AUTOMATIC CLASSIFICATION OF ECG SIGNAL WITH WAVELET STATISTICAL CHARACTERISTICS USING NEURAL NETWORK

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Abstract: *Cardiac abnormality is the most common threat to human life. ECG is the most common way to examine the heart abnormality problem. We present automatic detection of two type's classes of ECG signal with statistical wavelet features using Multilayer Perceptron Neural Network as the classifier. The database used for the heart abnormality detection is MIT-BIH arrhythmia database. Butterworth and Chebyshev TypeII filter has introduced for denoising the signal. Wavelet features have extracted from the preprocessed ECG signal by using DWT(discrete wavelet transform). 3600 samples have taken from each signal and split into frames. The total samples of the signal split into 4 windows and each frame contains 900 samples and DWT has applied in each frame or window to get wavelet coefficients which determine the characteristics of the signal. These wavelet coefficients are the input feature of the classifier for training and testing the model, which gives 100% accuracy for normal cases and 90% abnormality detection is achieved.*

Keywords: **ECG, MIT-BIH Arrhythmia, Discrete wavelet Transform, Neural Network.**

1. Introduction

Electrocardiogram (ECG) analysis is the most common method uses in the field of biomedical signal processing. To detect cardiovascular / heart diseases ECG plays a vital role. Cardiovascular diseases are the number 1 cause of death in the world which completely blocks the blood vessels. According to the WHO, there are 17.9 million people which die due to heart disease globally each year. There are so many types of heart disease which includes Arrhythmia, Coronary artery disease, Myocardial infarction which is known as heart attack, heart failure and other diseases which affect our heart.

Mainly, there are three types of components in the ECG signals. Each wave contains different information which includes amplitudes, duration, and morphology. High blood pressure, cholesterol, smoking, overweight, etc. are the different cause which increases the overall risk of heart disorder. During long term monitoring, the automatic analysis of the ECG signal is important to classify the different diseases of the heart. A huge amount of data is a very time-consuming task for the doctors or analysts for studying manually and hence, there is a need for a computational method and machine learning technique for classification of the ECG signal. [https:// doi.org/10.1098/ rsif.2017.0821].

It is necessary to extract vital information from the ECG signal to explore and find new features for its use as an input in the artificial neural network to classify the ECG signal [Karpagechilvi*et al.*(2010)]. In the past studies, many researchers have work with the ECG signal to detect the heart disorder. Several algorithms have been developed for the classification of the ECG signals. Here we have discussed the existing work.

Stalin Subbiah *et al.(2015)*proposed a technique for pre-processing to cancelling the noise using Gaussian filter, median filter, FIR-filter and Butterworth filter is used for feature extraction, wavelet transformation and QRS components features are used a classifier input to identify the normal and abnormal heartbeat [Subbiah *et al.*(2015)].

A research performed by Ajeet Kumar *et al.* a method which he proposed uses a 10 sec ECG signal for normal and arrhythmia or abnormal ECG classification. The database has taken from MIT-

BIH normal sinus database and supraventricular arrhythmia database. To train the neural network Levenberg-Marquardt function is used and 100% accuracy for Normal Sinus Database gives by the proposed model [Sharma and Bhardwaj (2015)].

A research performed by Nitin Kumar Sahu *et al.* which uses ANFIS (Adaptive Neuro-Fuzzy Interface System) model to identify the normal and abnormal ECG signals. MIT-BIH normal sinus and MIT-BIH Supraventricular database have been taken for training and testing the neural network. The Feed-forward back propagation algorithm is used to minimize the errors in this model and Trapezoidal member function is used as an input and output. From this MIT-BIH normal sinus database 18 sample has taken and 61 samples taken for abnormal to train and test the model. The proposed model gives the accuracy of 100% for normal and 91% for abnormal. The overall classification rate has achieved 95% accuracy [Sahuand Ayub, (2015)].

Kulkarni *et al.* extracted the morphological and statistical features such as RR interval heart rate, arithmetic mean, median, variance, skewness, kurtosis respectively for ECG analysis using discrete wavelet transformation (DWT). For classification of the ECG signal, KNN classifier has used with the classification accuracy of 86.95%. The sensitivity and specificity results are 87.09% and 86.66% respectively. [Kulkarni and Lale, (2016)]. A major disadvantage for the ECG classification is feature selection using the proper feature extraction technique. To overcome the problem, a window method is used before applying discrete wavelet transform and extracts some statistical features for each window.

2. DWT (Discrete Wavelet Transform)

DWT (Discrete Wavelet Transform) is the mathematical tool used for various signal and image processing applications which is used in both the continuous and discrete-time signals. It is used for denoising the signals and features extraction technique. It consists of a no. of series of filters (high pass and low pass filter) and sub-sampling. The multilevel task is performed by DWT. In each level two types of coefficients, which are as approximation coefficients and detail coefficients obtained after DWT applied on the preprocessed signal [Wali *et al* (2012)]. These, approximation coefficients contain a low-frequency component and details coefficients contain the high-frequency components. The approximation coefficient continuously passes through the various filter bank until the required level of decomposition has been achieved or reached [Dr. Hemchandra*et al.*(2020)]. Commonly, Haar wavelets, Daubechies wavelets, coiflets, etc. with various different wavelets families are used. In this study, Dabechies(db) wavelets are used.

3. Methods

The task of classification for ECG signal can be broadly divided into three parts: Preprocessing, features extraction and classification. Fig. 1. Shows the method in this work.

Fig.1. The workflow diagram of the ECG classification system.

3.1 Datasets

The database provided by MIT-BIH Arrhythmia from physionet ATM [physionet.org]. The database contains 48 no. of recordings including male and female. Each record has 30 minutes duration and sampled at 356 Hz. In this study, 10 seconds duration signal has been used and splitting the database into two parts normal and arrhythmia or abnormal for the classification ECG signals.

3.2 Preprocessing

In the Electrocardiogram (ECG) signal, the various types of noises are present: baseline drift noise, power line noise, electrode contact noise and other types of noise. Therefore, this stage is very vital for ECG signal processing. To remove the noise we use the band-pass filter, Butterworth filter and Chebyshev Type-II filter has designed for this work. The frequency of ECG signal lies between 0.5 Hz to 100 Hz. It is necessary to pre-process the ECG signal before feature extraction and classification to get higher accuracy. Butterworth and band-pass filter is used for baseline drift noise removal, and higher frequency removal Chebyshev Type-II filter is used. Fig. 2 and Fig. 3 shows the raw and pre-processed ECG signal respectively.

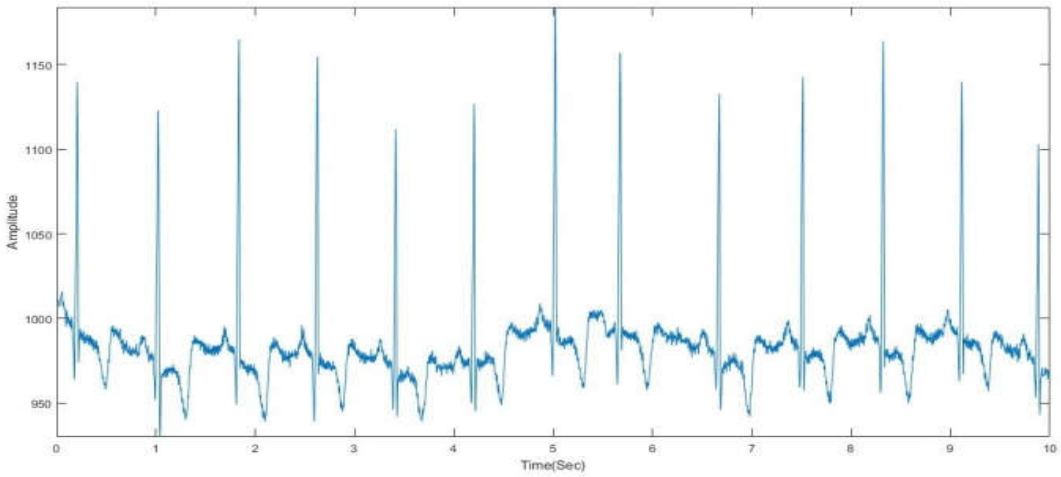

Fig.2. Unfiltered ECG signals.

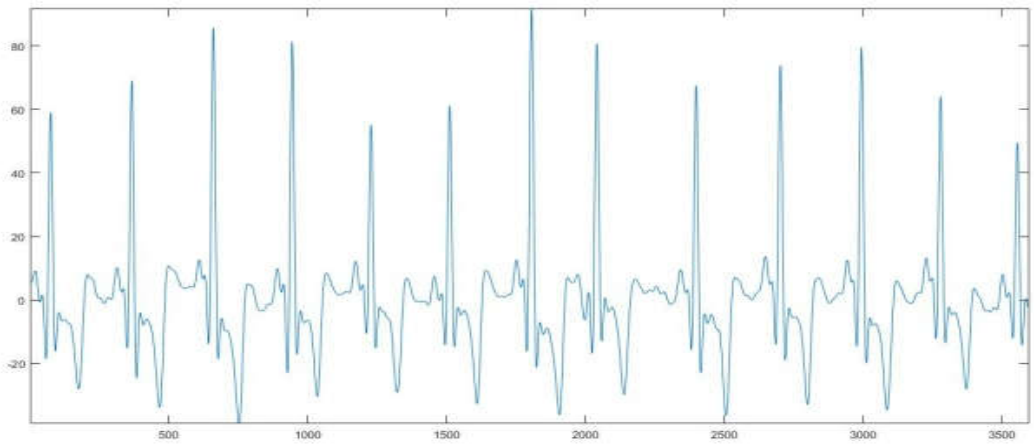

Fig. 3. Baseline wander removal and filtered signals.

3.3 Feature Extraction

The process of feature extraction is very important for the classification of the ECG signals. In this step, features are extracted from the preprocessed ECG signal using DWT (Discrete Wavelet Transformation) using 10 seconds of ECG signal from MIT-BIH Arrhythmia database. [http://www.physionet.org/physiobank/database/mitdb].

From this, the required statistical features are extracted from the DWT coefficient.

The features are

- Energy
- Entropy
- Mean
- Median
- Standard Deviation

In this study, the features are extracted using DWT. The wavelets are used Daubechies (db3) are applied in the 3600 samples from 10 seconds ECG signals and divided the signal into 4 windows of equal samples of 900 samples per window. The DWT is carried out to 4 levels and obtained the detailed and approximation coefficients. From each window, 20 statistical features are calculated to represent the ECG signals. Fig.4 shows the three levels of decompositions.

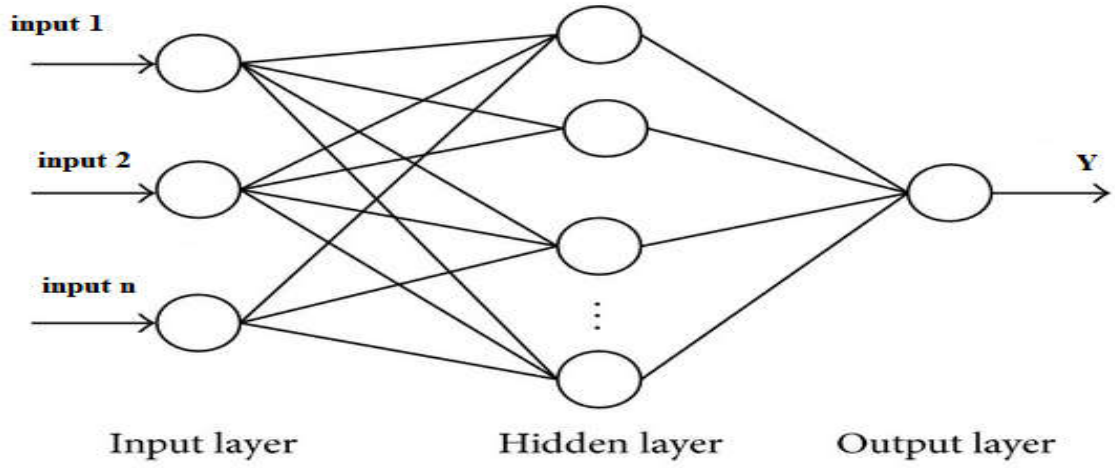

Fig.4. Three level tree of DWT

3.4 Classification

This is the final step where the ECG signals are recognized with the help of classifier. In this stage, the extracted features are the input of the classifier to identify the normal and abnormal ECG signals. Neural network (NN) classifier is used in this work. In the next section, the classification process is described.

4. Neural Network

Multi layer perceptron (MLP) Neural Network classifier is used as classifier to compare the features of two types of signals. To solve specific problem, Artificial neural network is used. Three layers are present in the neural network: input, output and hidden layer. The neural network first trains the network by presenting it with the training data to find the relationship between the features of ECG signal with proper trained algorithm. The trained algorithm which is used is Back propagation algorithm with the connection of weights between layers. The algorithm calculates the mean square error, in this results the minimum mean square error has chosen to differentiate the two types of ECG signal [R.Atangana,*et al (*2020)].

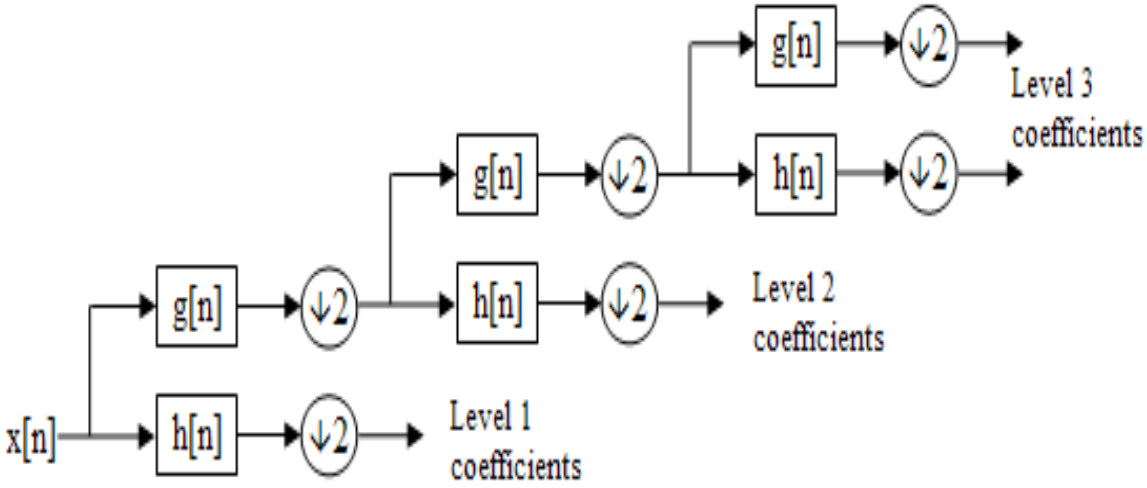

Fig.5 The architecture model of MLP.

5. Results

In this study, MIT-BIH Arrhythmia database has been used form which 45 records are taken of 10 seconds signals of 3600 samples. The above datasets are first preprocessed using Chebyshev type II filter to cancel various types of noise. Then the preprocessed signal is divided into windows where each window contained 900 samples. Then for feature extraction, discrete wavelet transform has applied in each window and we obtained 20 attributes. Total 80 attributes are obtained from all windows to represent the ECG signals. The statistical features that were extracted are the input of the artificial neural network. The database is separated into normal and abnormal class. There are 25 and 20 records from normal and abnormal respectively. The Table 1. Shows the total number of training and testing records used for the classification of ECG. It shows the 100% accuracy for normal ECG subjects and 90% accuracy of abnormal ECG subjects.

Table 1. Training, Testing and Accuracy of MIT-BIH Arrhythmia database.

Types of Records	Total Records	Training Records	Testing Records	Accuracy
Normal	25	18	7	100%
Abnormal	20	10	10	90%

6. Conclusion

In this experiment, MIT-BIH arrhythmias database for 10 seconds signal of 3600 samples has been used for the classification of ECG signal and the signals are partitioned into 4 windows, which contains 900 samples per window. Then, we extracts some statistical features by applying discrete wavelet transformation (DWT). The features that were extracted are energy, entropy, median, mean, and standard deviation and these features are passed through the artificial neural network with back propagation algorithm. The results show the 100% accuracy for normal ECG subjects and 90% accuracy of abnormal ECG subjects are achieved.

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