Heart Disease Detection Using ECG Waves: A Survey

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Abstract*— *Cardiac Arrhythmia is a condition in which the heartbeat is may be fast or slow than the normal ones. Nowadays, a consistent electrocardiogram (ECG) analysis and classification play an important role in the diagnosis of cardiac abnormalities. ECG provides useful information about the functional status of the heart. Analysis of ECG is of great importance in the detection of cardiac anomalies.

***This paper provides different medical data mining and machine learning techniques are being implemented to extract valuable information from ECG signal for prediction of heart disease. But, the accuracy of the desired results is not yet satisfactory*.**

Keywords: ECG Signal Analysis, Data Mining, Machine Learning Techniques, Cardiac Arrhythmia, Classification, ECG features,CNN. Right Atrium, Right Ventricle, Left Ventricle, Left Atrium.

I. INTRODUCTION

Heart Attacks are the major cause of death in the world today, particularly in India. According to a recent study by the Indian Council of Medical Research (ICMR) near about 25% of deaths between the ages of 25-69 years cause due to different heart-related problems. So Accurate and precise prediction of the heart attack is important to save the patient's life.

The prediction of heart disease mainly depends on Electrocardiogram (ECG) data. The ECG tool plays a vital role in diagnosing and treatment of several diseases related to cardiac. Normally hearts beat for 60 bits/minute. If the heartbeats may be fast or slow than the normal ones or they may be fluctuating then there are chances of getting heart abnormalities. Early diagnosis of heart-related problems can potentially reduce the mortality rate and help patients maintain a better quality of life.

An electrocardiogram (ECG)[1][4] measures the electric activity of the heart and has been widely used for detecting heart diseases due to its simplicity and non-invasive nature. By analyzing the electrical signal of each heartbeat, it is possible to detect some of its abnormalities. ECG is the electrical movement of the heart it produces electrical signals which are called PQRSTU waves. The most vital wave is the QRS complex [4][8].

A. ECG Signal Analysis

The healthy ECG signal with the standard intervals is shown in figure 1. It offers information about the rhythm, morphology and heart rate. The various ECG parameters like heart rate, QRS complex, PR interval, ST-segment elevation, ST interval of ECG signal are used for analysis [4]. Any illness in rhythm in the ECG signal is a clue of cardiac arrhythmia. It is identified and analyzed by analysis of the noted ECG signal. ECG signals differ from person to person due to the difference in size, position, age, the anatomy of the heart, chest configuration, body weight, and other factors.

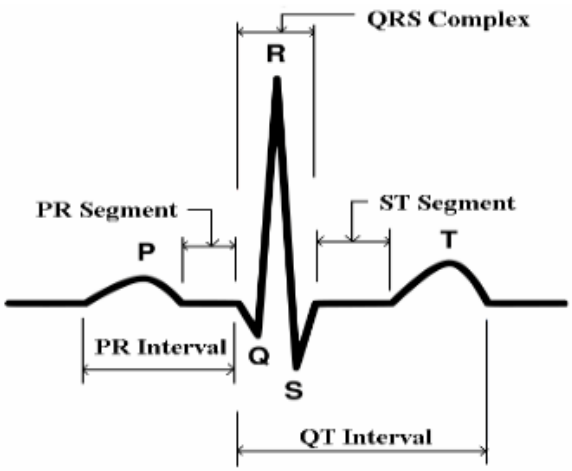

Figure 1: ECG Signal

The letters P, Q, R, S, and T are used to represent the peaks and valleys of the ECG waveform and in few instants. The heart upper chambers activation is represented by the P-wave, while the heart lower chamber activation is represented by the T-wave and QRS complex [4] [8]. The QRS complex does a vital role in identifying the problems that occur with the functioning of the heart. An extensive study of ECG signal which includes heart rate QRS duration and ST-segment etc. is done after the identification of the QRS complex. In this sense, QRS detection provides the fundamental for almost all automated ECG analysis algorithms [8].
ECG Interpretation includes the appearance of the wave and interval on the ECG curve. The main ECG features for normal waves with time interval are

1) QRS duration

2) R-R interval

3) P-R interval

4) Q-T interval

5) R-wave amplitude

6) P-wave Duration

7) T wave duration.

The range for normal P-R interval is 65-85BPM). P-R interval (Indicates the proper functioning of a Sino-atrial node), Q-T interval (Indicates the rate, the velocity of blood flow from atrial to ventricular chambers), Isoelectric line (indicates the resting time in the heart takes seconds in a single heartbeat, R wave amplitude (indicates the rate of blood flow from atrial to ventricular chambers), P wave amplitude (Indicates the extent of atrial excitation), T wave amplitude (indicates the extent of ventricular relaxation).

II. LITERATURE SURVEY

A. Discriminating ECG signals using Support Vector Machines[1]

S. Shahbudin et al. [1] proposed an ECG classification analysis using Continuous Wavelet Transform (CWT) and a Support Vector Machine (SVM)[4]. CWT is used to remove the noise of the ECG signal and to extract distinctive features and used as the inputs to the SVM classifier. This paper gives a classification of 4 types of beats of ECG signals namely Normal (N), and three abnormal beats; Left Bundle Branch Block (LBBB), Right Bundle Branch Block (RBBB) and Aberrated Atrial Premature (AAPC).

B. Prediction and Classification of Cardiac Arrhythmia[2]

ASU Gupta et al. [14] have developed a model by combining SVM and Random Forests. After feature selection, SVM with a polynomial kernel of degree 2 and Random Forests were combined. First, the SVM was used as a one-class classifier and then the random forest was applied. A confusion matrix was also presented. The accuracy of this model was found to be 77.4%

C. Utilization of an Artificial Neural Network in the Prediction of Heart Disease

Mohd. Khalid Awang et al. [3] proposed a model for the prediction of cardiac arrhythmia using artificial neural networks mainly predicting angina in patients. They have built a Heart Disease Management Information System to collect data of patients and a Neural Network simulator with the activation function as a binary sigmoid. The accuracy of this model was 88.89%.

D. Prediction of Heart Disease at an early stage using Data Mining and Big Data Analytics: A Survey

Salma Banu N.K et al.[5] provides a survey of different DM techniques available involving Naïve Bayes (NB), Decision tree (DT), Neural network (NN), the Genetic algorithm (GA), Artificial intelligence (AI) and Clustering algorithms like KNN, and Support vector machine (SVM).

E. Detection of Cardiac Disease using Data Mining Classification Technique

Abdul Aziz et al.[6] gives the detection of cardiac disease using data mining classification techniques. This application of classification technique gives the decision tree for the detection of heart disease. The classification tree uses the factors including age, blood sugar, and blood pressure; it can detect the probability of patients fallen in CD by using fewer diagnostic tests which save time and money.

F. Denoising and Feature Extraction of ECG Using Discrete Wavelet Transform

Navariaet. Al. [7]ECG signals are used because ECG signals contain medical information about cardiac activities of the heart. An ECG signal contains noises such as wandering, baseline, electromagnetic interference, high-frequency noises, and power line interference. DWT is used to de-noise the ECG signals and it also uses to extract the feature. And PTB diagnostic is used to detect the QRS complex it is used to locate the Speaks, Q peaks, and R peaks. QRS peaks are used to identify abnormalities in ECG signals.

G. Support Vector Machine for Cardiac Beat Detection in Single Lead Electrocardiogram

S. Mehta [8] proposed an Entropy-based method for the detection of QRS complexes (cardiac beat) in the single lead Electrocardiogram (ECG). The entropy criterion is used to enhance the QRS complexes. Support Vector Machine (SVM) is used as a classifier to delineate QRS and nonQRS regions.

H. Prediction of Heart Disease Using Machine Learning

Aditi Gavhane et al.[9] develop an application that can predict the vulnerability of a heart disease given basic symptoms like age, sex, pulse rate, etc. The machine learning algorithm neural networks are used to get the most accurate prediction results.

Jyoti Rohilla et al. [10] analyzed some of the data mining algorithms to predict heart disease. They have used a heart disease dataset from the UCI machine learning repository and analyzed using the WEKA tool, shown that decision tree algorithms performed well in predicting heart disease.

Aishwarya B. Chavan Patil et al. [11] use two data mining classification techniques like Artificial Neural Network(ANN) and Naive Bayes is used to assisting in the diagnosis of the heart disease to provide medication accordingly. The AVR-328 microcontroller is used as a gateway to communicate to the various sensors along with temperature sensor, heartbeat sensor, ECG sensor, the sensor for keeping a track of drip levels and a sensor to keep track of motion. The system is efficient with low power consumption capability, easy setup, high performance and time to time response.

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A. CONCLUSION

Predicting Cardiac Arrhythmia before-hand can save the lives of patients by treating it. As the ECG signals are time-series data, with large enough datasets, and advanced machine learning techniques we can get astonishing results in predicting cardiac arrhythmia. This paper gives an overview of different approaches used by the researcher for the prediction of cardiac abnormality. A large collection of methods are identified for recognition of heart disease.

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