International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-8, June 2020

Classification of Arrhythmia Conditions using Neural Networks

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ABSTRACT: In this paper, we are discussing about a heart disease called Arrhythmia and how it can be identified using the Electrocardiogram. Electrocardiogram (ECG) is a graphical form for electrical activity of cardiac muscle. A healthy human heart beats, 72 times per minute under normal conditions. For every heartbeat the cardiac muscle undergoes specific electrical activity which identifies the pattern in the ECG signal. It consists of PQRST wave which represents heart functions. The patterns of the ECG signal change due to the abnormalities in the heartbeat. The abnormality in the ECG is called Arrhythmia.

I. INTRODUCTION

Each and every day in this universe, new technologies are being developed which is helping in the betterment of the human race by providing us a sophisticated life. Even if we say that new technologies have helped us to reduce the death rate, there still some fields in the medical industry which require a lot of improvement. One among them is cardiology. If deaths caused by diseases are categorized into two, namely communicable and non-communicable, heart diseases cause around 70 percent of the deaths caused by non-communicable diseases. Irrespective of the age, both children and adults are suffering due to cardiac ailments.

These deaths are not only caused by our unhealthy lifestyle but also due to the misdiagnosis of these diseases. Most of the heart diseases are misdiagnosed by the physicians. Especially, this abnormal heart beat rhythmic condition diagnosis can go misdiagnosed if the rhythm slightly deviates from the normal rhythm which is not predominantly visible and may go unnoticed becoming a life treat. In order to reduce and eliminate such treats Neural network bases cardiac Arrhythmia system have been proposed to take care of the error to a reasonable extent.

This can render great help in easy diagnosis of very minute abnormalities and could be life changing. This can even reduce the time taken for diagnosing.

1.1 Cardiac Arrhythmia

A cardiac arrhythmia is any abnormal heart rate or rhythm. It can be classified into different classes. Some cases of arrhythmia can be critical and only with quick response can the patient reduce risks of complications. Cardiac arrhythmia can be diagnosed using the electrocardiograph.

Revised Manuscript Received on June 30, 2020.
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But most of the times, human errors can lead to wrong interpretation of data which in turn causes misdiagnosis. People who wrongly diagnose a fatal case of cardiac arrhythmia can be accounted for medical malpractice. Hence, computer assisted analysis of the ECG data and arrhythmia detection and classification can play a huge role as a decision support system to the doctors. Following are some of the facts which show the importance of the problem:

- Studies showed that most of the misdiagnosed heart attacks were due to improper analysis of the patient's ECG
- One study showed that as compared to electro cardiographers, the doctors treating the patients were misreading as normal about 36% of abnormal T wave
- Although millions of dollars are being invested in the medical field, still the misdiagnosis of the heart diseases have not completely reduced.

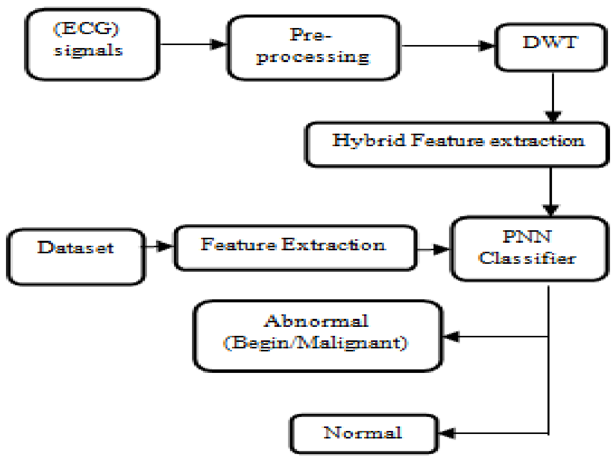
1.2 Classification of Electrocardiogram using Machine Learning:

Machine learning algorithms are extensively used in developing decision support systems in medical field. Through this project, we intend to use supervised machine learning algorithms to analyze the various features of the electrocardiogram (ECG) of the patients and other physiological characteristics. The Cardiac Arrhythmia data set publicly available on UCI Machine Learning Repository has been utilized for developing the classifiers. The objective of this project to build a system for detecting abnormal heart beats using machine learning algorithms.

II. METHODOLOGY

2.1 BLOCK DIAGRAM

Block Diagram



Discrete wavelet Transform:

For decomposing the waves, an evaluation based on the spectrum of the waves is used. This approach is called Discrete wavelet transform (DWT) which breaks the signals into orthogonal wavelets. It is used to decompose the signals into approximation and details. DWT makes use of two types of windows namely long term and quick term windows. The former is used for low frequencies and the latter for high frequencies. While processing the image, each and every pixel of the image is applied two filters. The low pass lets through only the low frequency signal which helps in smoothening the image. The high pass filter only allows only high frequency signals which eventually leads to sharpening the image.

ECG DWT Features:

The Daubechies wavelet has very indistinguishable morphological structure to that of the ElectroCardioGram signal. The 6th request Daubechies wavelet is picked for examining the ECG. The heartbeat wave deterioration occurs at 8 levels. In this manner returning 16 coefficients. Out of sixteen, eight of them are approximations and the other eight coefficients are subtleties. For all the sixteen coefficients, mean, standard deviation and fluctuation are chosen. With the assistance of these qualities, the morphological highlights of the ECG are extricated.

Probabilistic neural network (PNN)

A probabilistic neural system (PNN) is a feed forward neural system which is broadly utilized in arrangement and example acknowledgment issues. In the PNN calculation, the parent probability distribution function (PDF) of each class is approximated by a Parzen window and a non-parametric capacity. At that point, utilizing PDF of each class, the class likelihood of another information is evaluated and Bayes' standard is then utilized to distribute the class with most elevated back likelihood to new info information. By this technique, the likelihood of misclassification is limited. In a PNN, the tasks are sorted out into a multilayered feed forward system with four layers

- Input layer
- Hidden layer/Pattern layer
- Summation layer
- Output layer

Input layer

Every neuron in the input layer has its own indicator variable. Of all the classified variables, N-1 neurons are utilized when there are N number of classifications. It then helps in normalizing the values by performing operations of subtraction and division on median and interquartile range respectively. The information neurons that contain all the significant information feed the qualities to every one of the neurons present in the hidden layer.

Hidden layer

This layer contains one neuron for each case in the training data index. It stores the estimations of the indicator factors for the case along with the target value. A concealed neuron figures the Euclidean separation of the experiment from the neuron's inside point and afterward applies the radial basis function (i.e.,a real-valued function having dependency particularly on the distance between the input and some fixed point usually called the target point) using specified sigma values.

Summation layer

For PNN systems there is always a neuron of one pattern which serves as an example for that category of target variable. Basically the target category of each training case is stored with the concealed neuron in the hidden layer itself. The neurons that emerge out of the hidden layer are specifically given to the pattern neurons which has similar properties of the hidden neuron.

Output layer

The yield layer analyzes the weighted decisions in favor of each target class aggregated in the example layer. The one with the largest vote is used to predict the target category.

READING OF INPUT SIGNAL:

The ECG graph that is in the form of an image is provided as an input which after undergoing steps like wavelet decomposition ,feature extraction helps in classifying if the heart condition of the person specific to that ECG is normal or abnormal.

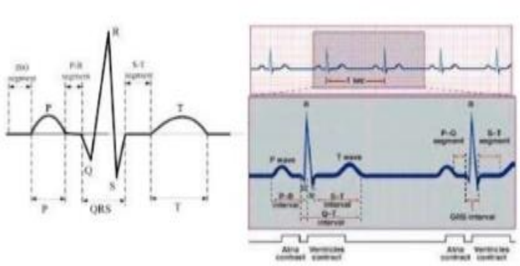
HAAR WAVELET DECOMPOSITION:

A wavelet is a wave-like wavering with an adequacy that starts at zero, increments and the reductions back to zero. By and large Wavelets are deliberately created so that they have significant features and properties eventually making them valuable for signal processing. Wavelet deterioration is applied to every t-f picture portrayal of the signs bringing about corner to corner, vertical and even segments which are additionally utilized in the extraction of features. Of the different wavelets like Discrete Mayer, Symlet 6, Biorthogonal etc., we use Haar wavelet to transform the input signal.The basic idea of Haar wavelet decomposition is to transform an image into a matrix that depicts the actual image in which each of the matrix entry denotes a pixel of the image. Here the image is transformed into a matrix with maximum of 270 columns. This matrix representation is further used for feature extraction process.

III. FEATURE EXTRACTION:

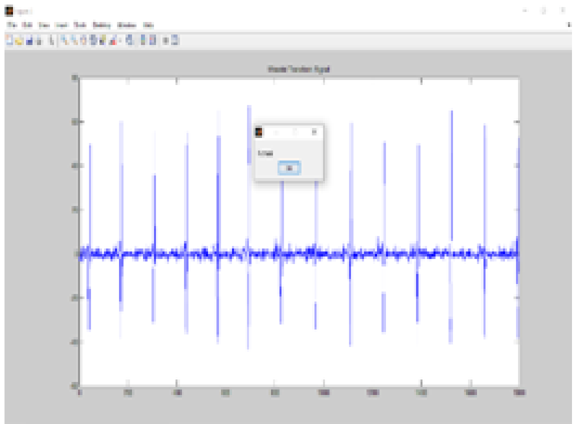
Feature extraction essentially is a kind of dimensionality decrease that effectively speaks to fascinating and significant pieces of the picture in a reduced structure that can be additionally utilized for handling without the dread of losing critical assets. This aides in handling and finishing the undertakings rapidly and effectively. A portion of the highlights extricated here incorporate mean, most extreme, least, standard deviation, entropy, Average sign level, Zero Crossing time rate, Fundamental vitality level and the entirety of all these.The above features are also extracted for all the sample signals trained using the PNN algorithm and a vector is formed.

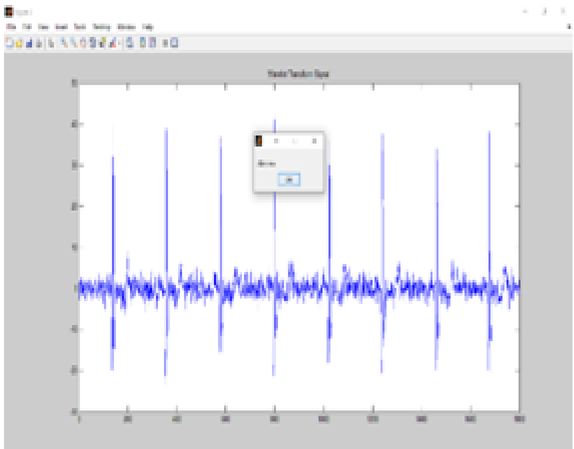
This vector formed is then used for comparing with the input waveform's features.



IV. CLASSIFICATION OF NORMAL AND ABNORMAL HEART CONDITIONS:

The energy levels and the feature vector formed from the input signal is compared with the levels and features of the trained samples. Based on the output of this comparison the exact condition of the heart is displayed using a message box as normal or abnormal heart condition.





V. CONCLUSION

1. Through this project, we aimed to detect and classify cardiac arrhythmia into classes. We have obtained a very high accuracy with the arrhythmia detection model (model 1). Also, by reducing the threshold, the sensitivity of the detection models can be increased further.

2. For the purpose of detection, the models can be utilized as a decision support system and serves the objective of the project.

However, as far as classification (model 2) to the different classes of arrhythmia is concerned, with the given imbalanced data set that is heavily skewed towards class 1, obtaining a very accurate classification of all arrhythmia classes is not feasible.

But since we have identified a set of strong predictors that make sense from a physiological point of view, it can be concluded that the models will definitely perform better if trained on a bigger data set that has more number of rare class instances.

3. A key result we obtained from the binary classification is that a heart rate less than 51 is a clear indication of arrhythmia. So, for patients with a heart rate less than 51, if the model classifies a patient to normal class, it could potentially be a case of misclassification and should be looked into.

4. As stated throughout this report, the main intention of this project was to develop an auxiliary decision support system to assist medical professionals in detecting and classifying arrhythmia.

As far as detection is concerned, the model 1 can be used as a decision support system that may guide the professionals in confirming the presence of arrhythmia with a fairly high certainty. So as to have an efficient classification model (model 2) in place, more data points of the rare classes maybe needed.

5. Since we have utilized only the readings of ECG as the features, adding other features that a medical professional may utilize in his diagnosis may improve the performance of the model.

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Retrieval Number: G5367059720/2020©BEIESP
DOI: 10.35940/ijitee.G3367.069820
Journal Website: www.ijitee.org

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Blue Eyes Intelligence Engineering
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