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Automated Diagnosis of Heart Arrhythmia Using Recurrent Neural Network

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Abstract
The term "cardiac arrhythmia" refers to irregular heartbeats. This study's major goal is to use deep learning algorithms to detect cardiac arrhythmias from ECG signals with the least amount of data pre-processing necessary. To automatically detect irregularities, our method combines recurrent structures with CNN, such as recurrent neural networks (RNN), long short-term memories (LSTM), gated recurrent units (GRU), and a mixture of CNN and recurrent structures. Contrary to traditional analysis approaches, deep learning algorithms do not rely on feature extraction-based analysis techniques. All tests are executed for 1000 epochs within a defined range of learning rates to ascertain the best parameters for the deep learning approaches.

1. Introduction

Cardiac arrhythmia is a disease or an agility where improper heartbeats occur. According to a study, between 2 and 3 persons in North America and Europe suffer with atrial fibrillation. Adults with heart rates over 100 beats per minute are said to have tachycardia, whereas those with rates under 60 beats per minute are said to have bradycardia. Even so, it's called precarious contraction. Fibrillation or flutter are terms used to describe the uneven beat, if the beat occurs too early. There are various different classifications for cardiac arrhythmia in addition to the heart rate standards. An ECG is a bio signal that shows the exertion put forth by the autonomous nerve system (ANS), which regulates the cardiac meter. ECG captures the heart's electrical activity as an outcome. It's an on-invasive and productive tool for investigating and detecting arrhythmias in the heart. Recurrent Neural Networks have lately surfaced as a boon for deconstructing time-series data. The ECG waveform illustrates the whole heart activity. ECG waveform anomalies are indicators of cardiac arrhythmias due to their peculiar morphology. In order to identify the cause of any arrhythmia, the ECG waveform is studied. Arrhythmia identification is a subject that has been the subject of much research. Myocardial infarctions (MI), sometimes known as heart attacks, are the severe arrhythmias described below.

A single lead ECG's data was used to detect MI with a precision of 94.74. To accomplish the same goal with a precision of 96, multiscale eigenspace analysis was done on data from an ECG with 12 leads. To determine MI, discrete wavelet transform (DWT) assessment of 12 nonlinear characteristics taken from 12 leading ECG

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data was utilized, yielding an accuracy of 98.8. Deep learning methodologies are now increasingly applied in this discipline. CNN was used to carry out the automatic detection of normal and Myocardial infarction, and its accuracy is 95.22 percent. Using CNN, it was possible to identify inferior MI in ECG with the precision of 84.54. The data set of MIT-BIH was used to classify four different types of arrhythmias with a 99.38 accuracy rate along with another data set as input. An artificial neural network (ANN) was used to classify the ECG data from the MIT Arrhythmia database into normal and pathological states, with a precision of 96.77 percent. There are many publications that categorize particular forms of cardiac arrhythmia using ECG as a standard input.

2. Related Studies

The purpose of the Automatic Cardiac Arrhythmia detection system is to provide immediate aid for the Heart issues of the patients and keep tabs on them from the normal patients who don't have heart-related issues. We use CNN, CNN-RNN, CNN-LSTM, and CNN-GRU as deep learning-based analysis techniques. Cardiologists can use our work as an automated tool to help with the initial assessment of patients with cardiac arrhythmias.

Automatic myocardial infarction detection using ECG signals with deep convolutional neural network application

An essential diagnostic tool for identifying many cardiovascular illnesses, including myocardial infarction (MI), is the electrocardiogram (ECG). The electrical activity of the heart is captured by the ECG, and these signals may indicate that something is wrong with the heart's function.

However, due to their incredibly modest amplitude and duration, the ECG signals are difficult to visually decipher. We thus offer a special method for automatically identifying Myocardial Infarction using ECG signals. In this study, we automated the detection of normal and MI ECG beats (both with and without noise) using a convolutional neural network (CNN) approach. We were successful in achieving an average accuracy of 93.53% and 95.22% using ECG beats with and without noise. Additionally, this study doesn't use feature extraction or selection. As a result, our proposed system can effectively identify unfamiliar ECG signals even in the presence of noise. Therefore, the technique can be applied in medical settings to help medical professionals detect MI.

A new technique for myocardial infarction localization and diagnosis using pattern recognition. In this research, heart attack in the left atrium of the heart was detected and localized using two new characteristics, the integrals of the T-wave and total, which were computed using patient and normal ECG data from a single cycle. For this objective, we previously used several body surface potential map data features. However, as we are aware that the conventional ECG is more widely used, we concentrated on using it for MI detection and localization. We employ the T-wave integral because the key impression of the T-wave in MI is represented by this feature. The second component of this study focuses on an ECG cycle's total integral since we believe that the MI alters the ECG signal morphology and results in alterations to it. Because Artificial Neural Networks (ANN) have very strong classification accuracy for distinguishing between normal and aberrant signals, we employed these methods to identify and locate the MI. Because of its nonlinearity, the Probabilistic Neural Network kind of Radial Basis Function was utilized, along with classifiers such the k-Nearest Neighbors (KNN), Multilayer Perceptron (MLP), and Naive Bayes Classification.

3. Methodology

Automated detection of cardiac arrhythmia serves two purposes:

1. To vary normal patients from other patients.

2. To give immediate aid to emergency heart patients.

A non-invasive method for evaluating the autonomic nervous system is heart rate variability (HRV) analysis. More precisely, HRV analysis measures the relationship between sympathetic and parasympathetic activity in autonomic functioning. The HRV signal has gained significant attention in recent years for the automatic identification and classification of arrhythmias. In this study, we automatically classified cardiac arrhythmias into five types using a neural network classifier. A neural network classifier is trained by the main signal, the HRV signal and its linear and nonlinear parameters were extracted from it.

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The MIT-BIH arrhythmia database was used to test the suggested method, and with a degree of accuracy of 99.38%, satisfactory results were attained.

$$H = R^d \times R^k \rightarrow R^k$$

$$H(x,h) = f(w_{xh}x + w_{hh}h + b)$$

$$w_{hx} \in R^{k\times d}, w_{hh} \in R^{k\times k} \ \ and$$

$$b \in R^k$$

Here $w_{xh}, w_{hh},$ *and* w_{hx} represent the weighted matrices.

The objective of this research is to create an automated method for diagnosing heart arrhythmia. We use a two-class categorization to determine whether a cardiac arrhythmia is present in the supplied ECG signal. We use ECG data from Physio Net's MIT-BIH arrhythmia database, which is accessible to the general public. The first extensively used dataset for evaluating the effectiveness of cardiac arrhythmia detection algorithms is the database of MIT-BIH arrhythmia.

4. Result

The proposed project's operation is: The dataset is uploaded and in above screen a graph is shown, and its x- and y-axes correspond to the stages of the disease, records for that disease that were located in the dataset.

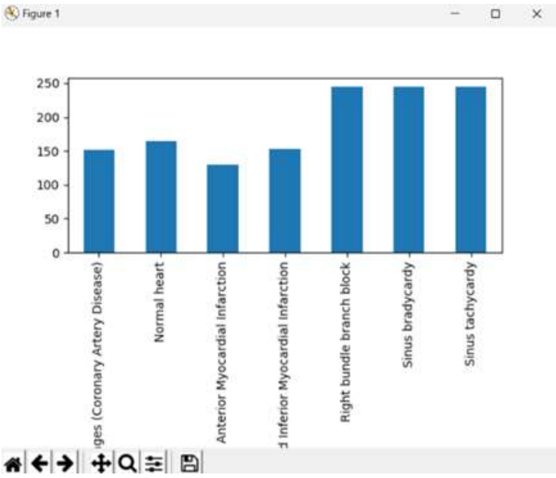

Figure 1 Number of records and stages of the diseases

Click on 'pre-process dataset 'button for pre-processing and splitting data into test and train.

Figure 2 Details of Pre-processed data

Above screen shows numerically converted dataset showing size of the dataset, details of test and train data split. To get confusion matrix, press the 'LTSM algorithm' button. TRUE classes are shown on the y-axis and Predicted classes are shown on the x-axis of the matrix graph. While other colours show valid predictions, blue boxes show incorrect guesses.

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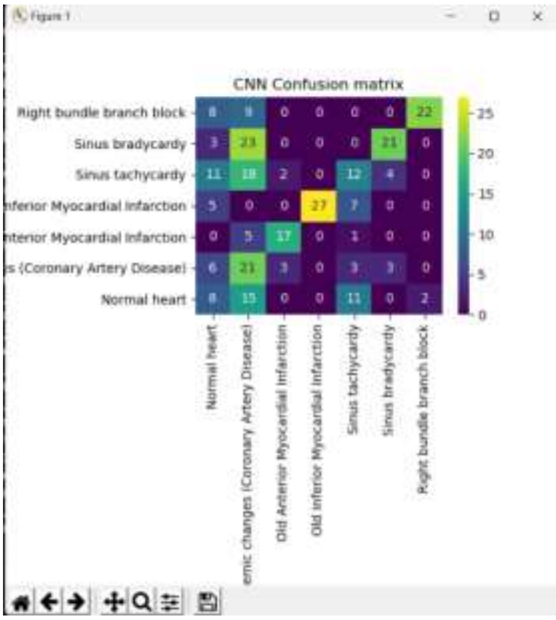


Figure 3 Confusion matrix of CNN algorithm

Click on 'Run CNN algorithm 'to train CNN and get more accurate predictions.

Click on 'LSTM &CNN Training Graph' to get below graph. Here, the x-axis represents the training epoch, the y-axis represents train accuracy and loss values, the greenline representing LSTM accuracy, the orange line representing CNN accuracy, the red line representing CNN loss, and the blue line representing LSTM loss.

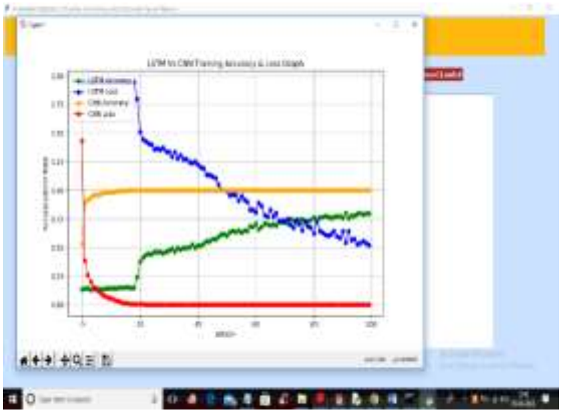
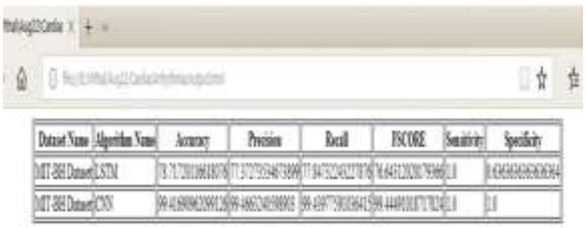


Figure 4 Graphical representation of accuracies of Algorithms

Click on 'performance table' to get below output.



Dataset Name	Algorithm Name	Accuracy	Precision	Recall	FSCORE	Sensitivity	Specificity
MIT-BIH Dataset	LSTM	[illegible]	[illegible]	[illegible]	[illegible]	1.0	[illegible]
MIT-BIH Dataset	CNN	[illegible]	[illegible]	[illegible]	[illegible]	1.0	1.0

Figure 5 Performance table

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5. Conclusion

Heart rhythm irregularities are known as cardiac arrhythmias. Certain cardiac arrhythmias may cause untimely cardiac death as well as consequences including heart attack and stroke. Therefore, early arrhythmia diagnosis and identification are crucial. Arrhythmia detection opens the door to the subsequent stages of categorization and identification. Using the publicly accessible MIT-BIH arrhythmia database, to classify supplied ECG data, we developed a non-invasive approach based on recurrent neural networks be. The suggested system's main highlight is that no feature engineering or noise filtering algorithms are required. The collected findings show that our methodology accurately classifies ECG as either normal or arrhythmic, outperforming other published results. Despite producing exceptional outcomes, deep learning networks have a drawback: their intricate internal operations are not well understood. This could be avoided by determining the eigenvalues and eigenvectors in various time routes and re-modelling the nonlinear deep networks into a linear form. In a later investigation, real-world datasets from hospitals with cardiac care units may be gathered and used to implement the same methodologies.

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