Heart Disease Prediction Using Machine Learning

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Abstract- *In recent times, Heart Disease prediction is one of the most complicated tasks in medical field. In the modern era, approximately one person dies per minute due to heart disease. Data science plays a crucial role in processing huge amount of data in the field of healthcare. As heart disease prediction is a complex task, there is a need to automate the prediction process to avoid risks associated with it and alert the patient well in advance. This paper makes use of heart disease dataset available in UCI machine learning repository. The proposed work predicts the chances of Heart Disease and classifies patient's risk level by implementing different data mining techniques such as Naive Bayes, Decision Tree, Logistic Regression and Random Forest. Thus, this paper presents a comparative study by analysing the performance of different machine learning algorithms. The trial results verify that K-nearst neighbors algorithm has achieved the highest accuracy of 90.16% compared to other ML algorithms implemented.*

Keywords- Decision Tree, Naive Bayes, Logistic Regression, k-nearest neighbors algorithm, Heart Disease Prediction

I. INTRODUCTION

The work proposed in this paper focus mainly on various data mining practices that are employed in heart disease prediction. Human heart is the principal part of the human body. Basically, it regulates blood flow throughout our body. Any irregularity to heart can cause distress in other parts of body. Any sort of disturbance to normal functioning of the heart can be classified as a Heart disease. In today's contemporary world, heart disease is one of the primary reasons for occurrence of most deaths. Heart disease may occur due to unhealthy lifestyle, smoking, alcohol and high intake of fat which may cause hypertension [2]. According to the World Health Organization more than 10 million die due to Heart diseases every single year around the world. A healthy lifestyle and earliest detection are only ways to prevent the heart related diseases.

The main challenge in today's healthcare is provision of best quality services and effective accurate diagnosis [1]. Even if heart diseases are found as the prime source of death in the world in recent years, they are also the ones that can be controlled and managed effectively. The whole accuracy in management of a disease lies on the proper time of detectionof that disease. The proposed work makes an attempt to detect these heart diseases at early stage to avoid disastrous consequences.

Records of large set of medical data created by medical experts are available for analysing and extracting valuable knowledge from it. Data mining techniques are the means of extracting valuable and hidden information from the large amount of data available. Mostly the medical database consists of discrete information. Hence, decision making using discrete data becomes complex and tough task. Machine Learning (ML) which is subfield of data mining handles large scale well-formatted dataset efficiently. In the medical field, machine learning can be used for diagnosis, detection and prediction of various diseases. The main goal of this paper is to provide a tool for doctors to detect heart disease as early stage [5]. This in turn will help to provide effective treatment to patients and avoid severe consequences. ML plays a very important role to detect the hidden discrete patterns and thereby analyse the given data. After analysis of data ML techniques help in heart disease prediction and early diagnosis. This paper presents performance analysis of various ML techniques such as Naive Bayes, Decision Tree, Logistic Regression and Random Forest for predicting heart disease at an early stage [3].

II. RELEATED WORK

Lot of work has been carried out to predict heart disease using UCI Machine Learning dataset. Different levels of accuracy have been attained using various data mining techniques which are explained as follows.

Avinash Golande and et. al.;studies various different ML algorithms that can be used for classification of heart disease. Research was carried out to study Decision Tree, KNN and K-Means algorithms that can be used for classification and their accuracy were compared[1]. This research concludes that accuracy obtained by Decision Tree was highest further it was inferred that it can be made efficient by combination of different techniques and parameter tuning.

T.Nagamani, et al. have proposed a system [2] which deployed data mining techniques along with the MapReduce algorithm. The accuracy obtained according to this paper for the 45 instances of testing set, was greater than the accuracy obtained using conventional fuzzy artificial neural network. Here, the accuracy of algorithm used was improved due to use of dynamic schema and linear scaling.

Fahd Saleh Alotaibi has designed a ML model comparing five different algorithms [3]. Rapid Miner tool was used which resulted in higher accuracy compared to Matlab and Weka tool. In this research the accuracy of Decision Tree, Logistic Regression, Random forest, Naive Bayes and SVM classification algorithms were compared. Decision tree algorithm had the highest accuracy.

Anjan Nikhil Repaka, ea tl., proposed a system in [4] that uses NB (Naïve Bayesian) techniques for classification of dataset and AES (Advanced Encryption Standard) algorithm for secure data transfer for prediction of disease.

Theresa Princy. R, et al, executed a survey including different classification algorithm used for predicting heart disease. The classification techniques used were Naive Bayes, KNN (K- Nearest Neighbour), Decision tree, Neural network and accuracy of the classifiers was analyzed for different number of attributes [5].

Nagaraj M Lutimath, et al., has performed the heart disease prediction using Naive bayes classification and SVM (Support Vector Machine). The performance measures used in analysis are Mean Absolute Error, Sum of Squared Error and Root Mean Squared Error, it is established that SVM was emerged as superior algorithm in terms of accuracy over Naive Bayes [6].

The main idea behind the proposed system after reviewing the above papers was to create a heart disease prediction system based on the inputs as shown in Table 1. We analysed the classification algorithms namely Decision Tree, Random Forest, Logistic Regression and Naive Bayes based on their Accuracy, Precision, Recall and f-measure scores and identified the best classification algorithm which can be used in the heart disease prediction.

III. PROPOSED MODEL

The proposed work predicts heart disease by exploring the above mentioned four classification algorithms and does performance analysis. The objective of this study is to effectively predict if the patient suffers from heart disease. The health professional enters the input values from the patient's health report. The data is fed into model which predicts the probability of having heart disease. Fig. 1 shows the entire process involved.

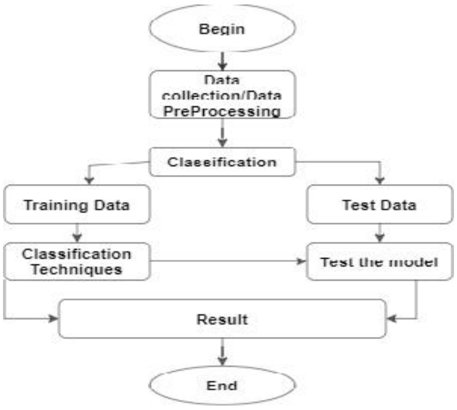
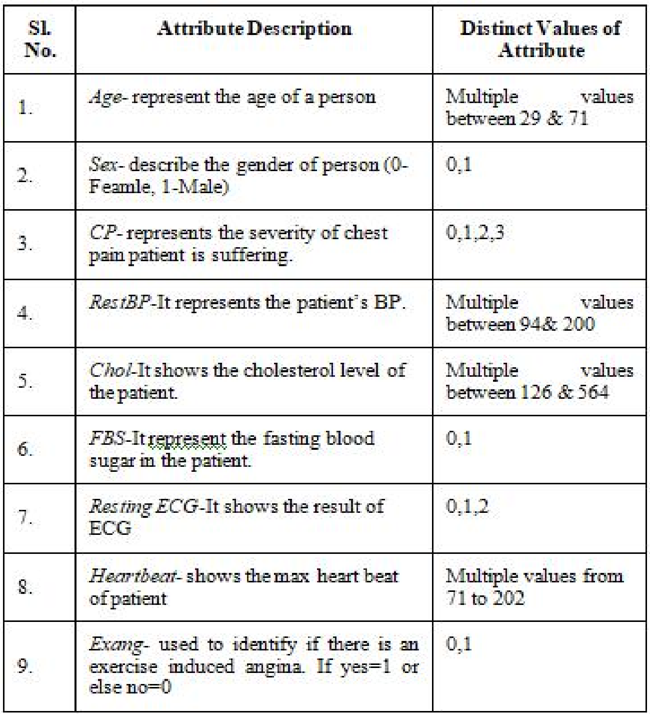


Fig. 1: Generic Model Predicting Heart Disease

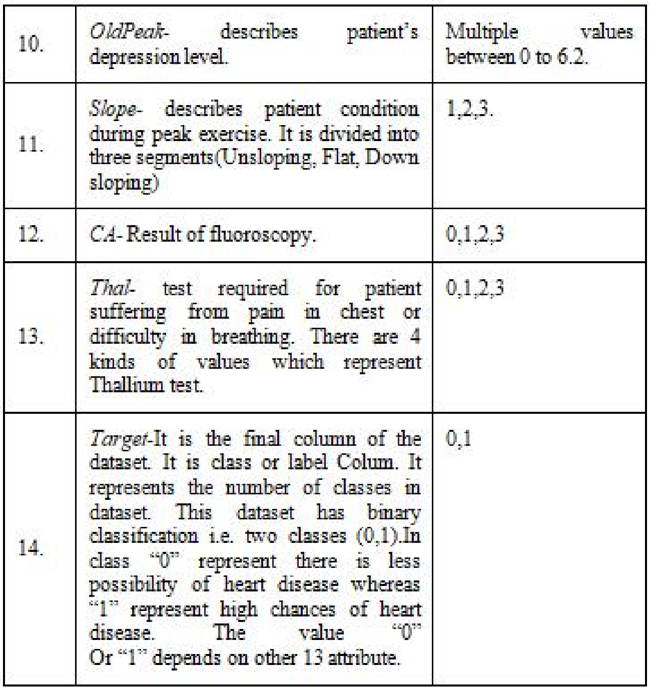
A. Data Collection and Preprocessing

The dataset used was the Heart disease Dataset which is a combination of 4 different database, but only the UCI Cleveland dataset was used. This database consists of a total of 76 attributes but all published experiments refer to using a subset of only 14 features [9]. Therefore, we have used the already processed UCI Cleveland dataset available in the Kaggle website for our analysis. The complete description of the 14 attributes used in the proposed work is mentioned in Table 1 shown below.

TABLE I. FEATURES SELECTED FROM DATASET



Sl. No.	Attribute Description	Distinct Values of Attribute
1.	*Age*- represent the age of a person	Multiple values between 29 & 71
2.	*Sex*- describe the gender of person (0-Feamle, 1-Male)	0,1
3.	*CP*- represents the severity of chest pain patient is suffering.	0,1,2,3
4.	*RestBP*-It represents the patient's BP.	Multiple values between 94& 200
5.	*Chol*-It shows the cholesterol level of the patient.	Multiple values between 126 & 564
6.	*FBS*-It represent the fasting blood sugar in the patient.	0,1
7.	*Resting ECG*-It shows the result of ECG	0,1,2
8.	*Heartbeat*- shows the max heart beat of patient	Multiple values from 71 to 202
9.	*Exang*- used to identify if there is an exercise induced angina. If yes=1 or else no=0	0,1



10.	*OldPeak*- describes patient's depression level.	Multiple values between 0 to 6.2.
11.	*Slope*- describes patient condition during peak exercise. It is divided into three segments(Unsloping, Flat, Down sloping)	1,2,3.
12.	*CA*- Result of fluoroscopy.	0,1,2,3
13.	*Thal*- test required for patient suffering from pain in chest or difficulty in breathing. There are 4 kinds of values which represent Thallium test.	0,1,2,3
14.	*Target*-It is the final column of the dataset. It is class or label Colum. It represents the number of classes in dataset. This dataset has binary classification i.e. two classes (0,1).In class "0" represent there is less possibility of heart disease whereas "1" represent high chances of heart disease. The value "0" Or "1" depends on other 13 attribute.	0,1

Logistic Regression is a classification algorithm mostly used for binary classification problems. In logistic regression instead of fitting a straight line or hyper plane, the logistic regression algorithm uses the logistic function to squeeze the output of a linear equation between 0 and 1. There are 13 independent variables which makes logistic regression good for classification.

Naïve Bayes algorithm is based on the Bayes rule[]. The independence between the attributes of the dataset is the main assumption and the most important in making a classification. It is easy and fast to predict and holds best when the assumption of independence holds. Bayes' theorem calculates the posterior probability of an event (A) given some prior probability of event B represented by P(A/B)[10] as shown in equation 1 :

B. Classification

The attributes mentioned in Table 1 are provided as input to the different ML algorithms such as k-nearest neighbors, Decision Tree, Logistic Regression and Naive Bayes classification techniques [12]. The input dataset is split into 80% of the training dataset and the remaining 20% into the test dataset. Training dataset is the dataset which is used to train a model. Testing dataset is used to check the performance of the trained model. For each of the algorithms the performance is computed and analysed based on different metrics used such as accuracy, precision, recall and F-measure scores as described further. The different algorithms explored in this paper are listed as below.

i. K-nearest neighbors

k-nearest neighbors algorithms are used for classification as well as regression. It creates a tree for the data and makes prediction based on that. Random Forest algorithm can be used on large datasets and can produce the same result even when large sets record values are missing. The generated samples from the decision tree can be saved so that it can be used on other data. In random forest there are two stages, firstly create a random forest then make a prediction using a random forest classifier created in the first stage.

ii. Decision Tree

Decision Tree algorithm is in the form of a flowchart where the inner node represents the dataset attributes and the outer branches are the outcome. Decision Tree is chosen because they are fast, reliable, easy to interpret and very little data preparation is required. In Decision Tree, the prediction of class label originates from root of the tree. The value of the root attribute is compared to record's attribute. On the result of comparison, the corresponding branch is followed to that value and jump is made to the next node.

iii. n

$$P(A|B) = (P(B|A)P(A)) / P(B) \qquad (1)$$

IV. RESULT AND ANALYSIS

The results obtained by applying K-nearest neighbors, Decision Tree, Naive Bayes and Logistic Regression are shown in this section. The metrics used to carry out performance analysis of the algorithm are Accuracy score, Precision (P), Recall (R) and F-measure. Precision (mentioned in equation (2)) metric provides the measure of positive analysis that is correct. Recall [mentioned in equation (3)] defines the measure of actual positives that are correct. F-measure [mentioned in equation (4)] tests accuracy.

$$Precision = (TP) / (TP + FP) \qquad (2)$$

$$Recall = (TP) / (TP+FN) \quad (3)$$

$$F\text{– } Measure = (2 * Precision * Recall) / (Precision + Recall) \qquad (4)$$

- TP True positive: the patient has the disease and the test is positive.
- FP False positive: the patient does not have the disease but the test is positive.
- TN True negative: the patient does not have the disease and the test is negative.
- FN False negative: the patient has the disease but the test is negative.

In the experiment the pre-processed dataset is used to carry out the experiments and the above mentioned algorithms are explored and applied. The above mentioned performance metrics are obtained using the confusion matrix. Confusion Matrix describes the performance of the model. The confusion matrix obtained by the proposed model for different algorithms is shown below in Table 2. The accuracy score obtained for Random Forest, Decision Tree, Logistic Regression and Naive Bayes classification techniques[12] is shown below in Table 3.

TABLE II. VALUES OBTAINED FOR CONFUSION MATRIX USING DIFFERENT ALGORITHM

Algorithm	**True Positive**	**False Positive**	**False Negative**	**True Negative**
Logistic Regression	22	5	4	30
Naive Bayes	21	6	3	31
k-nearest neighbors	22	5	6	28
Decision Tree	25	2	4	30

TABLE III. ANALYSIS OF MACHINE LEARNING ALGORITHM

Algorithm	**Precision**	**Recall**	**F-measure**	**Accuracy**
Decision Tree	0.845	0.823	0.835	81.97%
Logistic Regression	0.857	0.882	0.869	85.25%
K-nearest neighbors	0.937	0.882	0.909	90.16%
Naive Bayes	0.837	0.911	0.873	85.25%

V. CONCLUSION

With the increasing number of deaths due to heart diseases, it has become mandatory to develop a system to predict heart diseases effectively and accurately. The motivation for the study was to find the most efficient ML algorithm for detection of heart diseases. This study compares the accuracy score of Decision Tree, Logistic Regression, Random Forest and Naive Bayes algorithms for predicting heart disease using UCI machine learning repository dataset. The result of this study indicates that the Random Forest algorithm is the most efficient algorithm with accuracy score of 90.16% for prediction of heart disease. In future the work can be enhanced by developing a web application based on the Random Forest algorithm as well as using a larger dataset as compared to the one used in this analysis which will help toprovide better results and help health professionals in predicting the heart disease effectively and efficiently.

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