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A System to detect Heart Failure using Deep Learning Techniques

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Abstract - *Cardiovascular diseases or Congestive Heart Failure is one of the leading causes of deaths all over the world. It accounts for almost a million people's deaths on a yearly basis. Also, 3-5% of hospital admissions are due to heart failure occurrence. This is an alarming situation when something needs to be done to impede the progression of the disease hence boosting the quality of life. Although traditional machine learning methods have been implemented previously, this is a diligent effort in the direction of a prior revelation of the disease which might help in reducing the number of deaths. This paper proposes the use of algorithms like Boosted Decision Tree (for detection), CNN (for subtype estimation), and finally predicting possible unfortunate events. The primary focus is on accuracy of detection of CHF, prevention being the major concern.*

Key Words: **Congestive Heart Failure, Deep-Reinforcement Learning, Convolution Neural Network, Electrocardiogram, Boosted Decision Tree**

1. INTRODUCTION

According to the recent studies, heart disease appeared to be one of the leading causes of deaths all over the world. Heart diseases or cardiovascular diseases refer to the condition which directly or indirectly affect the functionality of the heart. Conditions involving blocked blood vessels which may lead to heart attack and other strokes also come under heart diseases. This article focuses specifically on heart failure, which is one of the forms of heart disease.

Heart failure in simple form can be explained as the inability of the heart muscles to pump blood efficiently. This may lead to an unhealthy heart and thus an unhealthy life. Detection of heart failure in a patient is necessary because the condition of the heart worsens day by day if not given the right treatment. Once the heart failure is detected in a patient, it is not possible to cure it. One can only increase the life expectancy up to some (or many) years depending on the treatment he/she receives and the stage or severity level of heart failure. Hence, it is important to detect heart failure in a patient at an early stage so as to get the right treatment appropriately.

In the past few years, several traditional machine learning algorithms were implemented to solve this problem of detecting heart failure at an early stage. However, the main drawback of these systems was that the models they built were static in nature. And hence, it affects the accuracy of the model if patients with new or outlying traits are given to the system.

To tackle this problem, the use of CNN, along with the traditional machine learning algorithms is demonstrated in this paper. Making use of the deep learning algorithms increases the accuracy of the system as well. The use of machine learning algorithms like boosted decision tree is used at the initial stage to find the probabilities of a patient being prone to heart failure. The CNN layer comes into picture to accurately detect the heart failure once the probability obtained in the decision tree surpasses a threshold. The next section will help you in better understanding of the proposed system.

2. LITERATURE SURVEY

Some recent studies related to heart failure have been mentioned below.

Firstly, Elfadil et al. [2] proposed a technique for detecting heart failure in patients using spectral analysis and neural networks. Their approach was to divide the power spectral densities into six regions (From R1 to R6), and to use a neural network with 6 input nodes and only a single output node. The inputs to these 6 input nodes are the densities which are divided into the six regions. The output node is just a single node which classifies into two classes, normal or CHF. The accuracy rate of the network obtained was 83.65%.

Yang et al. [3] proposed a scoring model for diagnosis of heart failure at an early stage. The model was based on Support vector machine, and the Bayesian principal component analysis was used for assigning data at missing values. The model classified the patients into three groups, which are, healthy group, heart failure prone group and heart failure group. The accuracy of the model was found to be 74.4%.

The authors Shouman et al. [4] proposed a system for detection of heart diseases using single and hybrid data mining techniques. The proposed system determines gaps in previous studies on heart disease diagnosis and cure. The model aims to methodically fill those gaps to explore further advancement in diagnosis using data mining techniques.

The authors Miao et al. [5] developed a system using deep neural networks to enhance efficiency and reliability of diagnosis of heart diseases. The model utilizes multiple layer architecture of deep learning. The propose system has a classification model which uses training data and a model for prediction which makes prediction with help of a dataset. The testing results of the system showed truthfulness of 83.67%, sensitivity 93.51% and specificity of 72.86%.

Chang—Sik Son, et al. [6] worked towards early diagnosis of Congestive Heart Failure in emergency rooms. They designed a decision-making model which uses Rough Sets (RS) and Decision Trees. Among the data, two subsets were determined: RS-based and LR-based. 10-fold cross validation method was conducted to compare the decision making models. The generated model was found to outperform the other models and was 97.5% accurate.

Heart Failure subtypes detection is of utmost importance and Alonso-Betanzos, et al. [7] proposed a paradigm that does so by using Ejection Fraction (EF). Based on the metric Ejection Fraction, nearly half of the HF patients have preserved ejection fraction and other half reduced ejection fraction. These are the major two subtypes patients are distinguished into.

Two basic categories of CHF are: Systolic CHF and diastolic CHF. Yalcin Isler [8] makes use of Heart Rate Variability (HRV) analysis to discriminate patients accordingly. Use of Nearest Neighbor and Multi-Layer Perceptron (MLP) helps to achieve an accuracy of 96.43%.

The authors Mahmud et al. [9] have provided a survey on application of Deep Learning (DL), Reinforcement Learning (RL) and their combination Deep-Reinforcement Learning (deep RL) on biological data. Also, a comparison is carried out on the basis of performance when DL techniques are applied on different datasets.

The authors Bhurane et al. [10] proposed an automated approach for the diagnosis of CHF using ECG signals. Short ECG segments were made use of for the experiments. Using frequency localized filter banks, five different features were extracted. They have used Quadratic Support Vector Machine (QSVM) for training and classification purpose. Accuracy was found to be 99.66%.

U. R. Acharya et al. [11] presented an 11 layer deep CNN model for CHF diagnosis. The model requires less preprocessing of ECG signals and neither engineered features or classification. The model achieved an accuracy of 98.97% for one of the datasets taken. The model helps cardiologists by providing fast interpretation of ECG signals.

3. PROPOSED SYSTEM

The proposed system consists of four modules based on the learning curve given in [1]. We have used various machine learning techniques as well as deep learning techniques for this purpose. Our architecture goes as below.

3.1 Detection of Heart Failure

This is our main module wherein we detect whether a patient is heart failure prone or not. We have firstly used a two-class boosted decision tree which is developed using a dataset of 10801 patients which consist of parameters such as AVGHEARTBEATSPERMIN, PALPITATIONSPERDAY, CHOLESTEROL, BMI, HEARTFAILURE, AGE, SEX, FAMILYHISTORY, SMOKERLAST5YRS and EXERCISEMINPERWEEK. This algorithm gives us a probability of to which extent the patient is heart prone. If the probability is higher than or equal to 50%, we pass the ECG recordings of the respective patients to the CNN layer. The CNN algorithm is trained using FANATASIA dataset which is a public dataset available on PhysioNetBank. The dataset consists of 60000 recordings of various patients. The dataset was split into 2 parts consisting of training and testing data. On the trained module we then pass the ECG recording which is reshaped into 3D for the CNN module. This layer finally gives us a rough estimation with greater accuracy if the patient is truly heart failure prone or not.

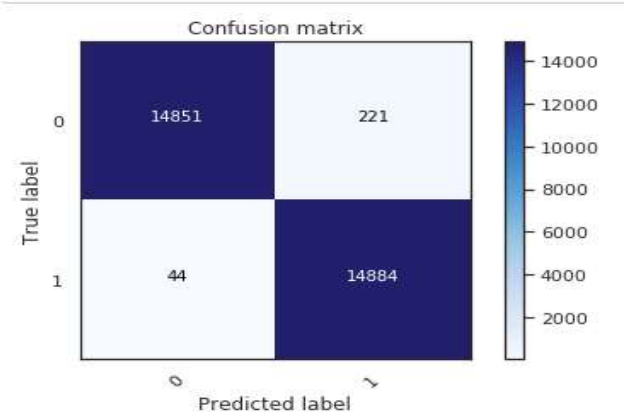

Fig -1 Confusion matrix for HF Detection

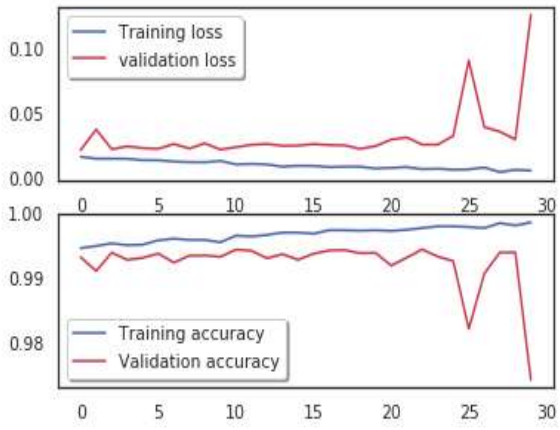

Fig -2 Loss and Accuracy Curves

3.2 Detection of Heart Failure Type

We have used SVM as our algorithm for this module. The algorithm gives us an accuracy of 84%. The dataset was a public dataset which has parameters like systolic pulmonary artery pressure, diastolic pulmonary artery pressure and heart rate etc. This module gives us a type estimation using 3 classes stable, rare and frequent. The dataset was split into train test in the ratio 9:1. We used K Cross Validation for testing which consists of 10 folds. Given below is the accuracy vs fold curve:

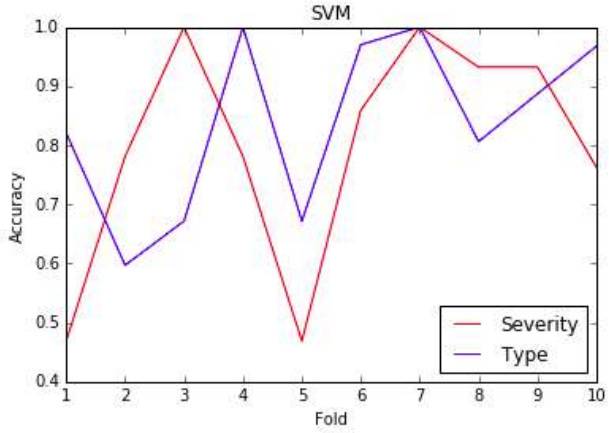

Fig -3 Accuracy vs Fold Curve

3.3 Detection of HF Severity

This module detects the severity of the heart failure and classifies the patients into classes from num0 to num4 with 0 being no HF, and 4 being the highest severity of HF. Artificial neural network is used for its functioning. The module achieved an accuracy of 88.3%.

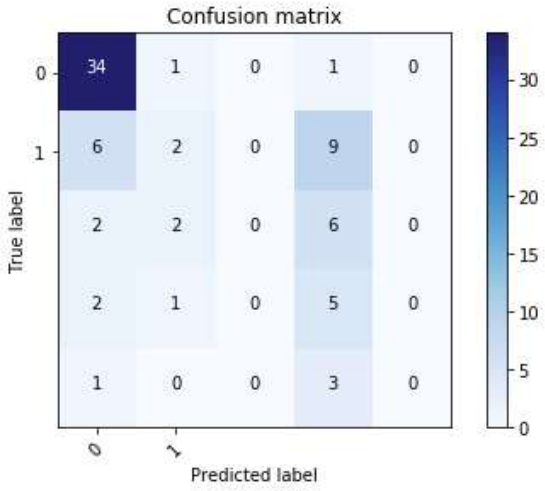

Fig -4 Confusion matrix of HF Severity

4. FUTURE SCOPE

The proposed system was based solely on Heart Failure/ CHF, which is, one of the many types of heart diseases. Similarly, various algorithms like CNN can be used to predict if a person is prone to heart disease or not. And if so, should be able classify the type of heart disease accurately (up to some extent).

5. CONCLUSION

In this paper a useful system is proposed and developed which will be able to help the doctors in evaluating the medical condition of a patient and more specifically be able to detect if a patient is prone to heart failure or not. And if so, be able to accurately predict the type of heart failure and the severity of it as well. For the purpose of detection of heart failure, a boosted decision tree and the CNN module is used which gives an estimation of the patient being prone to heart failure. The SVM algorithm is used for detection of heart failure type, and an accuracy of 84% is obtained. And to measure the severity of heart failure, an artificial neural network is used, which according to the measures, show 88.30% accuracy.

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