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Survey on Electrocardiogram (ECG) Arrhythmia Classification

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Abstract

Electrocardiogram is an important tool for examining the heart activity of different cardiac diseases which are sometimes life treating. By viewing the ECG signal of every heartbeat, which is blend of exploit desire waveforms produced by diverse specific cardiac tissues institute in the heart, it is promising to spot a number of its abnormality. This paper focuses on different machine learning techniques that are used in the literature for cardiac arrhythmia classification and furthermore the paper does a comparison study of various techniques and their classification accuracy.

Keywords: Heart rate changeability, Arrhythmia classification, Non Linear analysis, Support vector machine, Electrocardiogram (ECG), Neural Network, Arrhythmia classification

1. Introduction

As per universal grade statement of World Health Organization (WHO) on non-communicable diseases, cardiovascular diseases (CVDs) take the lives of 17.7 million individuals every year, 31% of all total deaths [12]. Symptoms resembling chest pain, faintness, dyspnea and palpitation may arise, before the unpredicted event of a heart hit. It will be of immense aid if these unusual symptoms can be effortlessly detected and diagnosed so that appropriate action is taken straight away to those individuals who are vetting the symptoms. There are different types of cardiac arrhythmia each associated with some pattern as such we can detect by investigation of the ECG cardiac signals. The Electrocardiogram (ECG) indicates the heart motion of the patient. It offers doctors through helpful information of the heart functioning and the rhythm. ECG is done by placing the electrodes on the human chest for a limited amount of time and recording the ECG signal with an external device. Our heart is sectioned into four chambers –left atrium, right atrium, left ventricle, right ventricle. The right atrium first experiences the electrical impulse. Now, this impulse travels from right atrium to left atrium. This electrical impulse is referred to as P wave as it compresses the right atrium so in this way the deoxygenated blood flows from right atrium to right ventricle. This deoxygenated blood then flows to lungs through preliminary arteries. Now the electrical impulse that has traveled to left atrium compresses it. Here oxygenated blood flows into the left atrium through veins from lungs. Now the heartbeat is measured by noting how many QRS complexes have passed in one minute. Heart rate is expressed in bpm(beats per minute).In ST segment the ventricles are waiting to get repolarised. When T wave comes, the ventricles get repolarised so that blood can be pumped into it by an atrium. The full ECG cycle with P, Q, R, S, and T is shown in the figure 1. The physicians or experts for the manual examination frequently use the interval of these waveforms in ECG signals. Physical examination will be tiresome and very lingering due to vast quantity of data and at hand its possible that analyst might fail to spot extremely significant information. Therefore, it is essential to develop simple, resourceful method that sense and categorizes a range of heart disorders. A full routine description for cardiac arrhythmia classification is shown in figure 2 which is divided into four steps as follows: 1) ECG Pre-processing; 2) Heart rate segmentation; 3) Feature withdrawal; 4) knowledge/categorization. In each process, we take the decision and the final objective is to identify different types of heartbeat.

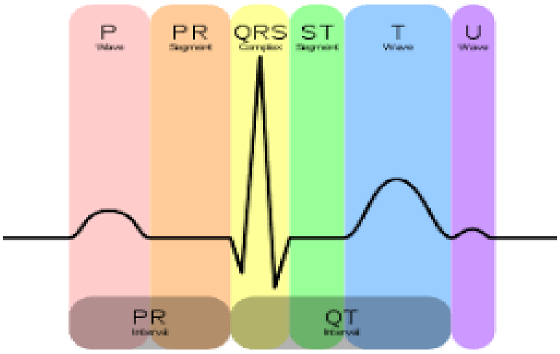

Fig 1: A complete ECG cycle

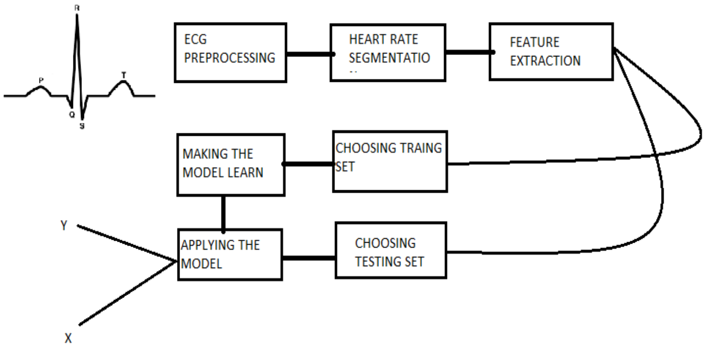

Fig 2: ECG Classification System.

Pre-processing and segmentation stages are widely covered in the literature review with various technique used , In feature extraction each of the literature focuses on having different feature set that could lead with good classification accuracy. Finally, we will look at the different classification algorithm used so far, which could lead to the optimal solution. The above diagram gives us the basic idea of how conventional ECG systems work. Initially we have the raw ECG waveform that is fed to the pre-processing in which the noise and the base line wander is removed using the low pass and high pass filter. Next stage QRS complex is identified to calculate the heart rate using the techniques discussed in the literature. In feature extraction, different time and frequency domain features are analysed to serve as the input to the classifier .In the final stage we divide the dataset into training and testing to validate the accuracy.

2. Pre Processing and Segmentation of the ECG Signal

Along with all ideas for dropping noise in ECG signals, the easiest used is the digital filters [13]. These works fine for the attenuation of the acknowledged frequency bands, such as the noise coming from the electrical activity. The setback with this idea is that the frequency of the noise has to be known early. On the other hand, the uninformed use of filters, distorts the morphology of the signal, and make it broken for diagnosing cardiac diseases. To avoid the morphological properties of the ECG signal most researcher started working on wavelet transform. Researchers [3] [5] [6] has carried out the pre-processing using the Discrete wavelet transform (DWT) by decomposing the signal at discrete band level db6 [6] and analyse the signal at different frequency band with different resolution. This whole process is done to extort the features from the ECG signal by decaying the signal at different sub-bands. There are many techniques widely used for pre-processing, but which to use is widely dependent on the final objective of the classification. Next, we look at the widely used algorithm for Heart beat segmentation .Once we have pre-processed the ECG signal the next step is to identify peak values of the PQRST interval, which act as the relevant feature in the next stage. RR interval act as the important parameter for classifying different cardiac abnormalities. In approach by Babak, joy [1] [6] *et.al*, they have used the Pan Tomkins algorithm [11] for detection the QRS complex. Once the Algorithm is able to find the QRS complex the next step is use the feature set that will act as the input to the classifier. For example, mean, standard deviation, approximation entropy of RR interval are used as the features for training our classifier.

3. Feature Extraction & Classification of Electrocardiogram

Most the of the ECG classification is done by the time and frequency domain features and classified using the artificial neural network, support vector machine and the fuzzy classifier. The important point noted here is, time and frequency domain features, which are acting as the input to the classifier. However, if we feed more feature set, the final classifier will best describe the data points in the dimensional space, but what the result is required is the feature vector that best discriminates data points from each class. In order to achieve the above result most researcher are using the dimensionality reduction technique such as the principal component analysis as described in [8] and Generalized Discriminant analysis [1]. Roshan *et.al* classified only four cardiac diseases using the artificial neural network and fuzzy equivalence relation classifier [6]. The input layer's node accepts the data and the following layers progresses the data by means of the activation function. The final layer has four neurons, giving grow to an output area of 16 probable classes. ANN is fed parameters as Average heart rate, Energy content in the band rate in hz, Heart rate sign being a dynamic signal, significant handy can be channelized from a phase-space plot obtained by demonstrating heart rate x(k) in X-axis and x(k + m) in Y-axis. A more proficient classifier is urbanized by means of fuzzy correspondence relation [2]. The development of arrangement involves obtaining a fuzzy relation matrix used for each class of data and then comparing a clean participation with every collection for categorization. The fuzzy similarity relation requires the properties of reflexivity, equilibrium, and transitivity, be satisfied. If it's true only for the first two it is termed as a fuzzy compatible relation. Philip *et.al* classified the ECG signals using the Levenberg Marquardt (LM) back propagation the reason for using this method was it was fast in training the network which is an advantage in the ECG signal processing [7]. Features used in this are the average power spectral analysis of the subbands using the discrete wavelet transform the signals are decomposed into sub-bands. The Artificial neural network (ANN) are feed with all other parameters as neurons optimize the weights of those as inputs to a layer or two of hidden neurons and the weights of those neurons combine to conclude the categorization. The result is a nonlinear grouping of the inputs contributing to the classification, optimized for the available data. Omar *e t.al* designed a feedforward multilayer perceptron (MLP) neural network .The amount of neurons in the hidden layer is lay down to the amount of description to be investigated [5]. For time domain related features the neuron calculation was the same to the waveform vector plus one neuron on behalf of the RR intervals ratio. For nontime-related features, the size of the neuron is set to waveform vector. For training the network a total of 18 files were selected from the MIT arrhythmia database. And classified as Normal, left bundle branch block (LBBB), Right bundle branch block (RBBB), Paced beat and Premature Ventricular Contraction (PVC). The classifier was tested in two groups to determine its performance. First, a total of 93, 281 beats from 40 files of the MIT database were classified in order to prove high accuracy and robustness. Second, a smaller dataset of seven records from the same database was selected for an exhibition of the value of timing period to be taken as a whole Performance. Another approach discussed is by classifying the ECG features using the reduced feature set [1]. Initially, 15 features were extracted from the HRV signal later to have a better learning rate for the classifier and to improve the accuracy the 15 time and frequency domain features were reduced most discriminating seven features by applying the GDA algorithm. The input dated in mapped to the radial basis kernel function to a high dimensional feature space next an LDA function is applied to the mapped data to find those vectors that best discriminates among the other classes in the feature space. Classification using Support vector machine is done by using this reduced feature set. SVM classifies the data only in two classes .if we need classification into additional classes we have to use the one against all approach in this a set of dual classifiers is taught to be able to detach each class from all the other classes. Then each data vector is classified to the class for which highest conclusion value is determined. Markos *et.al* [4] classified the ECG waveform as normal or arrhythmic by using time domain analysis and time-frequency analysis. The model spectral examination is applied to the RR intervals for cardiac arrhythmia detection.For each 32 RR intervals, we apply the Fourier investigation and PCA is in turn applied to diminish the amount of Fourier coefficients. A feed-forward back propagation neural network is trained and the output of the neural network is fed to the decision rules.

Table [1] describes the methods and accuracy obtained in the literature .All the methods are worked on ECG segments and heart rate variability from the MIT arrhythmia database [9] [10]. Most of the work is done with respect to few classes (2, 4, and 6) of cardiac arrhythmia. Most widely used classifier are the neural network and support vector machine(SVM).A dimensionality reduction technique is used in [1] known as generalized Discriminant analysis which uses Linear Discriminant analysis once the dimension space is being uplift to a higher dimension to reduce the features set which best discriminates each other from their classes.

Literature	Methods	Dataset	Arrhythmia Detection	Sensitivity	Specificity	Positive predicitivity	Accuracy
Babak *et al* [2]	Time domain & frequency domain+ SVM	Heart rate variability (HRV)	6 classes NSR,SSS,BII,AF, PVC	92.57	98.88	90.21	98.49
	Dimension reduction using GDA + SVM			95.77	99.40	93.56	99.16

S.Kara *et al* [7]	Discrete wavelet features+Neural network	ECG segments	2 classes AF detection	100	100	100	100
Omer *et al*.[9]	Neural network +wavelet transform & timing interval features	ECG beat Classification	classes PVC, NSR, others				95.16
Tsipouras *et al* [8]	Neural network +Time features	HRV segments	Nornal, Arrhythmic	89.53	89.48		
Tsipouras *et al* [8]	Neural network + Time frequency features	HRV segments	Normal, Arrhythmic	89.95	92.91		
U Rajendra *et al*[3]	ANN Fuzzy Equivalence Relation	HRV Segment	Normal, Cardiomyopathy, Complete heart block, Ectopics				85 90
Roshan *et al* [10]	Feed forward neural network + LS-SVM	ECG + PCA	Nornal,RBBB,LBBB,APV,VPC	99.90	99.10	99.61	98.11

Table 1: Comparison of the literature Survey.

Conclusion

This paper focuses on the different algorithms and methods that are used in the cardiac arrhythmia classification. It also provides brief comparisons of the various methods with the accuracy. In the literature, most of the researchers have carried out their work in only few classes. The Future work can be carried on more number of Arrhythmia classes from the MIT database[9][10].

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