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Heart Arrhythmia Detection using Deep Learning

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Abstract - *Heart Arrhythmia (also known as cardiac arrhythmia) is a group of conditions in which the heartbeat is irregular, too fast, or too slow. Arrhythmias occur due to problems with electrical conduction system of the heart. The proposed system is going to discuss and explain the prediction of abnormal beats in a patient and represent it using an ECG graph. Then after detecting the abnormal beats, we will train two deep learning models based on the abnormal beats (preferably ANN, CNN) to determine which of the two models will provide us with better performance. The performance can be measured with a number of factors like accuracy, precision etc., here it is done by accuracy and represented using AUC - ROC curve.*

***Key Words*: Heart, Arrhythmia, ECG, Beats, CNN, ANN…**

1. INTRODUCTION

The Electrocardiogram (ECG) is an established technique in cardiology [1] for the analysis of cardiac condition of the patients. In its basic definition, ECG is the electrical representation of the contractile activity of the heart, and can be recorded fairly easily by using surface electrodes on the limbs or chest of the patient. The ECG is one of the most recognized and used biomedical signal in the field of medicine. Computer interpreted ECG s in clinical use today have limitation in diagnostic accuracy [2][3] which creates the for need human help and accurate analysis using different types of interpretation.

Recently deep learning has emerged as a promising feature [4] for ECG interpretation. As deep learning has a number of algorithms and neural networks with their unique usability[5], each of these features allow deep learning technique to extract features automatically from original images/signals and optimizing the model by back propagation technique. As deep learning[13] is an excellent technique involving complex algorithms to perform classifications, it can be used to fetch the data from an ECG graph and train this data into two of its neural networks for measuring the performance with respect to the data recorded on the ECG graph.

Specifically deep learning has evolved as an important technology in finding simple solutions for the pre - existing things with certain solutions. As in this project Neural networks are used such as CNN [7], ANN where CNN is used for image classification of ECG graph. It consists of many layers for filtering ECG segments applying necessary inputs and previous outputs. When CNN was used with highly imbalanced data [7] the accuracy of CNN was reduced to 89.07% and 89.3% in noisy and noise-free ECG s.

From the above information we get to know or understand that when the CNN model is properly trained, it can serve as an effective model as compared to others for measuring the performance of abnormal heartbeat by screening ECG and identifying the different types of frequencies in the arrhythmic heartbeats.

The proposed system deals with deep learning technique which is used to overcome the limitations identified in earlier proposed systems for heart arrhythmia detection by using an ECG. In this, the abnormal heart beats are identified and passed through an ECG graph finally training two neural networks to predict which one of the two will provide a better performance metrics being used is accuracy.

2. LITERATURE SURVEY

An Electrocardiogram (ECG)[12] is an important tool for the assessment of cardiac arrhythmia's in clinical and daily routine. Earlier a number of techniques and projects have been carried out to predict and detect the abnormalities of the heart using a number of methods. One of the methods included Cardiac arrhythmia detection using photoplethysmography [8]. This ECG signal which was not suitable for use in wearable devices. This detection method using photoplethysmography [8]provides an inexpensive and more device friendly method to enable one's heart rate. This method is used in devices such as fit-bit bands, watches etc. This method uses PPG wave forms to detect heart rate.

Another earlier adopted method for heart arrhythmia's was by using 2D ECG images [10]. This method was used to detect heart arrhythmia using 2D convoluted neural network for classification of different types of arrhythmia's. The ECG signals where segmented into heart beats, converting them into grey-scale input for CNN[15] structure. The accuracy obtained from this system was around 97.42%. Since the method makes use of 2D CNN there are few limitations. These limitations can be overcome by using the proposed project which makes use of 1D CNN as it has the following advantages:-

- There are no signal processing methods before CNN.
- The original time-series signal is input directly, which guarantees the authenticity of input.

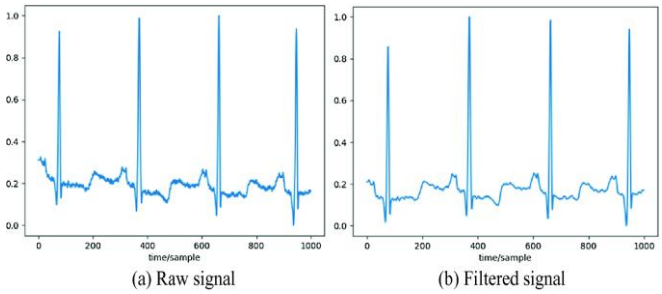

Figure 1: Heartbeat classification using CNN

The Figure 1 represents heartbeat classification using CNN and how ECG graph is varying related to heartbeats. The more commonly used device for reading the heart rate include through fit band, smart watches as discussed above but these devices do not provide any information regarding heart arrhythmia.

Likewise there are similar techniques, methods as above which are used to predict heart arrhythmia detection using an ECG signal. All these earlier proposed papers gave an idea to develop a project which can be used to detect heart arrhythmia with an ECG signal in addition to that passing it to a number of neural networks in order to determine which of the neural networks can provide better performance using various metrics. This project is further explained in detail in the proposed system how it functions and how it is different from other projects currently present in the real world.

3. PROPOSED SYSTEM

The data is collected from MIT-BIH Arrhythmia database which consists of ECG recordings measured at 360 Hz from 1970. The dataset is processed to determine the abnormal heart beats currently present among the patients we are currently observing for the project. Then finally training neural networks and predicting the performance.The different stages in which the proposed system works in described in the following sections below:

3.1 Detection of abnormal heart beats

The first stage includes reading the dataset in order to identify the abnormal beats present in the patients recording. Each of the symbols in the ECG recordings have their own representation such as normal beats, abnormal beats and non-beats.

The Normal Beats used in the proposed system ==> N

The Abnormal Beats used in the proposed system==> S,s,J,j

The Non- Beats include ==> [,]

We identify and sum up all these beats into three categories in order to identify the abnormal beats from the patients.

3.2 Generating ECG graph for Abnormal Beats

The next stage includes we will use one of the patients record to identify the abnormal beats present in the ECG recordings and plot the ECG graph representing the normal and abnormal beats with abnormal beats occurring at what time index shown clearly on the graph.

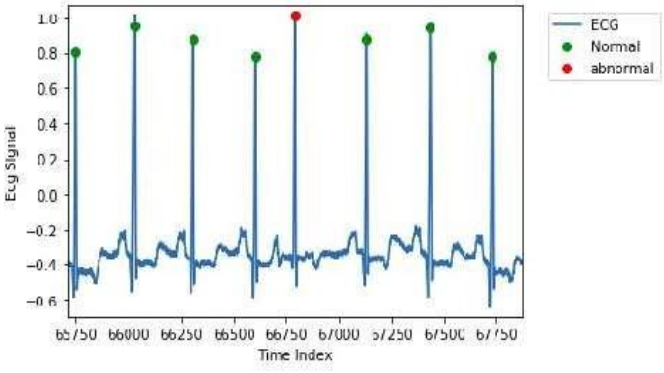

Figure 2: ECG graph representing Normal and Abnormal beats.

3.3 Training the Neural Networks for Performance Metrics

The next stage includes processing all the patient's recordings for training the neural networks. The

networks used here are Dense Neural Network and Convoluted neural network. Each of these Neural networks vary in their performance depending upon a number of factors like activation functions, dropout rates, etc.

3.3.1 Dense Neural Network

It is a neural network where layers are densely connected by neurons in a network layer. Each neuron in a layer receives an input from all the neurons present in the previous layer, thus they are densely connected.

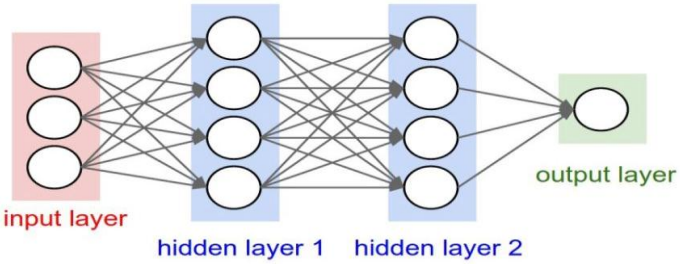

Figure 3: Dense Neural network on TensorFlow Playground

The Figure3 describes a basic DNN on a Tensorflow Background.The metrics used in this project is accuracy which is used to measure the performance of this neural network for the given dataset. The type of model used in this process is sequential as the data can processed sequentially one after the other. The model is trained and tested with input data and finally recording the reports from the classification.

3.3.2 Convolution Neural Network (CNN)

A Convolution Neural Network (CNN)[12][16] is a special type of deep learning algorithm which uses a set of filters and convolution operators to reduce the number of parameters. Here in this project we will use 1D CNN instead of 2D CNN as 2D CNN is used for images. Here 2D CNN is not required as we are going to adjust and reduce the parameters for training the dataset instead of images to measure the performance.

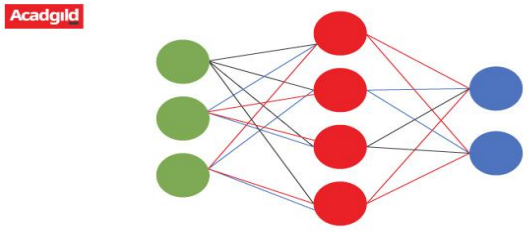

Figure 4: CNN representation

In this project since Keras CNN model is used we reshape our data just a bit for training the model and getting the required result. As it is not image classification in this project, 1D CNN is used which makes of filters, kernel size and other necessary requirements to determine the performance. Like Dense neural network this model also makes use of Sequential type of model for better processing of input data. After the data is reshaped, the reshaped data is provided as an input while fitting/adding the parameters for convolution network for training purpose. The metrics used for this model is also accuracy same as dense neural network in order to determine which among the two can provide better performance in terms of measuring accuracy. The performance can be represented using roc_curve and auc_curve explained in the next section.

3.3.3 Performance Representation using ROC_Curve

In order to accurately determine the performance of neural networks, the best method is to determine it using AUC_Curve. The Receiver Operating Characteristic (ROC) curve is a graphical plot that allows us to assess the performance of binary classifiers. Area Under Curve(AUC) score is used when we have imbalanced datasets as in case of this project which is calculated from ROC and is a very useful metric for measuring performance in case of imbalanced datasets.

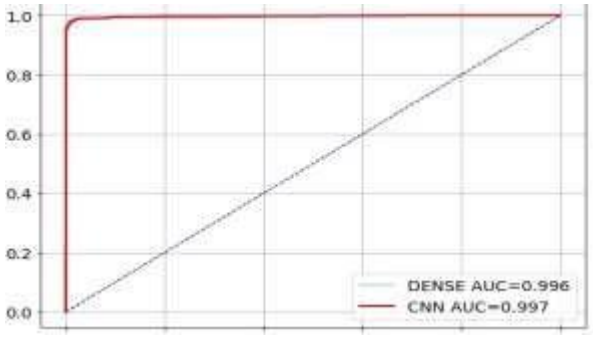

Figure 5: ROC curves for CNN and Dense Neural Network

4. RESULTS AND DISCUSSION

ECG data is received from online database which has recorded the real-time ECG readings. Using these readings we have detected heart arrhythmia in patients the abnormalities present in the data are represented using ECG graph. Then in order to determine which neural network can provide better performance with respect to the available data, we are going to train the dataset and

predict the performance. With respect to earlier studies[10] which has detected heart arrhythmia using only CNN , this project is an enhanced version of it where we train two neural networks and then predict which of them provide us with a better performance.

5. CONCLUSIONS

In the clinical routine, computer aided diagnosis of heart arrhythmias can reduce the workload of cardiologists[17]. As Machine Learning is evolved drastically in recent years, it has reduced the workload of many things with the help of its algorithms. In this paper, a proper understanding of different abnormal beats in an ECG recording is simplified and those beats are graphically represented using a graph.

The proposed System talks about different deep learning algorithms which are used to measure the performance in terms of accuracy. From the developed project we get an understanding that CNN provides a better performance (accuracy) as compared to Dense Neural Network which is represented using ROC curve.

With the recent state-of-the-art performances of deep learning, the biomedical scientists are coming one step closer to effective utilization of deep learning techniques[11] to be carried out to assist clinicians and patients alike in the near future.

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