

Heart Disease Prediction Using ANN Based Ensemble Framework (ANNEF) Approach

Ramatenki Sateesh Kumar^{1*}, M. Sunitha Reddy², S. Sameen Fatima³

Abstract

The heart is the most important organ in the human body. One of the deadliest illnesses, heart disease is to blame for countless deaths worldwide. Because of the formation of fatty plaques in arteries, the heart fails to supply enough blood to other body areas to carry out its usual functions in heart disease (atherosclerosis). Age, a sedentary lifestyle, a family history of heart disease, stress, and other factors are all risk factors for heart disease. The World Health Organization estimates that 1.79 billion people die every year. If cardiac disease is detected early, the death rate can be reduced. In the diagnosis of cardiovascular disorders, machine learning plays an important role (CVDs). With the use of a Heart Disease Dataset, experimentation is undertaken using machine learning approaches to pick a better Heart Disease Prediction System (HDPS) (HDD). The HDD is made from publicly available datasets from the Cleveland, Hungary, Switzerland, VA Long Beach, and Statlog heart disease repositories. The final dataset contains 1190 records with 13 attributes such as age, gender, type of chest pain, resting blood pressure, serum cholesterol, fasting blood sugar, resting ECG, maximum heart rate, exercise-induced angina, ST depression in patients' ECG, peak slope in ST-segment of ECG, number of vessels colored by fluoroscopy, and thalassemia to characterize heart diseases. The 14th attribute, 'Disease', on the other hand, is a Boolean variable that indicates whether the patient has heart disease or not, and it is chosen as a target attribute. Experimentation using ensemble frameworks referred to as ANN-based Ensemble Frameworks was done to improve the effectiveness of the heart disease prediction system (ANNEF). EKNN, K-Nearest Neighbors algorithm (KNN), Support Vector Machine (SVM), CART (Decision Tree method), and Logistic regression classifiers were used to create these ensemble frameworks. Instead of majority voting, this meta-output model is used to predict heart disease. The accuracy of ANNEF was enhanced to 95.69%.

Keywords: Heart disease, machine learning, ensemble framework, accuracy, KNN, SVM, logistic regression

*Author for Correspondence

Ramatenki Sateesh Kumar
E-mail: sateeshramatenki@staff.vce.ac.in

¹Assistant Professor, Department of Computer Science & Engineering, Vasavi College of Engineering, Hyderabad, Telangana, India

²Assistant Professor, Department of Computer Science & Engineering, Vasavi College of Engineering, Hyderabad, Telangana, India

³Registrar & Professor, Department of Computer Science & Engineering, Anurag University, Hyderabad, Telangana, India

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INTRODUCTION

The most frequent causes of death worldwide are cardiovascular diseases (CVD) [1], sometimes known as heart disorders [2–8]. Coronary heart diseases, also known as cardiac diseases, are caused by the constriction of coronary blood arteries as a result of fatty plaque formation. Heart disease occurs when the heart's blood arteries narrow, and the heart fails to send enough blood to other body components to perform their anticipated functions. Heart problems can be caused by unhealthy lifestyle behaviors such as a poor diet, lack of exercise, being overweight, and smoking. According to the World Health Organization (WHO), coronary heart disease causes more than 17.9 million deaths worldwide

each year [1, 9–15]. 4 million of these deaths were caused by coronary heart disease, while 6 to 7 million were caused by heart stroke. More than 90% of CVD deaths can be avoided by following a healthy diet, exercising regularly, avoiding tobacco smoking, and limiting or avoiding alcohol consumption. Because the causes that cause heart disease are already understood, death rates can be decreased even more if the disease is diagnosed earlier, and sufficient medicine is taken [16]. It is also worth noting that different types of coronary heart disorders account for more than 24% of deaths in India. As a result, an early prognostic system is required to reduce deaths caused by cardiac illnesses. Machine Learning plays an important role in the early detection of CVDs [17–21].

REVIEW OF LITERATURE

The different data mining methods utilized for forecasting cardiac disease were examined by Krishnaiah *et al.* [22]. They looked at how different papers employed different approaches. Taking a diverse number of features and ways for implementation, their findings revealed varying levels of accuracy. The Fuzzy Intelligent Techniques improved the prediction system's accuracy, according to their findings [23].

Chitra *et al.* used the Supervised Learning Algorithm to predict cardiac disease [24]. SVM was used to compare the findings. The patient's record is classified using a Cascaded Neural Network (CNN) classifier. The CNN classifier is given 13 attributes as input to assess the illness risk. A total of 270 patients' records were included in the dataset [21, 25–29]. The CNN classifier outperformed the well-known SVM classifier in terms of accuracy.

The classifier method was utilized by Medhekar *et al.* to identify cardiac disease [30]. They utilized a Naive Bayes classifier to classify the data. The data is divided into five groups by the system [31–33]. The technology forecasts the patient's risk level for each fresh sample that arrives. They tested with different train-to-test set ratios.

ANN BASED ENSEMBLE FRAMEWORK

Introduction

This section proposed Ensemble Framework using Artificial Neural Network-based Ensemble Framework (ANNEF). The results of ANNEF were compared with the results of base classifiers E-KNN, K-Nearest Neighbor algorithm, Support Vector Machine algorithm, Decision Tree algorithm, and Logistic regression. UCI heart disease dataset discussed in "ANN Based Ensemble Framework" is used to train and validate Ensemble Framework models [34–40].

Artificial Neural Network-based Ensemble Framework (ANNEF)

ANN is a machine learning algorithm, built on a human neuron model [41]. The human brain is made up of millions of neurons. It sends signals and processes them in the form of electrical signals. Such neurons are connected to a particular shape known as arcs or synapses. Synapses allow signals to pass through the neurons [42, 43]. At each node, every arc is associated with a weight. Use the values received by the node as input, and define an activation function along the incoming arcs, modified by the arc weights. Neural networks arise from huge numbers of simulated neurons [41, 44–46].

A neural network is made up of three types of layers. The input layer takes the raw information as input and that may be fed into the network [47]. One or more hidden layers are in between the layers of input and output [48–52]. It applies weights to the inputs and directs them as output through an activation function. The output layer behavior depends on the operation of the hidden units and the weights between the hidden units and the output units (Figure 1) [41].

Algorithm 3.1: ANN-based Ensemble Framework (ANNEF).

Input: Heart Disease Dataset.

Output: Confusion matrix and performance measures.

Method:

1. Split the dataset into training and testing.
2. Train all base classifiers namely EKNN, KNN, SVM, CART, LR.
3. For each test data point compute the following:
 - 3.1. Discover the predicted class label of each base classifier.
 - 3.2. Apply the majority voting method to allocate the class label to test data item.
4. Repeat step-3 for all the test data items construct confusion matrix from actual and predicted class labels.
5. Calculate performance measures such as accuracy, Positive predictive value (precession), true positivity rate (recall), F-score from the confusion matrix.

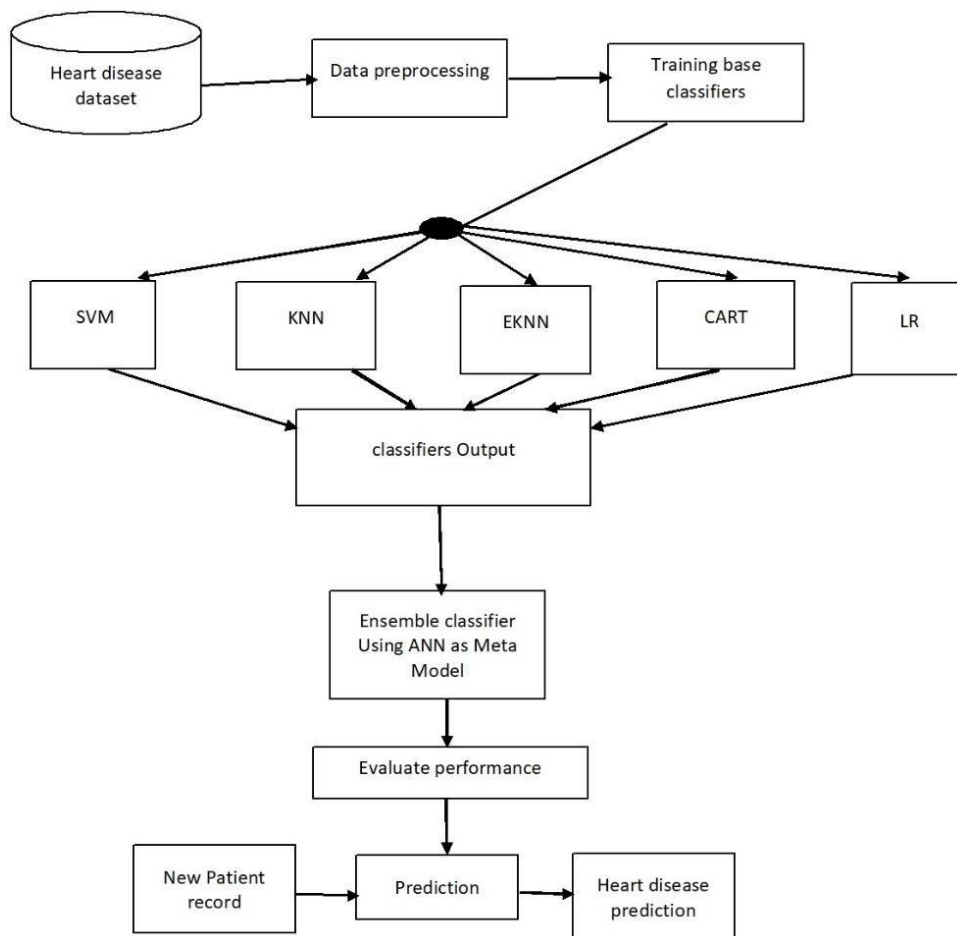


Figure 1. ANNEF Flow Chart.

Algorithm 3.1 explains the working of ANNEF. In this ensemble model, ANN is used as a meta-model. This meta-model is designed using three hidden layers [53–58]. To identify the appropriate number of hidden layers for ANN, experiment is conducted using a different number of hidden layers and compared the results in terms of error rate, execution time, accuracy, precision, recall, and F measure [11], the results are as shown in the Table 1. From the experiment results, three hidden layers were found to be an optimal number of hidden layers.

Table 1. Confusion matrix of ANNEF.

	Predictive Positive	Predictive Negative
Actual Positive	TP(132)	FN(2)
Actual Negative	FP(6)	TN(46)

ANNEF Experimentation Results

Table 1 illustrates the confusion matrix of the ANNEF classifier. 132 positive cases were predicted as positive. 46 true negative cases are there, i.e., from total negative test data items ANNEF predicts 46 as negative [59–63]. There are 6 false-positive cases means 6 negative test data tuples are predicted as positive by the classifier. Two false-negative cases indicates that the classifier predicts these two positive test tuples as negative. In this research, positive means patient suffering from heart disease and negative means there is no heart disease [64–66].

Table 2 indicates the performance measures of the proposed ANNEF classifier. Table 3 describes the comparison of ANNEF performance measures with MVEF and all base classifiers [67].

Table 3 illustrates ANNEF performance and comparison with other classifiers such as MVEF, EKNN, KNN, CART and LR. The results showed that ANNEF predicts heart disease more efficiently compared with other classifiers [68].

Figure 2 shows the result comparison of the proposed classifier ANNEF with all other base classifiers.

Table 2. Performance measures of ANNEF.

Measure	Value
Accuracy	95.69
Precision	95.65
Recall	98.50
F Measure	97.05

Table 3. Comparison ANNEF performance measures base classifiers.

Performance measure	ANNEF	EKNN	KNN	SVM	CART	LR
Accuracy	95.69	91.40	83.15	83.66	80.97	83.01
Precision	95.65	94.20	88.32	85.86	86.86	85.11
Recall	98.50	94.20	88.97	92.35	87.5	92.56
F Measure	97.05	94.20	88.64	88.98	87.17	88.68

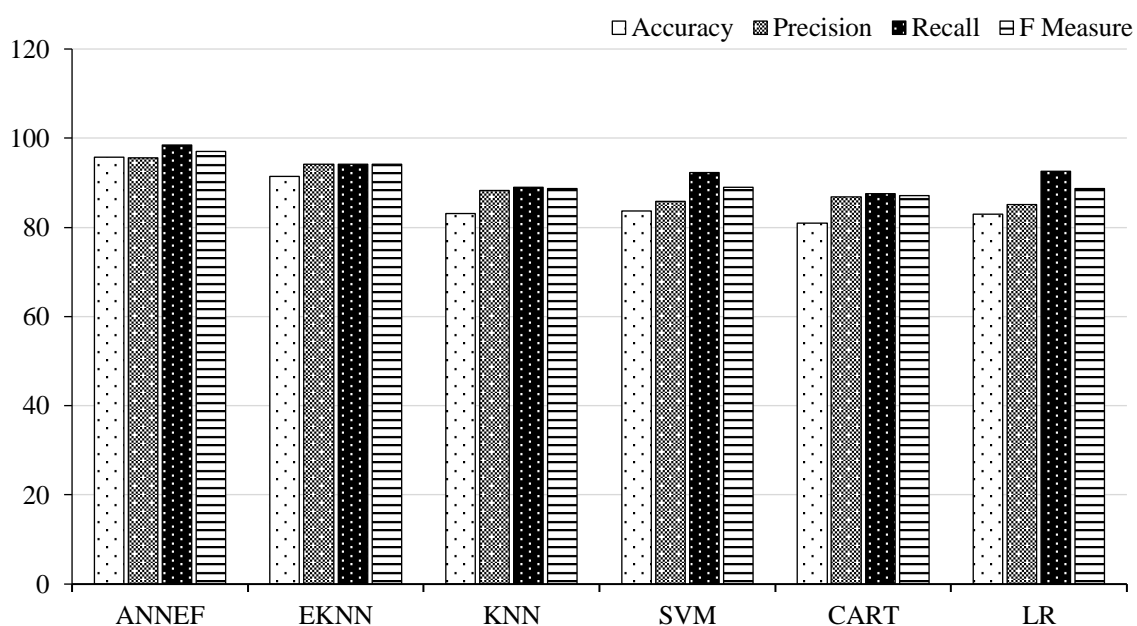


Figure 2. ANNEF result comparison all other base classifiers.

CONCLUSION AND FUTURE WORK

The research in the domain of predicting heart disease using Machine Learning is still in its infancy. But there are many heart-related ailments that can be predicted at an early stage using the ML algorithms that would help the doctors. When all critical care units in hospitals have the data available in real-time, all it takes is to apply the right approach to predict heart disease and treat it better. Therefore, this work can help doctors to predict the presence or absence of heart disease with the best accuracy by using the best machine learning algorithms and also assists non-professional health workers in heart disease prediction at the early stages.

Future Scope of Research Work

There is a lot of scope for future work for this research which is explained as follows:

- These models can be further improved using data analytics and advanced machine learning which can predict future heart disease problems using the present patient's condition.
- These algorithms can be applied to other areas of class imbalance like fraud detection, gene disorders, etc.
- Make use of data pipelines to automate the process of data capture and predictions.
- The models can be further improved and recall by using unstructured ML algorithms to avoid False Negatives.
- A wearable IoT device [62] can be designed that continuously monitors the patient's condition and warn the patient as early as possible before a sudden heart attack.

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