	214	12	12	0	0	0	100	100%	100%
36	215	18	18	0	0	0	100	100%	100%
37	217	12	11	1	0	0	100	100%	100%
38	219	13	13	0	0	0	100	100%	100%
39	220	12	12	0	0	0	100	100%	100%
40	221	13	13	0	0	0	100	100%	100%
41	222	13	13	0	0	0	100	100%	100%
42	223	14	14	0	0	0	100	100%	100%
43	228	12	12	0	0	0	100	100%	100%
44	230	14	14	0	0	0	100	100%	100%
45	231	10	10	0	0	0	100	100%	100%
46	232	8	8	0	0	0	100	100%	100%
47	233	17	17	0	0	0	100	100%	100%
48	234	15	15	0	0	0	100	100%	100%
	<b>TOTAL</b>	<b>611</b>	<b>592</b>	<b>18</b>	<b>12</b>	<b>0</b>	<b>100</b>	<b>98.39%</b>	<b>100%</b>

Table 1: Different MIT-BIH Records Sensitivity, Predictivity, Specificity

## VI. CONCLUSION AND FUTURE WORK

The simulation results showed that the proposed algorithm performs better with the ECG data. This paper represents a method implemented for the Identification of QRS complex in ECG signal using PHA Hierarchical algorithm. The method has been comprehensively tested using the MIT-BIH ECG database covering wide variety of QRS complexes. A considerable detection rate 98.39% is obtained. It is observed that the information obtained through this algorithm is very useful for ECG classification and diagnosis. It is also possible to extend this method for automatic ECG signal analysis and diagnosis.

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