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ECG Pattern Analysis Using Artificial Neural Network

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Abstract: *(ECG) Electrocardiogram is the most noteworthy analytical examining tool used to determine the heart's health status. The most common heart disease is Arrhythmia, which can be detected by observing ECG and QRS complex noise and distortions within a patient's given time interval. ECG waves consisting of a P, QRS, and T wave can be used to analyze the pattern for any abnormalities present in the heart. Any noise or distortion seen in ECG is directly associated with abnormalities in the heart, so the major job of this project is to reduce the complexity and time in the classification of an ECG signal.*
The project focuses on the biomedical signal processing-based approach for real-time self-classification of ECG signals; these features are usually a combination of statistical and morphological features. Adaptive Neuro-Fuzzy Inference System (ANFIS) is trained to distinguish the ECG pattern once the feature extraction is done. We classify the three classes as Normal, Fusion, and PVC. ANFIS is one of the most reliable methods for classification purposes of the three classes. Its result usually indicates an accuracy of more than 95%. Analyzing long term ECG signal say 24 hours is a time consuming and tedious job, hence is expected to automate the whole procedure of classification and diagnostics.

Keywords - *Artificial Neural Network (ANN), Fusion, PVC, Normal, Electrocardiogram (ECG), Python*

I. INTRODUCTION

The human heart is an organ that pumps the blood throughout the body through the circulatory system; any problem in the heart is measured and observed by using electrocardiography which is nothing but the process of producing ECG signals constructed with analog electronics, which consists of a combination of P, QRS, T waves which directly indicates the present situation of heart accordingly. Diseases such as Arrhythmia are caused by abnormal working and pumping of the heart, can be easily noticed by observing the ECG signals of a patient, distortions present in the graph can depict the problem. This is one of the most common and reasonable methods used as a bioelectric signal data collection and treatment. Most of the hearts cardiac problem can be observed as certain distortions in ECG signals obtained as bioelectric data signals, which are usually observed manually by medical practitioners only, and as we know, any abnormal heartbeat can occur randomly anytime during the treatment as a result of drugs given for treatment, which is very tedious and time-consuming to analyze say a 24 hour ECG signal, which of would surely contain thousands of data samples of heartbeats.

In the proposed work, we used the artificial neural-based automated network to assist doctors in detecting any problem present in heart blood circulation, such as cardiac Arrhythmia and any abnormality in ECG signal wave consisting of P, QRS, and T wave of a given sample data. For reference purposes, we have used the Normal, Premature Ventricular Contraction (PVC), Fusion signals from the MIT-BIH Database, which various health organizations already use for extracting the useful and necessary features of ECG signals for using it as training data for Artificial neural network. A signal's basic and principal components are obtained by principal component analysis, or Convolutional neural network, which usually consists of two parts of hidden layer feature extractions and classification part; processed data is used for training ANN model to accurately and precisely identify different classes of ECG signal.

II. LITERATURE REVIEW

This study's main motive is to analyze the ECG pattern using an Artificial neural network and provide sustainable data for medical doctors for the treatment of various heart diseases. The automated network system is always better to observe the heart's functioning as it provides real-time output without any observation of any medical practitioners. Which also results in more accuracy and precision.

There are already many kinds of research and work done to analyze ECG patterns using artificial neural networks. G. Thippeswamy and Biradar Shilpa [1] presented the model with the MIT BIH database in which 80 % of data was used for training the network, and 20 % data was used for testing purposes. Prarthana B.Sakhare and Dr. Rajesh Ghongade [2] used the ten features extraction methods and classified them using ANFIS classifier, which is similar to feed-forward network but with the connection in an adaptive network only indicates the flow directions of signals between the nodes and there is no weight associated with the connections.

Prof. Alka S. Barhatte [3] described noise separation in ECG signals using the fast ICA technique where the separated signals are based on kurtosis value which depends on statistical properties. Archana Ratnaparkhi and Rajesh Ghongade[4] processed the ECG signals using the Tompkins algorithm to improve the temporal features of ECG, which was followed by the Savitzky- Golay filter. Tapash Barman [5] developed a classification model based on rough Set theory for ECG signal database of samples were prepared by extracting some time plane features which are nothing but attributes.

III. BLOCK DIAGRAM

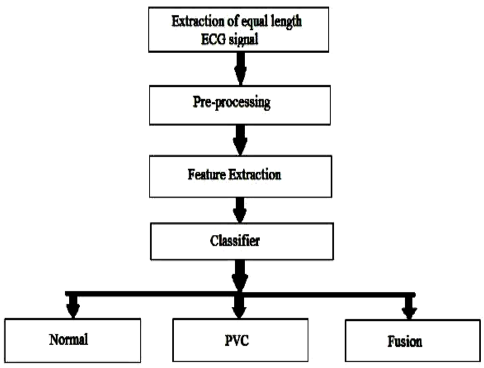

Fig.1 Block Diagram of the proposed system

IV. METHODOLOGY

The proposed block diagram with a flow chart of various steps involved to achieve the required classification output involves three steps: ECG sample data preprocessing followed by feature extraction and classification. At first, we start with an equal-length ECG signal extraction, which usually consists of continuous signals of heartbeats.

For training our artificial neural network, we used MIT-BIH arrhythmia data consisting of 48 half-hour excerpts of two-channel ambulatory ECG recordings obtained from 47 subjects chosen from random sets of 4000. This dataset set is preprocessed, which involved DCT (discrete cosine transform), Mean, and normalization of each phase of data as the database may contain artifacts of certain baseline wanders and other types of noises.

Feature extraction is followed after preprocessing of signal, a type of dimensionality reduction that efficiently represents interesting parts of an image as a compact feature vector. This approach is useful when image sizes are large and reduced feature representation is required to quickly complete image matching and retrieval tasks, and this process filters irrelevant and redundant features from our dataset. Feature extraction is a process of dimensionality reduction by which the initial set of data is usually reduced to more manageable groups for further processing. Characteristics of these large datasets are many variables that require much computing to process. Classification is the next part involved in the CNN model after feature extraction, which includes several convolution layers followed by max-pooling and activation functions; the SOFM (self-organizing feature map) classifier is a similar structure used as a feed-forward network and is trained using unsupervised learning to produce a low dimensional representation of input space of training samples.

V. IMPLEMENTATION

A. *Training of ANN (Artificial Neural Network)*

For training an Artificial neural network, we used the Convolution method (CNN), which is nothing but a deep learning algorithm that can take and process an input image, assign importance weights and biases to various aspects of ECG signal data and differentiate one from another. For training, the artificial neural network convolution and ReLU algorithms were used in series along with the pooling method.

The Rectified Linear Activation Function (ReLU) is used as a very high-performing network. This function mainly takes a single number as input, returning 0 if the input is negative.

Backpropagation training algorithm used is made to work in two steps one in feeding the network forward along with the values and secondly for calculating the error and propagating

it back to previous stages for training with new functions.

For training purposes, we used a 70 – 30 ratio, where 70% of data sets were used for training purposes, and 30% of samples were used for testing purposes, which means 420 samples were used for training each characteristic and 180 samples were kept for testing out of 600 samples taken after processing the dataset of MIT-BIH.

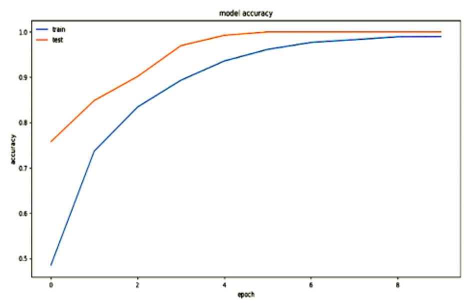

Fig.2 Accuracy Graph of the trained network

Accuracy graph obtained after training the convolutional neural network, where accuracy is continuously improved by training the network over a while, we trained it for 6 times in continuation and obtained the accuracy of 96% plotted with epoch on x-axis and accuracy on the y-axis. Epoch represents the one complete cycle through the full training dataset, which was done many times to obtain the best generalization, which usually keeps mixing with the ongoing iterations. Meanwhile, there is assurance that a network will cover and get better by letting it learn for n numbers of epochs as it is dependent on machine learning to decide the number of epochs sufficient for any network, but when this is applied to other areas of learning such as reinforcement learning, we usually see agent taking new routes every time to complete the same task. Thus, an epoch for an experimental agent performing many actions for a single task may vary from an epoch for an agent trying to perform a single action for many tasks of the same nature. Fig.3, shown below, is the error graph of the trained artificial network obtained by repeating the number of epochs and iterations, where loss and epochs are represented on the y and x-axis, respectively.

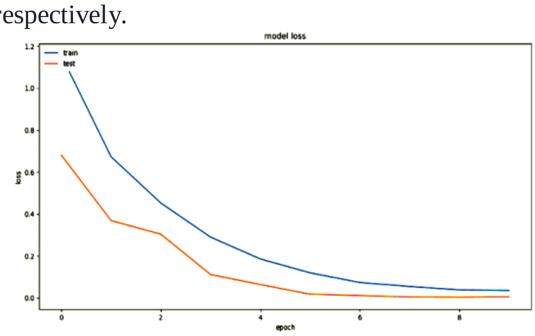

Fig.3 Error Graph for Trained ANN

B. CLASSIFICATION

Processing techniques are finished and wrapped up in this classification step, where data is being already processed, and features are extracted using various algorithms discussed above. A fully connected neural network, which is an essential component involved in convolutional neural networks, which have always been proved to be most successful in recognizing and classifying images and samples, this CNN process begins with convolution and pooling, breaking down the samples into features and analyzing them independently. This process feeds into a fully connected neural network structure that provides the final classification on data decision, as shown in Fig 4.

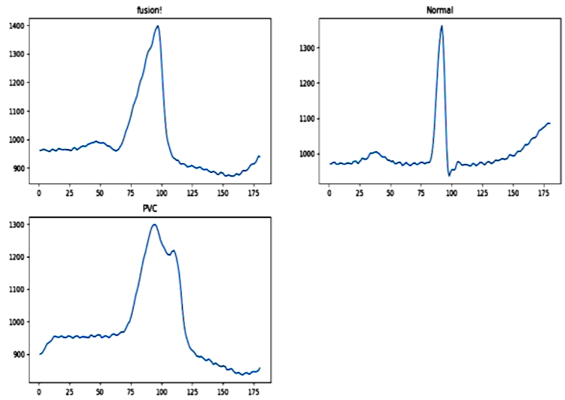

Fig.4 Classification of all three parameters

C. TESTING

Testing is one of the important performance metrics to check the working of our CNN (convolutional neural network) model; some methods yields output in terms of binary output "0" and "1" to indicate result to be positive or negative, respectively. Here Local and global pooling layers were used to streamline the underlying computation; the pooling layer reduced the dimensions of the data by combining the outputs of the neuron cluster at one layer into a single neuron in the next layer, local pooling combines the small clusters, typically 2*2 global pooling acts on all the neurons present in the convolutional layer. The softmax function is used as a squashing function. Squashing functions limit the output of the function into the range 0 to 1. This allows the output to be interpreted directly as a probability. An HTML page was designed for real-time input and classification of the sample by proving its location in Fig 5 and Fig.6

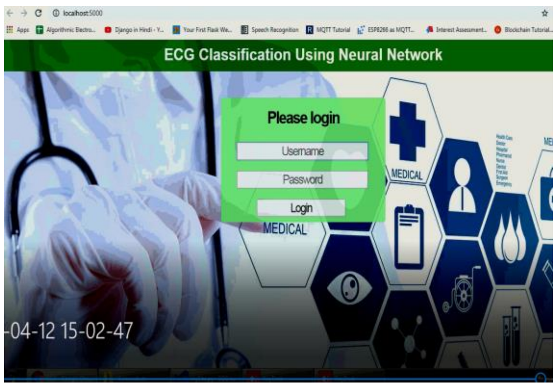

Fig.5 Login page for classification

Fig.6 Sample testing output

VI. RESULT AND DISCUSSION

In this project, we developed and analyzed a new ECG pattern classifier method, trained using CNN (convolutional neural network) using python as a platform for various functions. MIT-BIH database was used for training our artificial neural network using Machine learning and backpropagation algorithm. We created two different data sets for training and testing of data. 600 beats of each criterion were taken out of 1800 set created. We attained an accuracy rate of 96%whike training our network, which can be easily increased by training our network system more numbers until it figures out all the possible paths available to reach the destination and produce some necessary output. ConvNets were used instead of the feed-forward network to make, learn the neural network learn from errors and improved data as the feed forward network is non-recursive, and they do not form a cycle. Noise separation could have been done using the ICA technique, which decomposes a two-dimensional matrix into a spatial map and set of time courses; such techniques are used to extract multiple networks. Python was preferred over Matlab as there are numerous libraries present along with good community support and user-friendly libraries present to implement Machine learning accordingly. We achieved an accuracy of 96% from our trained artificial neural network, which can be improved by increasing a network's training cycles.

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