A Literature Survey in ECG Feature Extraction

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ABSTRACT

In this paper discusses the comparative study of Electro Cardiogram (ECG) feature extraction for the prediction of ventricular arrhythmia using a unique set of ECG features extraction and classifier algorithm. This ECG feature extraction is one of the important significant roles in diagnosing most of the cardiac diseases. In ECG, P-QRS-T waves provide the one cardiac cycle in heart beat activity. This ECG feature extraction measured the amplitudes and intervals in the ECG signal for subsequent analysis. The amplitudes and intervals value of P-QRS-T segment measuring the working of heart beat in every human. Recently, several research and techniques have been implemented for analyzing the ECG signal. All these techniques and algorithms have their merits and demerits. This paper discusses the various techniques and transformations proposed earlier in literature for extracting feature from an ECG signal.

KEYWORDS: Artificial Neural Networks, Cardiac Cycle, ECG signal, Feature Extraction, and Support Vector Machines.

INTRODUCTION

A Sudden Cardiac Death (SCD), which happens within one hour of onset of symptoms because of cardiac causes. The health data accumulated from more than 190 countries show heart disease remains the No. 1 global cause of death with 17.3 million deaths each year, according to “Heart Disease and Stroke Statistics from the American Heart Association (AHA). That number is expected to rise to more than 23.6 million by 2030, the report found. In every year no of deaths are increases and in most cases is the final result of ventricular tachycardia (VT) or ventricular fibrillation (VF).

An Arrhythmia is an abnormal rhythm of the heart function and it is caused by problems with our heart’s electrical system. The electrical impulses may occur too fast, too slow, or irregularly - causing the heart beat too fast, too slowly, or erratically. When the heart beat doesn’t happen properly, it can't pump the blood effectively. So blood pump doesn’t flow the lungs, brain and all other organs can't work properly and may shut down or be damaged and it causes the sudden death.

Ventricular arrhythmia is an abnormal ECG rhythm and is responsible for 75% to 85% of sudden deaths in persons with heart problems unless treated within seconds [1]. Ventricular Fibrillation (VF) is one type of rhythm characterized by the disordered activation of ventricles, and it causes abrupt stop of blood circulation and degenerates further into a pulseless or flat ECG signal indicating no cardiac electrical activity. There are two basic kinds of arrhythmias. Bradycardia is when the heart function rate is too slow - less than 60 beats per minute (bpm). Tachycardia is when the heart function rate is too fast - more than 100 (bpm).
The implantable cardioverter-defibrillator has been considered as the best protection against sudden death from ventricular arrhythmias in high-risk individuals. However, most sudden deaths occur in individuals who do not have high-risk profiles. Electrocardiogram (ECG) is a nearly periodic signal that reflects the activity of the heart. Long-standing ECG monitoring is the criterion standard for the diagnosis of ventricular arrhythmia. The 12-lead ECGs are obtained and analyzed to detect any changes in the characteristics of the ECG signal. By extracting information about intervals, amplitudes, and waveform morphologies of the different P-QRS-T waves, the onset of the ventricular arrhythmia can be detected. The sample one set of P-QRS-T waves is shown in Figure 1. Ventricular arrhythmias should be recognized and treated promptly in an effective manner the patients for avoiding mortality.

![ECG Signal](image)

**Fig. 1:** A Sample ECG Signal showing P-QRS-T Wave

This feature extraction schemes find the amplitudes and intervals in the P-QRS-T wave’s analysis for classifying the normal and abnormal of the heart beat activity. This amplitudes and intervals in the P-QRS-T waves concluded the performance of heart of every human.

This paper focused an over view on several techniques and transformations used for extracting the feature from ECG signals. In addition the future improvement gives a wide ranging inspiration for enhancement and development of the feature extraction techniques.

The remainder of this paper is structured as follows. In Section 2, discusses the related work that was earlier proposed in literature for ECG feature extraction. In Section 3, it gives the general idea of further improvements of the earlier approaches in ECG feature detection, and Section 4 concludes the paper with fewer discussions.

II. Literature Review:

In ECG, extracting the features of the P-QRS-T waves has been studied from early time and lots of sophisticated techniques as well as conversion have been presented for accurate analysis and ECG feature extraction. This section of the paper discusses various techniques and transformations proposed earlier in literature for extracting feature from ECG signals.

Nourhan Bayasi et al [1] presented the fully integrated digital ESP for the prediction of ventricular arrhythmia that combines a unique set of ECG features with naive bayes classifier algorithm. The P-QRS-T waves were investigated and employed to extract the fiducial points in real-time and adaptive techniques for the detection and delineation of furthermore, seven features that characterize the different intervals of the ECG signal were take out and used that data feed to the naive Bayes to classify the each heartbeat as normal or abnormal. The ESP was implemented using the state-of-the-art 65-nm technology, and based on the design constraints; it occupied an area of 0.112 mm² and consumed a total power of 2.78 μW with prediction accuracy of 86%.

Tien-En Chen et al [2] discussed the first (S1) and second (S2) heart beat sound recognition based only on sound characteristics. These two assumptions of the individual periods of S1 and S2 and time durations of S1-S2 and S2-S1 are not involved in the detection process. These technique use the deep neural network (DNN) concept is used for recognized the S1 and S2 heart beat sounds. In DNN, the first heart sound signals are first converted into a sequence of MFCC (Mel-frequency cepstral coefficients) and then by using K-means algorithm are applied to cluster features into individual groups to refine their illustration and discriminative capability. The refined features are then feed to the DNN classifier to carry out the S1 and S2 identification. The DNN based method can achieve the high precision with greater than 91% accuracy.

Nima Karimian et al [3] explained the challenges of Electrocardiogram (ECG) with respect to noise immunity and abnormalities. Here discussed the Interval Optimized Mapping Bit Allocation (IOMBA)
technique is applied the normal and abnormal ECG signals beneath multiple session circumstances. In this technique investigated the different feature extraction methods like wavelet and discrete cosine transform are used to find the best technique method for feature extraction the ECG Signals. The simulation experiments results of these methods show that 217-bit, 38-bit, and 100-bit keys with 99.9%, 97.4%, and 95% average reliability and high entropy can be take out from normal, abnormal, and multiple session ECG signals, correspondingly.

Farzad et al [4] focused the detection the specific fiducial points of the Seismocardiogram (SCG) signal with or without using the Electrocardiogram (ECG) R-wave as the reference point. The identified fiducial points were used to find the cardiac time intervals. In sensitivity and complexity of the SCG signal, the presented algorithm was intended to strongly reject the low-quality cardiac cycles, which are the ones that include unfamiliar fiducial points. This presented algorithm is applied to concurrent ECG and SCG signals, the desired fiducial points of the SCG signal were effectively estimated with a high detection rate.

Weihua [5] demonstrated the skin-potential variation (SPV) insensitive dry electrode is used to remove the interference of SPV. In this methods is based on the conventional Micro Needles Array (MNA) that is based on electrode, a layer of Parylene membrane is coated at the root of micro needles to insulate the electrode from the corneum layer. Only tips of the needles are exposed to make it can contact with the stratum germinativum layer directly. The simulation results, skin potential will not be coupled into the recording electrode. It will not influence the bio-potential recording in the dynamic state region. In this noise removal in ECG signals for correctly identified the pattern.

Ramun [6] explained the ST segment of an Electrocardiogram (ECG) is very important parameter for the correct diagnosis of an acute myocardial infarction. In most clinical ECGs are measured and recorded using an AC coupled ECG amplifier. The first-order high-pass filters used for the AC coupling can affect the ST segment of an ECG signals. In this effect is stronger the higher the filter’s cut-off frequency is and the larger the QRS integral. Ramun explained the formula that estimates these changes in the ST segment and therefore allows for correcting ST recorded that are based on an AC-coupled ECG.

Shiu [8] explained an integrated electrocardiogram signal processor (ESP) for the identification of heart diseases. The system employed an instrumentation amplifier and a low-pass filter (LPF) to remove the baseline wander and the power line interference form the ECG and employed a time-domain morphological analysis for the feature extraction and classification based on the evaluation of the ST segment. The system was carried out in a field programmable gate array and consumed a total of 40.3μW power and achieved an accuracy of 96.6%. The main disadvantage of the system is that it uses fixed search window with predefined size to locate S and T fiducial points, which is not suitable for real-time scenarios.

Saxena et al [7] discussed the approach for efficient feature extraction form ECG signals. In this paper deal with a competent composite technique which has been created for signal retrieval, data compression, and feature extraction of ECG signals. After the signal retrieval from the compressed ECG data, it has been originate that the network not only compresses the ECG data, but it also improves the quality of recovered ECG signal with respect to elimination of high frequency interference present in the original ECG signal. By the implementation of Artificial Neural Network (ANN), the compression ratio is increases as the number of ECG cycle period increases. Moreover the features extracted from ECG Signals by amplitude, slope and duration criteria from the recovered signal match with the features of the original ECG signal.

III. Materials And Measuring Parameters:

An Arrhythmia is an abnormal rhythm activity of the heart function and is caused by problems with our heart's electrical system. The electrical impulses may occur too fast, too slowly, or erratically - causing the heart to beat too fast, too slowly, or erratically.

When the heart doesn't beat properly, it can't pump the blood effectively. so the lungs, brain and all other organs can't work properly and may shut down or be damaged.

In recent survey, sudden cardiac death accounts for approximately 23.6 billion deaths in the countries per year, and, in most cases, is the final result of ventricular arrhythmias, including Ventricular Tachycardia (VT) or Ventricular Fibrillation (VF).

Ventricular arrhythmia is an abnormal ECG rhythm and is responsible for 75% to 85% of sudden deaths in persons with heart problems unless treated within seconds.

There are two basic kinds of arrhythmias. Bradycardia is when the heart beat rate is too slow - less than 60 beats per minute (bpm). Tachycardia is when the heart function rate is too fast - more than 100 bpm.

Ventricular Tachycardia (VT) is a fast rhythm of more than three consecutive beats originating from the ventricles at a rate more than 100 beats per min.

Ventricular Fibrillation (VF) is another rhythm characterized by the disordered activation of ventricles, and it causes immediate cessation of blood circulation and degenerates further into a pulseless or flat ECG signal indicating no cardiac electrical activity. It is tabulated in Table 1.
The implantable cardioverter-defibrillator has been considered as the best protection against sudden death from ventricular arrhythmias in high-risk individuals. However, most sudden deaths occur in individuals who do not have high-risk profiles.

Table 1: Various Abnormalities and their Characteristic Features

<table>
<thead>
<tr>
<th>S.No</th>
<th>Name of Abnormality</th>
<th>Features of Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tachycardia</td>
<td>Heart rate &gt; 100 beat per minute</td>
</tr>
<tr>
<td>2</td>
<td>Bradycardia</td>
<td>Heart rate &lt; 60 beat per minute</td>
</tr>
<tr>
<td>3</td>
<td>First degree heart block</td>
<td>Long PR interval</td>
</tr>
<tr>
<td>4</td>
<td>Second degree AV block</td>
<td>QRS dropped</td>
</tr>
</tbody>
</table>

Electrocardiogram (ECG) is almost periodic signals that echo the activity of the heart. Long-term ECG monitoring is the criterion standard for the diagnosis of ventricular arrhythmia.

The 12-lead ECGs are obtained and analyzed to detect any changes in the characteristics of the ECG signal. By extracting information about intervals, amplitudes, and waveform morphologies of the different P-QRS-T waves, the onset of the ventricular arrhythmia can be detected.

The some of the limitations of ECG is an inaccuracy in input feature vectors of the classifier caused by substantial overlapping of the frequencies of the P-wave, T-wave, QRS complex and the noise.

The problem of ECG variations among persons with the same cardio logical conditions affects the performance of existing arrhythmia classifiers.

Some arrhythmias can indicate serious cardiac danger and need immediate attention. The ECG action potential collected from each of the specialized cells found in the heart, and their contribution to the primary heartbeat waveform is shown in Figure 2.

Fig. 2: Action potential collected from each of the specialized cells found in the heart, and their contribution to the primary heartbeat waveform

The performance parameter of ECG normal and abnormal classification is specified in terms of sensitivity (SE), specificity (SP) and accuracy (ACC). SE is the percentage of correct detection of disease condition (in this case VF). The expression for SE is

Recall or SE = \[ \frac{TP}{TP + FN} \] (1)

SP is the percentage of correct detection of Non disease condition (in this case Non-VF). The expression for SP is

\[ SP = \frac{TN}{TN + FP} \] (2)

Accuracy is the probability to obtain a correct detection of VF and Non-VF. The expression for ACC is

\[ ACC = \frac{TP + TN}{TP + TN + FP + FN} \] (3)

where,
TP stands for the number of true detections (VT/VF has been classified correctly), FN denotes the number of false negative detections (VT/VF has been wrongly classified), and FP refers to the number of false positive detections.

**Conclusion:**

The comparative study of the ECG has been exhaustively used for diagnosing many cardiac diseases. Several methods and transformations have been presented previously in literature survey for extracting the features from ECG signals. This paper proposed the summary of different ECG feature extraction methods and algorithms proposed in literature. The ECG feature extraction methods were created for ECG must be highly accurate and fast feature extraction. Moreover the trodes for ECG recording, IEEE Transactions On Biomedical Engineering, 54(5): 1962-1974.

Several methods and transformations have been presented previously in literature survey for extracting the features from ECG signals. This paper proposed the summary of different ECG feature extraction methods and algorithms propose.

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