Arrhythmia Detection using MIT-BIH Dataset : A Review

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***Abstract*— Arrhythmia is a medical condition when the normal pumping mechanism of the human heart becomes irregular. The detection of arrhythmia is one of the most important step for diagnose the condition that can play an important role in aiding cardiologist with decision. In this paper a survey is carried out over various methods such as SVM, Neural networks, Wavelet transforms, etc focused to perform arrhythmia detection especially using MIT-BIH database. There are number of challenges in detection of arrhythmias in heart beat dataset. Although many researchers have suggested various approaches to resolve them, still there are requirements for invention and improvements.**

Keywords—Arrhythmia detection, Mit-bih dataset, Arrhythmia

I. INTRODUCTION

In recent years, diagnosis and treatment of various forms of diseases especially heart conditions are becoming a major area in research [1]. The early detection of abnormal heart conditions is particularly important for patients with heart disease. Based on this scenario, sudden cardiac death is still a largely unsolved public health problem [2]. The diagnosis of such conditions is possible through continuous monitoring of electrocardiogram (ECG) signals to identify the presence of arrhythmia.

Traditional methods of diagnosing and monitoring arrhythmia depends by human observation that identify the existence of particular signal features. Due to the high number of patients that need continuous observation of such condition, an automated arrhythmia detection is needed.

Several method have been presented in the past years in the area of arrhythmia detection to attempt simplify the monitoring task and solve this problem [3-5]. This methods work by processing the signals and classified based on the information obtained from the signal. However, considering the important of arrhythmia detection, there is still have areas for further enhancements in the detection methods.

This papers presents a review of previous work found in literature and explain the main techniques used in arrhythmia detection process. The papers reviewed in this survey used the MIT-BIH database as the signal in the detection process.

The rest of paper is organized as follows: Section II briefly explain about the arrhythmia. Section III provides the information about the MIT-BIH dataset. Section IV and V present the currents steps to detect arrhythmia and method found in literature for arrhythmia detection. Lastly, the paper is discussed and concluded in Section VI and VII.

II. ARRHYTHMIA

A. What is Arrhythmia

Arrhythmia is abnormal changes in the heart rate due to improper heart beating which causes failure in the blood pumping. There have conditions called as tachycardia, bradycardia, regular or irregular [6]. Tachycardia refers to a fast resting heart rate, usually over 100 beats per minute while bradycardia refers to slow resting heart rate, less than 60 beats per minute.

Arrhythmias can occur at any age [6]. Some arrhythmias have no symptoms, while others are dramatically debilitating and can even lead to sudden cardiac death. The common arrhythmias symptom is premature beats, palpitations or skipped beats, dizziness, fatigue, light-headedness and fainting.

The abnormal electrical activity of the heart can be life threatening. Arrhythmias are more common in people who suffer from high blood pressure, diabetes and coronary artery disease [7].

B. Types of Arrhythmia

There are several types of arrhythmias and each type have a patterns that possible to identify its type. There are two major categories of arrhythmias. The first category consists of arrhythmias formed by a single irregular heartbeat, herein called morpho-logical arrhythmia. The other category consists of arrhythmias formed by a set of irregular heartbeats, herein called rhythmic arrhythmias.

C. Arrhythmia in ECG signal

An electrocardiogram (ECG) is a graphical representation of the small electric waves being generated during heart activity. It provides information about the heart rate, rhythm and morphology.

ECG are used by cardiologists to detect abnormal rhythms of the heart. Cardiologists must deal with challenges in the diagnosis of arrhythmia due to the effect of noise in ECG signals and the nonstationary nature of the heart beat signal. ECG arrhythmia can be defined when electrical activity of any group of conditions the heart is irregular and can cause heartbeat to be fast or slow [6].

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The ECG are essentially non stationary signal where the arrhythmia may occur at random in the time-scale. The symptoms of disease may not show up all the time but would manifest at certain irregular intervals during the day. For effective diagnostics, together with the fact that the volume of the ECG data is enormous, the study is tedious and time consuming.

III. MIT-BIH DATABASE

The MIT-BIH Database was the first set of standard test material that generally available to evaluate arrhythmia detection. Since 1980, this database has been used for the basic research for cardiac dynamics at about 500 sites of the worldwide [8]. This database consists of 48 half-hour excerpts of two-channel, 24-hour ECG recordings collected from 47 subjects studied by the BIH Arrhythmia Laboratory. These 48 half-hour excerpts were split in two groups:

- 23 (the "100 series") were chosen at random from a collection of over 4000 Holter tapes, and the other
- 25 (the "200 series") were selected to include examples of uncommon but clinically important arrhythmias that would not be well represented in a small random sample.

ECG signals are collected from Physionet MIT-BIH arrhythmia database and need for analysis process. ECG signals was described by a text header file (.hea), a binary file (.dat) and a binary annotation file (.atr). An example can be seen in Fig. 1, in which there is annotations of signal for MIT-BIH database.

The header file (.hea) is a short text file that describes the contents of the signals (including the name of signal file, number of samples, signal format, type of signal and the detailed clinical information). Almost all records include a binary file (.dat) containing digitized samples of one or more signals stored in 212 format and most records include one or more annotation files (.atr). Annotation files contain sets of labels, each of which describes a feature of one or more signals at a specified time in the record

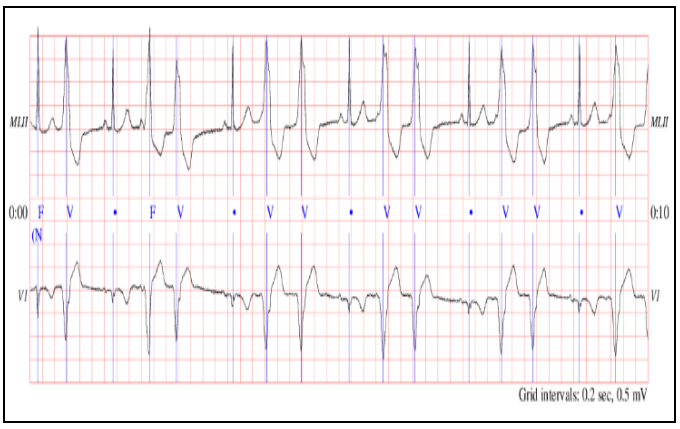

Fig. 1. Example of annotations in MIT-BIH database

IV. STEP FOR ARRYTHMIAS DETECTION

The detection process of arrhythmias can be difficult for a human being because sometimes it is required to analyze each heartbeat of the ECG signal that obtained by a holter monitor. Moreover, such manual analysis of medical data suffers from other factors such as human errors due to the fatique. As an alternative way, the computational method is used for automatic detection process.

There is four basic steps that can used for automated system to detect arrhythmia from ECG signals [9] :

(1) Preprocessing - Use technique to convert the raw data into a clean dataset to reduce the unwanted noise.

(2) Segmentation - Use segmentation technique to creating parts into conceptually meaningful or simple data for further analysis.

(3) Feature Extraction - Use feature selection techniques to get features that will be useful to improve the performance.

(4) Learning/Detection/Classification – Use learning, detection or classification techniques to identify normal or abnormal signal with good accuracies.

As shown in Fig. 2, the preprocessing and segmentation phase involves to removing the unwanted noises and interferences in the ECG signal. The feature extraction phase involves the extraction of significant features which represents the detailed analysis of ECG and further the classification phase involves the detection of type of arrhythmia based on the features of ECG.

Based on the step used to identify the condition of heartbeat, an action for each step is importantly apply to achieve the final objective. Each step of detection process have been widely explored in the previous studies [7,10]. Because of the method apply in every step directly influence and give significance to the results, and therefore, it should be carefuly chosen.

V. ARRHYTHMIA DETECTION METHOD IN MIT-BIH DATASET

There are various types of arrhythmia that are life threatening. Automated detection of these malfunctions play a major role in the diagnosis and treatment of the same. This process of detection/classification is done using different forms of algorithms and methods [1]. The algorithms are effective and time taken for computation. Computation depends on the techniques and the procedure involved in analyzing the signal under consideration.

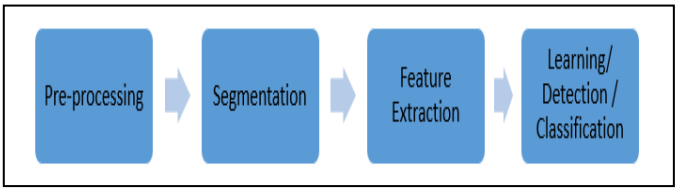

Fig. 2. Steps for arrhythmia detection

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TABLE I. METHODS USED FOR ARRHYTHMIA DETECTION

Year	Work	Method	Description
2018	Nanjundegowda et al [10]	Deep Neural Network	This method produce compositional models where the object is expressed as a layered composition of primitives. The DNN, minimize the cross entropy or noise between the actual and predicted outcomes. A DNN classifier, categorize the signal as normal or abnormal after classification output data are verified with ground truth images.
2016	Li, Hongqiang et. al [11]	SVM Classifier / Particle swarm optimization	This method utilize support vector machine (SVM) as a classifier to recognize different types of heartbeats. The particle swarm optimization algorithm is used to optimize the performance of the SVM classifier. The proposed method is more efficient since the reduction of dimensionality is not required and the calculation speed is faster.
2016	Li, Hongqiang et. al [15]	SVM Classifier / Genetic algorithm	This method uses support vector machine (SVM) as a classifier to recognize different types of heartbeats. Genetic algorithm was apply to improve the performance of the SVM classifier. Using MIT-BIH arrhythmia database for ECG beat classification, this proposed method show the excellent results and efficient to select optimal fetaures in the multi-domain feature space.
2016	V.H.C. de Albuquerque et al [3]	Optimun Path Forest Classifier	The proposed method's performance are compared with the different feature extraction methods and classifiers. The OPF discovered more skills to generalize data. This method is more efficient in terms of computation time of testing and training but sometimes possibilities of miss prediction activities were occurring.
2016	Kora and Krishna [4]	Wavelet Coherence	The method measures the similarity among two waveforms in the frequency domain. The features are extracted from ECG signal after that optimized with the help of Bat algorithm. The optimized features are classified using Levenberg Marquardt neural network classifier. These techniques select the relevant features and reduce the feature redundancy as well as improve the classification accuracy but, this architecture is a bit time consuming.
2015	Stallin et. al [16]	Extreme Learning Machine	This method use a finite number of input and outputs for training in supervised batch learning system to perform a good results. Compared with SVM and BPN, ELM provides the simpler implementation, learning speed is fast and provide better performance.
2015	Kishore et.al [17]	Genetic Algorithm / Neural Network	The proposed methods proposed the detection process based on three parameters accuracy, false acceptance Ratio (FAR) and false rejection rate (FRR). In this method, neural network use trained neurons that arranged in layers for the input parameters and produces the required output. The performance of this method to detect T-Cardia and BCardia diseases, shows the satisfactory results.
2013	Lopez et. al [18]	Artificial Neural Network	This approach combined the wavelet transform and artificial neural network to classify ECG arrhythmias. This approach uses joint Time-Frequency features, time domain features and Statistical feature to overcome the limitations classifying multiple kinds of arrhythmias. This methods performed the high accuracy.

2013	Bazi et. al [14]	Domain Transfer SVM / Weighted Kernel Logistic Regression Method	These methods produce a good performance of arrhythmias classification when the same domain is use for training and test dataset, and produce a low performance of the classification when the different domains is use for training and dataset. However, domain transfer SVM method show a high performance in the different domain.
2012	Daamouche et. al [5]	Wavelet Optimization	This approach finds the wavelets that indicate the beats of capability for discrimination calculated using the measurement of the efficiency for classiffier. The SVM classifier illuminates the accuracy of the proposed method and poly phase permits the wavelet filter bank from angular parameter. The wavelet method for ECG signal improves the classification accuracy but, this proposed technique not suitable for all datasets.

Several methods were suggested for arrhythmias automatic detection/classification in the literature, including: support vector machines [11], neural networks [10], wavelet transforms [5], bayesian classifiers [12] k-nearest neighbor [13] and logistic regression [14]. For higher performance two or more method are fused and are made to give better outcome. Table 1 below shows the different forms of methods used in various research.

VI. Discussion

Studies on references from literature revealed that there are number of challenges in detection of arrhythmias in heart beat dataset. Although many researchers, over the years have suggested various approaches to resolve them, still there are requirements for invention and improvements.

Based on the review, many past studies have identified several issues related to the automatic arrhythmia detection. Experimental results using MIT-BIH database shows that this dataset is extremely unbalanced. The large amount of data is required to classify the signal and its cause the additional complexity of the detection algorithm. Furthermore, the majority of the detection techniques, use the same records of training and testing dataset. However, this studies found only few techniques consider the training and test datasets from the different records.

Arrhythmia detection is the process for the detection of any sort of the change that is made in the heart during each heart beat. It is an analysis system that is used to measure the rate and the regularities of the heart beat. This output of the system should of good quality and accurate so that the problems related to heart should be correctly detected.

After studying the literature it is concluded that traditional work over the detection is done by using SVM, Neural networks, Wavelet transforms, etc but these system were complex, also the features obtained are different. So to increase the accuracy of the detection for the arrhythmia with less error and to evaluate the performance of the ECG signal, analysis further work can be done using some other technique. Because of that, the suitable algorithm is required to classify and detect the abnormal signal even in the unfavorable situation.

VII. Conclusion

In this paper, we have briefly define the arrhythmia and introduce the MIT-BIH database. We have also reviewed the existing step to identify the arrhythmia and review a number of the methods involved in the process of detection of arrhythmia. From the above review made from different literature papers, many efforts has been done related with arrhythmia detection using different methods especially using MIT-BIH database as a dataset. The detection method of abnormalities in heart beat data always is an area considered to be made efficient. The efficiency of each method used rely on the features obtained from the data. Due to the point that this deals with human life, more studies are done to make the utmost possibility of an efficient system to detect diseases at the shortest time possible.

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