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SURVEY ON VARIOUS ECG SEGMENTATION TECHNIQUES

Dhruv Patel, Prof.Mayur Sevak, Parikshit Mishra, Vatsal Shah
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Birla Vishvakarma Mahavidyalaya
dhurvpatel2308@gmail.com

Abstract

Heart is the most important organ of the human body. The heart pumps the blood throughout the body so it is necessary to track heart activity. An electrocardiograph is a technique to measure heart activity. In thistechnique,the electrode is attached on the surface of the body, and by recording those signals doctor diagnosis that symptoms of the person are normal or abnormal. ECG segmentation is one of the most important methods for the analysis of processing of ECG signals that comprises compression tasks, filtration, heart rate variability studies (HRV), and beats classification or grouping. In this study, we have surveyed various ECG segmentation techniques perform by various eminent authors working in this field. The purpose of this article is to provide an insight view of the algorithms and techniques utilized by these authors which can be helpful for the neophytes in this field.

Keywords: ECG, Waves of ECG, ECG Segmentation.

I. Introduction

SCA (Sudden Cardiac Attack) is the emerging disease in the twenty-first century irrespective of a person's age. Heart failure is one of the essential reasons that cause many people to lead to death.ECG is a technique used to measure the electrical activity of the human heart that offers cardiologists information about the functioning of the human heart. It is useful in determining and diagnosing heart rate, heart rhythm, abnormal electrical conduction, poor blood flow to the heart muscle, heart attack, coronary artery disease, hypertrophy of heart chambers. Figure 1 shows the ECG wave.[5]

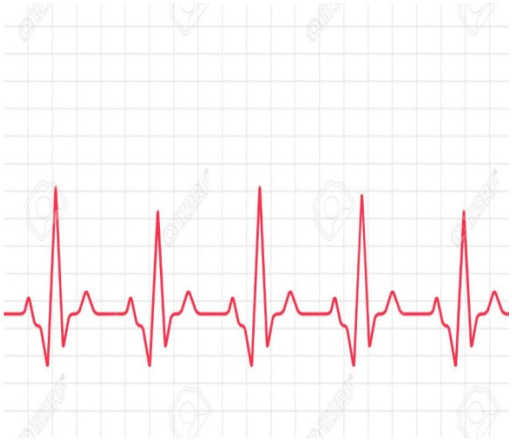

Figure 1: *ECG Wave.*

The whole ECG signal is decomposed in P-wave, QRS complex and T-wave. P-wave is a positive and first wave in ECG also known as atrial complex. It is produced due to the depolarization of atrial musculature. Q wave is a small negative wave that is continued as a tall R wave which is a positive wave followed by a small negative wave S wave. The QRS complex is also called the initial ventricular complex. It is due to the depolarization of ventricular musculature. Q wave is due to the depolarization of the basal portion of the interventricular septum. R wave is due to depolarization of the apical portion of ventricular septum and muscle. S wave is due to depolarization of the basal portion of the ventricular muscle near the atrioventricular ring. T wave is the final ventricular complex and is a positive wave. It is due to the repolarization of ventricular musculature. Figure 2 shows the waves that constitute the ECG.[6]

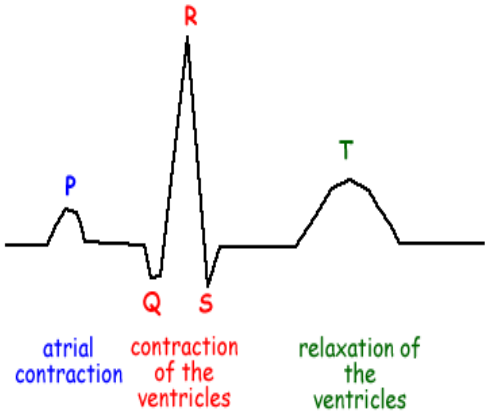

Figure 2: *Waves of ECG*

Analysis and processing of the ECG signal help to find the length of ECG segments (PR interval, ST interval, QT interval) and BPM of the signal to detect different types of heart activity or diseases. The length and BPM of the signal are used to indicate normal and abnormal behavior. The presence of noise may cause a change in amplitude and frequency of the signal that may cause an interruption in detecting the actual abnormality and may lead to error. A Digital filter can be used for the filtering of the ECG signal. The eminent analysis technique to determine the characteristic of ECG is by doing Segmentation of this wave. The main purpose of this analysis is to locate P wave, Q wave, R wave, S wave, T wave indices and to determine ECG segment length. A short detailed analysis of ECG can be achieved by using these techniques. In the Segmentation process, the whole signal is divided into characteristics like amplitude and frequency. Since ECG is a non-stationary signal, it is essential to preprocess the ECG signal before segmentation. For segmentation of ECG various algorithms like Wavelet Transform, Pan-Tompkins algorithm,METEORalgorithmetc. are available. From the ECG segmentation, we can calculate the waveindicesand length of,Q, R,S, Twaves and from that one can predict normality and abnormality in the ECG signal. If the abnormality is detected it can be classified atrioventricular Block, Hypokalemia, Hyperkalemia, Hypercalcemia, Hypocalcemia, Ventricular Tachycardia, Junctional Tachycardia, Atrial Tachycardia. ECG segmentation on MATLAB is shown in figure 3 which shows the P, Q, R, S, T wave indices using METEOR Algorithm.

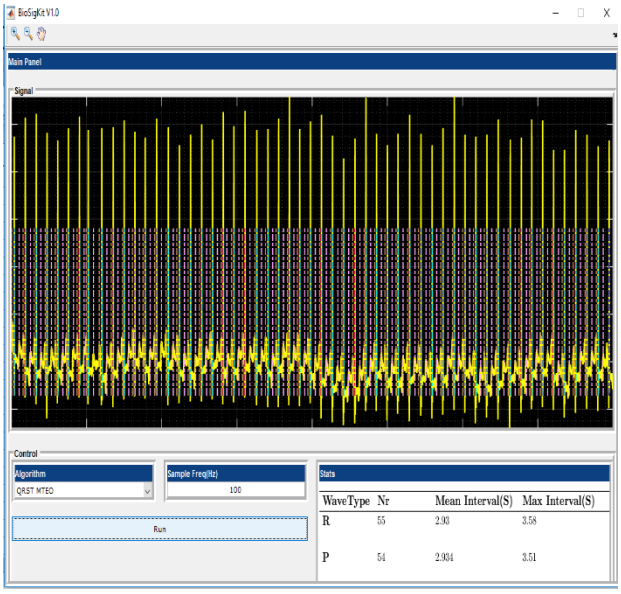

Figure 3: *ECG Segmentation*

II. Various segmentation process-A Survey

In Classification of Arrhythmia from ECG signal using MATLAB, The author Priyanka Mayapur et al [1]. has described the various arrhythmia associated with ECG and classify it based on length of the segments of the ECG as well as to detect the P, Q, R, S, T wave in ECG. The author has taken MIT-BIH, ECG recording then the software will remove the noise with Digital filters like IIR and FIR filters and detect the P,Q,R,S,T waves and states whether the ECG is normal or abnormal. Figure 5 shows the working of the system that is described in this research article. AHA and ESC database for analysis. The author has used inbuilt algorithms of MATLAB. Then the author has done plotting of ECG signal using the formula:

$$Yi = \frac{\text{yi}-\text{base}}{\text{gain}} \quad (1)$$

where Yi is the ECG sample. Then the author has evaluated Morphological and Dynamic features. The Dynamic feature includes extracting R-R interval, HRV, and R to P ratio. The equation of HRV analysis is given by:

$$\text{HRV} = \text{HRVmax} - \text{HRVmin} * 100 \quad (2)$$

The rate is given by

$$\text{rate} = \frac{60}{\text{R}-\text{R interval}} \quad (3)$$

R to P ratio is given by:

$$\frac{\text{Rpeak(amplitude)}}{\text{Peak(amplitude)}} \quad (4)$$

Morphological features include detection of P, Q, R, S, T wave indices, and QRS complex. The QRS complex is detected using the Pan Tompkins algorithm. Using the Moving Window Integration technique along with threshold detection method, P and T wave is detected.Figure 4 shows the flowchart of this article.

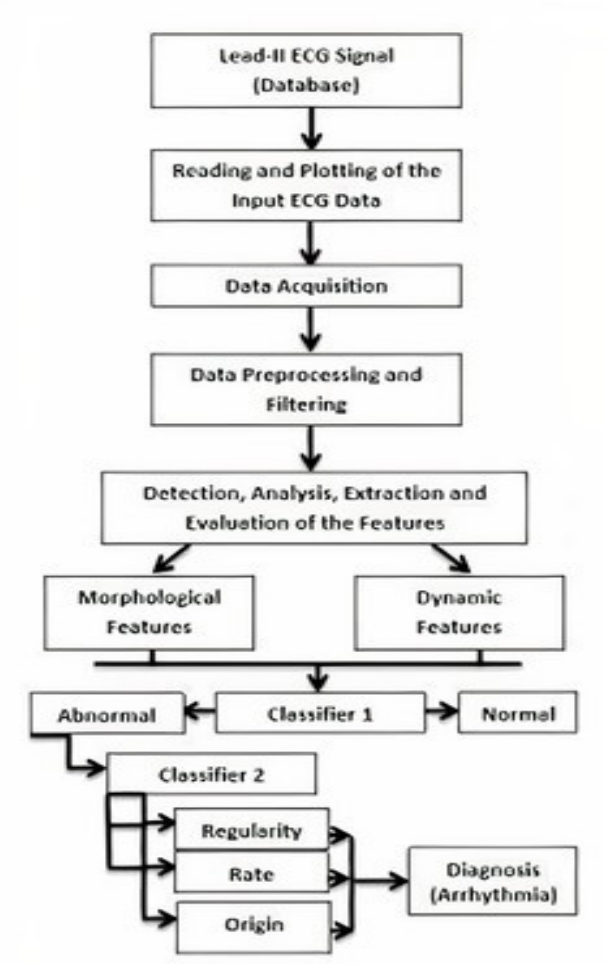

Figure 4: *Flowchart of the first article*.

Abnormalities State Detection from P-Wave, QRS Complex, and T-Wave in Noisy ECG, The authorsChandra Wijaya, Andrian, MawaddahHarahap, Christnatalis, Mardi Turnip, ArjonTurnip. [2] have utilized Bitalino and connect the ECG sensor with it after ECG recording Bitalino transfers the ECG recording through the cloud to the software. If the noise is present in the ECG recording then the software will remove the noise. In the softwareDigital filters like FIR and Butterworth filters are used to remove the noise.Lowpass, Highpass, and Bandpass filter have been realized which has cut off frequency 3Hz, 25Hz, 0.5-40Hz, and sampling frequency 1KHz each respectively. After filtering segmentation is done which computes the QRS complex and R-R interval. Finally feature extraction is done which detects P, Q, R, S, T wave indices.An experiment has been observed for 3 different activities performed by the people when sitting, walking, and jogging. The authors have taken ECG samples of 8 subjects and based on the experiments performed they finally compute the R peaks and BPM of the signals. Based onthe result obtained they classified it into normal and abnormal ECG. Figure 5 shows the working of the system that is described in this research article.[3]

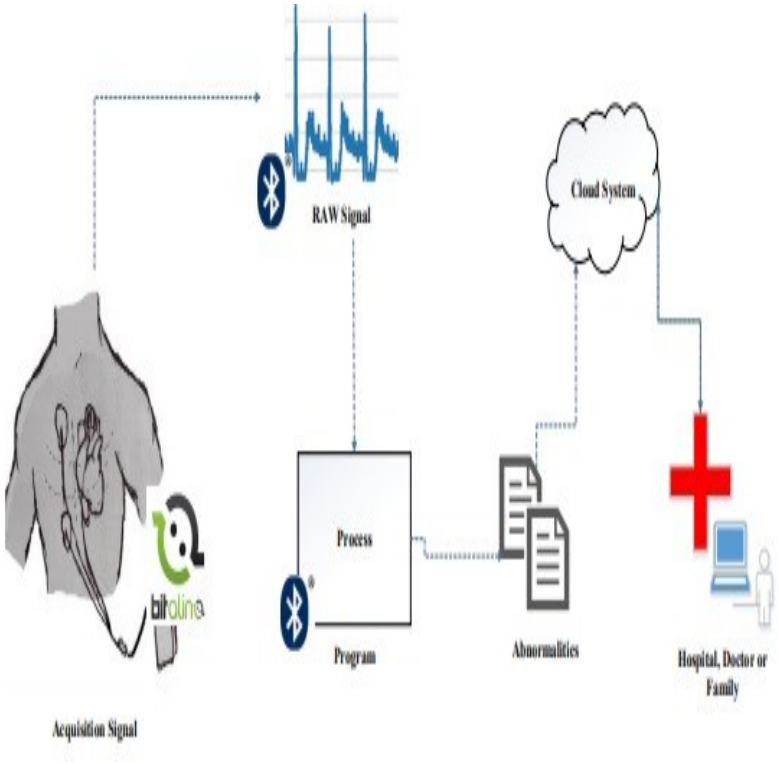

Figure 5: *Working on the system mentioned in the second article*

In Optimizing the Detection of Characteristic Waves in ECG Based on Processing Methods Combinations. The author Kresimir Friganovic, DavorKukolja, Alan Jovic, Mario Cifrek, and Goran Krstacic [7]. has described the various algorithm like Pan Tompkins, Elgendi's algorithm based on two movingaverage filters, Sun Yan's algorithms based on Mathematical Morphology operations, Martinez's algorithms based on Wavelet Transform, Martinez's algorithm based on Phasor Transform withmodifications on MIT-BIH arrhythmia, Q-T database and detect the P,Q,R,S,T waves and compare the computation complexity as well as accuracy.Then after they have computed which algorithm is faster to compute ECG. They concluded that Martinez's PT is more time demanding then Elgendi's method and Elgendi's method is more suitable for R peak detection. The MMF preprocessing and Martinez's algorithm is used for Real-time ECG processing when accurate detection of the peak is sought. The figure 6 shows the flowchart of this article.[7]

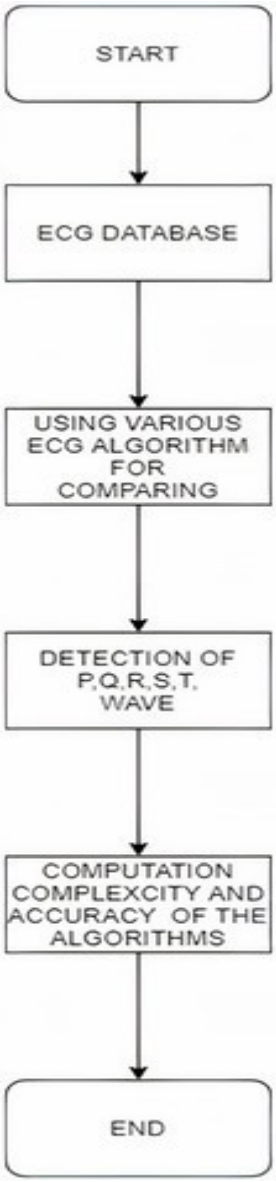

Figure 6: *Flowchart of the third research article*

In Analysis of ECG Signal and Classification of Heart Abnormalities Using Artificial Neural Network. The authors TanoyDebnath and Md. MehediHasan.[4] describes the Preprocessing of the ECG signal and then feature extraction is done using the Pan Tompkins algorithm and Artificial Neural Network. Pan Tompkins algorithm is used for the detection of QRS complex and Artificial Neural Network used to detect P and T wave. Equation associated with the Pan Tompkins algorithm is shown below.The author hastaken 38 samples of ECG of males and females. On testing, they calculate the R-R interval and Heart rate interval of these ECG samples and they have classified... If it is abnormal they have classified it as Bradycardia, Tachycardia, First degree Heart Block, Second degree Heart Block, and Complete Heart Block. The conditions for the heart abnormalities are given below in table 1.

Table 1: *Conditions for heart abnormalities*

Sr No:	Heart Abnormality	Conditions
1	Tachycardia	Heart Rate>100BPM
2	Bradycardia	Heart Rate<60BPM
3	Second Degree AV Block	QRS dropped
4	First Degree AV Block	Long PR interval
5	Complete Heart Block	Complete drop out of the cardiac cycle

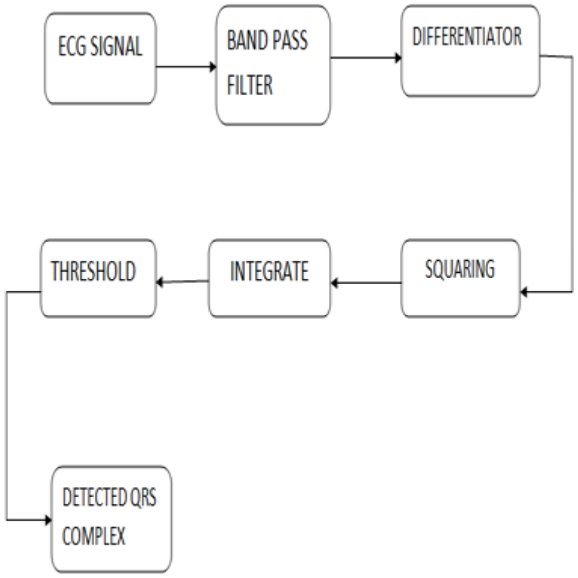

Figure 7: *Flowchart of fourth research article*

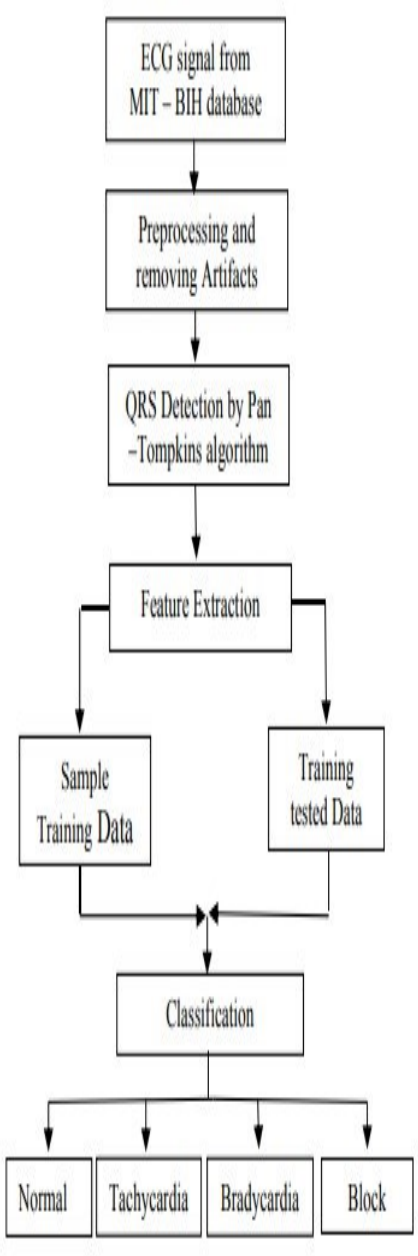

Figure 8: *Description of the fourth research article*

III. Conclusion

This paper concludes the work done to segment the ECG and prediction of abnormality by various authors. The author has applied various algorithms for the prediction of the abnormality and feature extraction like Pan Tompkins, Legend's algorithm based on two moving average filters, Sun Yan's algorithms based on Mathematical Morphology operations, Martinez's algorithms based on wavelet transform, Martinez's algorithm based on Phasor Transform. So in future this paper provides a good survey of the ECG segmentation and abnormality algorithms for researchers and also one develop their good ECG project based on this algorithm and one should also come to know how to deal with the ECG database.

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