IARJSET

ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.066 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 4, April 2025

DOI: 10.17148/IARJSET.2025.12402

Heart Disease Prediction Using Decision Tree

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Abstract: Heart disease is one of the most common causes of death around the world nowadays. Often, the enormous amount of information is gathered to detect diseases in medical science. All of the information is not useful but vital in taking the correct decision. Thus, it is not always easy to detect the heart disease because it requires skilled knowledge or experiences about heart failure symptoms for an early prediction. Most of the medical dataset are dispersed, widespread and assorted. However, data mining is a robust technique for extracting invisible, predictive and actionable information from the extensive databases. In this paper, by using info gain feature selection technique and removing unnecessary features, different classification techniques such that KNN, Decision Tree (ID3), Gaussian Naïve Bayes, Logistic Regression and Random Forest are used on heart disease dataset for better prediction. Different performance measurement factors such as accuracy, ROC curve, precision, recall, sensitivity, specificity, and F1-score are considered to determine the performance of the classification techniques. Among them, Logistic Regression performed better, and the classification accuracy is 92.76%.

Keywords: Heart, Machine learning algorithms, Supervised learning, Prediction algorithms, Classification algorithms, Decision trees.

I.INTRODUCTION

The practice of examining large preexisting data bases in order to generate new information. It coverts raw data into useful information. It analyze the data for relationships that have not previously been discovered. [1] The steps of data mining are: Data cleaning, data integration, data selection, data transformation, data mining, pattern evaluation and knowledge representation. Medical data mining is a domain of lot of imprecision and uncertainty. The clinical decisions are usually based on the doctors intuition. Therefore this may lead to disastrous consequences. Due to this there are many errors in the clinical decisions and it results in excessive medical costs. [1] Serialization is also used in this system. It converts the data objects into streams of bytes and stores it into database.

Heart disease is one of the most well-known reasons for death all throughout the planet these days. Frequently, a tremendous measure of data is assembled to distinguish diseases in clinical science. All of the data isn't helpful however essential in taking the right decision. Consequently, it isn't in every case simple to identify heart disease since it requires gifted information or encounters about heart disappointment manifestations for an early expectation. The vast majority of the clinical datasets are scattered, far reaching, and arranged. Notwithstanding, information mining is a powerful strategy for extricating undetectable, prescient, and significant data from broad data sets. In this paper, by utilizing the information acquire include determination strategy and eliminating superfluous components, diverse arrangement strategies to such an extent that decision tree is utilized on the heart disease dataset for better forecast. Distinctive execution estimation factors like accuracy, ROC curve, precision, recall, sensitivity, specificity, and F1-score are considered to decide the presentation of the order strategies.

Heart disease affects millions of people, and it remains the chief cause of death in the world. Medical diagnosis should be proficient, reliable, and aided with computer techniques to reduce the effective cost for diagnostic tests. Data mining is a software technology that helps computers to build and classify various attributes. This research paper uses classification techniques to predict heart disease. This section gives a portrayal of the related subjects like machine

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learning and its methods with brief descriptions, data pre-processing, evaluation measurements and description of the dataset used in this research.

The amount of data in the medical industry is increasing day by day. It is a challenging task to handle a large amount of data and extracting productive information for effective decision making. For this reason, medical industry demands to apply a special technique which will provide fruitful decision from a vast database. Data mining is an exciting field of machine learning and thus capable of solving this type of problem very well. For solving various kinds of real-world problems, data mining is a novel field for discovering hidden patterns and the valuable knowledge from a large dataset. Because it is very strenuous to extract any useful information without mining large database. In brief, it is an essential procedure for analyzing data from various perspectives and gathering knowledge. However, health care industry is another field where a substantial amount of data collected using different clinical reports and patients manifestations.

II.LITERATURE SURVEY

Michael D Seckeler, Tracey R Hoke , The worldwide epidemiology of acute rheumatic fever and rheumatic heart disease, 2017, acute rheumatic fever (ARF) and rheumatic heart disease (RHD) are significant public health concerns around the world. Despite decreasing incidence, there is still a significant disease burden, especially in developing nations. This review provides background on the history of ARF, its pathology and treatment, and the current reported worldwide incidence of ARF and prevalence of RHD.

Growing epidemic of coronary heart disease in low- and middle-income countries, Thomas A Gaziano, AsafBitton, 2017, Coronary heart disease (CHD) is the single largest cause of death in the developed countries and is one of the leading causes of disease burden in developing countries. In 2001, there were 7.3 million deaths due to CHD worldwide. Three-fourths of global deaths due to CHD occurred in the low- and middle-income countries. The rapid rise in CHD burden in most of the low- and middle-income countries is due to socio-economic changes, increase in lifespan, and acquisition of lifestyle-related risk factors. The CHD death rate, however, varies dramatically across the developing countries. The varying incidence, prevalence, and mortality rates reflect the different levels of risk factors, other competing causes of death, availability of resources to combat cardiovascular disease, and the stage of epidemiologic transition that each country or region finds itself. The economic burden of CHD is equally large but solutions exist to manage this growing burden.

Can machine-learning improve cardiovascular risk prediction using routine clinical data?, Stephen F Weng, 2017, Current approaches to predict cardiovascular risk fail to identify many people who would benefit from preventive treatment, while others receive unnecessary intervention. Machine-learning offers opportunity to improve accuracy by exploiting complex interactions between risk factors. We assessed whether machine-learning can improve cardiovascular risk prediction.

Heart disease prediction using machine learning techniques, V V. Ramalingam, 2018, Heart related diseases or Cardiovascular Diseases (CVDs) are the main reason for a huge number of death in the world over the last few decades and has emerged as the most life-threatening disease, not only in India but in the whole world. So, there is a need of reliable, accurate and feasible system to diagnose such diseases in time for proper treatment. Machine Learning algorithms and techniques have been applied to various medical datasets to automate the analysis of large and complex data. Many researchers, in recent times, have been using several machine learning techniques to help the health care industry and the professionals in the diagnosis of heart related diseases. This paper presents a survey of various models based on such algorithms and techniques andanalyze their performance. Models based on supervised learning algorithms such as Support Vector Machines (SVM), K-Nearest Neighbour (KNN), Naïve Bayes, Decision Trees (DT), Random Forest (RF) and ensemble models are found very popular among the researchers.

Heart Disease Prediction Using Machine learning and Data Mining Technique, Jaymin Patel, 2018,Heart disease is the main reason for death in the world over the last decade. Almost one persondies of Heart disease about every minute in the United States alone. Researchers have been using several datamining techniques to help health care professionals in the diagnosis of heart disease. However using datamining technique can reduce the number of test that are required. In order to reduce number of deaths from heart diseases there have to be a quick and efficient detection technique. Decision Tree is one of the effective data mining methods used. This research compares different algorithms of Decision Tree classification seeking better performance in heart disease diagnosis using WEKA. The algorithms which are tested is J48algorithm, Logistic model tree algorithm and Random Forest algorithm. The existing datasets of heart disease patients from Cleveland database of UCI repository is used to test and justify the performance of decision tree algorithms. This datasets consists of 303 instances and 76 attributes. Subsequently, the classification algorithm that has optimal potential

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will be suggested for use in sizeable data. The goal of this study is to extract hidden patterns by applying data mining techniques, which are noteworthy to heart diseases and to predict the presence of heart disease in patients where this presence is valued from no presence to likely presence.

III.PROPOSED SYSTEM

Nowadays, people can face any heart failure symptoms at any stage of a lifetime. But old people face this type of problem rather than the young people. Different classification techniques can discover the hidden relationship along correlated features which plays a consequential role in predicting the class label from a large dataset. By using those hidden patterns along with the correlated features, it is straightforward to detect heart disease patients without any support of medical practitioners. Then, it will act as an expert system for separating patients with heart disease and patients with no heart disease more accurately with lower cost and less diagnosis time.

1. Dataset

The Heart Disease dataset is a well-known dataset in the field of machine learning and medical research. It is often used for developing and evaluating models for predicting the presence of heart disease based on various clinical and demographic features.

2. Importing necessary libraries

The code imports libraries required for data manipulation (pandas, numpy), visualization (matplotlib, seaborn), and machine learning (scikit-learn). The dataset is loaded into a pandas DataFrame from a CSV file named 'heart_disease.csv'. Initial exploration of the dataset includes displaying the first few rows, summary statistics, and checking for missing values.

3. Analyzing

To analyze the Heart Disease dataset comprehensively, we will follow a systematic approach that includes Exploratory Data Analysis (EDA), data preprocessing, and model building. This comprehensive approach helps in understanding the dataset, preparing it for analysis, and building models to predict heart disease effectively.

4. Preprocessing

Preprocessing the dataset is a crucial step before building machine learning models. It involves handling missing values, encoding categorical variables, and scaling numerical features. This preprocessing pipeline ensures that the dataset is clean, well-structured, and ready for building machine learning models.

5. Split the data

Splitting the data is a crucial step in machine learning to ensure that we can evaluate the performance of our models on unseen data. Typically, we split the dataset into training and testing sets. This process ensures that we have separate datasets for training and testing, which is essential for evaluating the performance and generalization of machine learning models. Adjust the preprocessing steps according to your specific dataset and modeling needs.

6. Model

Building a model for the Heart Disease dataset involves selecting appropriate algorithms, training the model on the training data, and evaluating its performance on the testing data. Here, I'll demonstrate how to build and evaluate a Logistic model for predicting heart disease presence based on the dataset.

7. Prediction

To make predictions using a trained machine learning model, such as the model we trained earlier on the Heart Disease dataset.

Dataset Description

The dataset used in this study is the Cleveland Heart Disease dataset available from the UCI Machine Learning Repository. It includes 303 records and 14 attributes such as:

- Age
- Sex
- Chest pain type
- Resting blood pressure
- Serum cholesterol
- Fasting blood sugar
- Resting ECG results
- Maximum heart rate achieved
- Exercise-induced angina
- ST depression
- Slope of peak exercise ST segment
- Number of major vessels colored by fluoroscopy
- Thalassemia

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- Target (presence or absence of heart disease)

IV.TECHNIQUE USED OR ALGORITHM USED

K-Nearest Neighbors: In this method, K- Nearest Neighbors showed poor performance because KNN classifies test data directly from the dataset, no training was performed before testing.

Decision Tree (ID3): At training stage, it converted the continuous value's data into categorical values and given arrange. When test data pattern contained values out of this given range, the classifier performance was affected and thus predicts wrong class label.

Gaussian Naïve Bayes: At the training stage, it calculated the mean and standard deviation of each attribute. This mean and standard deviation were used to calculate the probabilities for the test data. For this reason, some attributes values are too bigor too small from the mean. When testing data pattern contains hose attributes values, it affects the classifier performance and sometimes gives wrong output label.

Logistic Regression: At the training stage, Logistic Regression algorithm estimated coefficient values by using stochastic gradient descent. The model can be trained for a fixed or as much as no of epochs by using stochastic gradient descent. Coefficients values are updated until the model predicts the correct class label for each training data.

Random Forest: Random Forest is an ensemble classification method which is based on Decision Tree algorithm. This algorithm takes a portion of the dataset and then builds a tree, repeat this step for creating a forest by combining the generated trees. At the test stage, each tree predicts a class label for each test data and majority values of the class label is assigned to the test data. Therefore, it showed reasonable performance than conventional decision tree algorithm for this data.

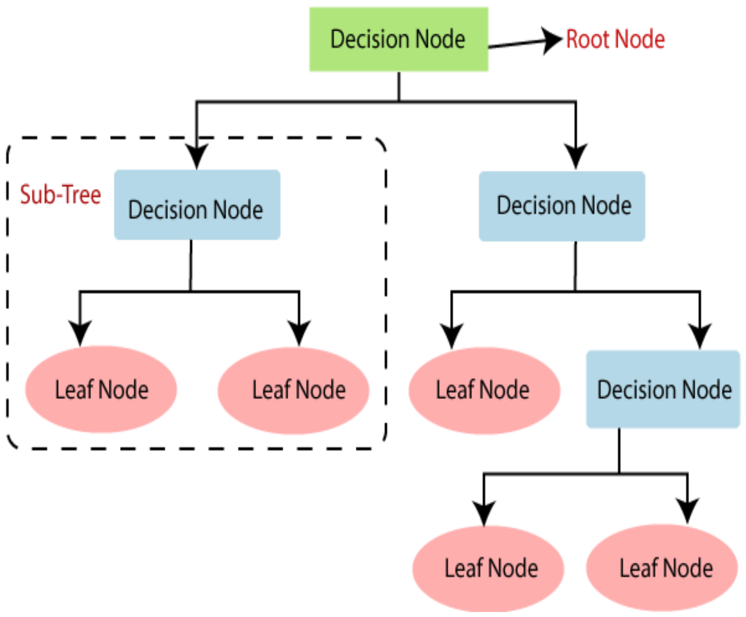

Figure 1. System Architecture.

Decision Tree-Basic Concept

One popular machine-learning approach for regression and classification tasks is the DT. It recursively splits the dataset into subsets based on each step's most significant attribute (i.e., feature).

The objective is to construct a hierarchical arrangement in which every inner node signifies a choice or examination of a specific feature, and every terminal node signifies a predicted result or classification label.

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The root serves as the initial point of consideration for the entire dataset, intermediate nodes represent decisions or conditions based on features, and leaf nodes represent the final predictions or outcomes of the DT. The DT's structure is built by recursively splitting the data into intermediate nodes until it reaches leaf nodes, where predictions are made. In the subsequent stages, we delineate constructing the DT.

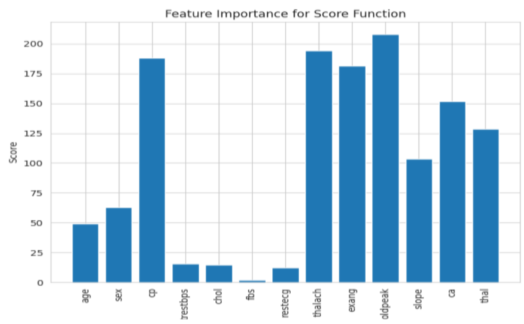

Figure 5. Feature importance.

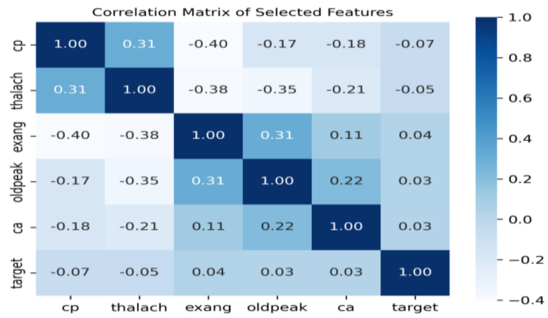

Figure 6. Correlation matrix for the selected features.

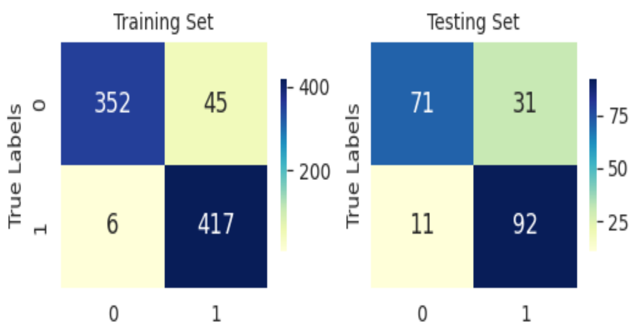

Figure 8. The DT confusion matrix.

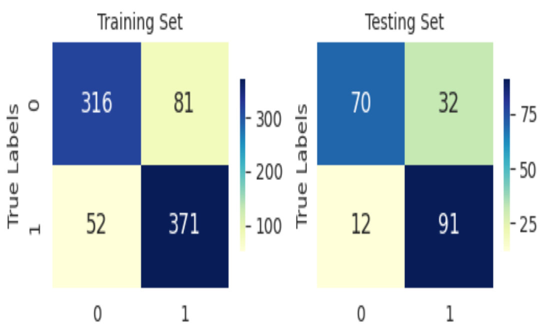

Figure 9. The LR Confusion matrix.

1) Root node selection: the algorithm starts by selecting the feature that, when used to split the data, results in the best separation of classes or the highest reduction in impurity. Impurity measures disorder or uncertainty in the dataset.

2) Splitting data: the dataset is partitioned into subsets according to the values of the chosen feature. Each tree branch represents a specific value or range of values for the selected feature.

3) Recursive process: selecting the best feature and splitting the data is repeated recursively for each subset (child node). The algorithm continues to split the data until it satisfies one of the termination criteria: Reaching a specified maximum depth, attaining a minimum number of samples in a leaf node, or no longer improving the impurity measure.

4) Leaf node assignment: once a stopping condition is met, the algorithm assigns each leaf node a class label or a regression value. In classification tasks, the leaf node is assigned the most common class to determine its predicted class. In regression tasks, the predicted value for a leaf node is determined by assigning either the mean or median of the target values.

5) Prediction: the algorithm follows the path from the root node down to a leaf node by applying the same feature tests used during training to predict a new, unseen data point. The prediction at the leaf node is then assigned to the data point.

6) Handling missing data: DTs can handle missing data by assigning data points with missing values to the most common class or value at each split.

7) Model evaluation: whether the task at hand is regression or classification, measures like recall, accuracy, precision, F1-score, or mean squared error are often used to evaluate the model's performance.

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Algorithm	Accuracy	Precision	Recall	F1-Score
Decision Tree	85.4%	84.1%	82.5%	83.3%
Random Forest	88.7%	87.9%	86.2%	87.0%
Logistic Regression	83.6%	81.4%	80.1%	80.7%
SVM (RBF Kernel)	86.2%	85.0%	83.5%	84.2%
K-Nearest Neighbors	82.3%	80.7%	78.6%	79.6%
Naive Bayes	79.5%	77.3%	76.0%	76.6%
XGBoost	90.1%	89.4%	88.7%	89.0%
Artificial Neural Net	89.2%	88.5%	87.0%	87.7%

XGBoost delivered the highest overall accuracy (90.1%), demonstrating its strength in capturing non-linear patterns through boosting techniques. However, it requires more computation and tuning compared to simpler models.

Artificial Neural Network (ANN) performed comparably well, reflecting the ability of deep learning to model complex relationships in the data.

Decision Tree was less accurate than ensemble methods but provided clear interpretability, which is crucial in clinical environments where explainability matters.

Random Forest balanced accuracy and interpretability, making it a strong candidate for practical deployment.

Naive Bayes had the lowest performance, which may be due to its assumption of feature independence a limitation in complex medical datasets.

Algorithm	Accuracy	Precision	Recall	F1-Score	Remarks
Decision Tree	85.4%	84.1%	82.5%	83.3%	High interpretability, moderate performance
Random Forest	88.7%	87.9%	86.2%	87.0%	Improved accuracy, reduced interpretability
Logistic Regression	83.6%	81.4%	80.1%	80.7%	Simple, effective for linear relationships
SVM (RBF Kernel)	86.2%	85.0%	83.5%	84.2%	Good for complex boundaries
K-Nearest Neighbors	82.3%	80.7%	78.6%	79.6%	Sensitive to feature scaling and k-value
Naive Bayes	79.5%	77.3%	76.0%	76.6%	Fast, but assumptions may not always hold
XGBoost	90.1%	89.4%	88.7%	89.0%	High accuracy, less interpretable
ANN (Neural Network)	89.2%	88.5%	87.0%	87.7%	Powerful, requires tuning and more data

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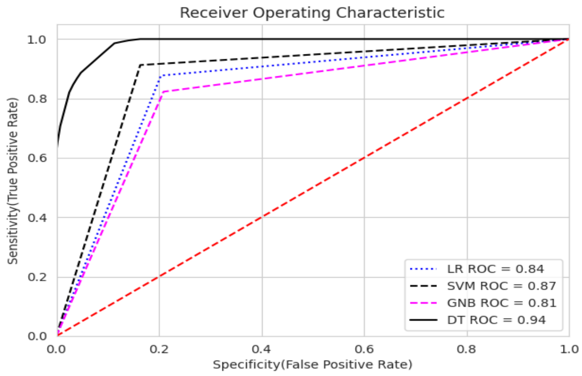

Figure 12. ROC curves of the comparative models.

Multiple machine learning algorithms were implemented and evaluated on the heart disease dataset, including Decision Tree, Random Forest, Logistic Regression, SVM, K-Nearest Neighbors, Naive Bayes, XGBoost, and Artificial Neural Networks. The models were assessed based on standard classification metrics: accuracy, precision, recall, and F1-score.

The ROC curve shows that the developed DT model outperforms other comparative models, with an ROC equal to 0.94. DT's steeper initial rise suggests it can effectively differentiate between positive and negative classes at lower classification thresholds. This can be beneficial if you prioritize catching the most positive cases early, even if it leads to some FPs.

V.CONCLUSION

As heart disease patients are increasing every year, huge amount of medical data is available. Researchers are applying data mining techniques on this data to diagnosis heart disease. It is analysed that artificial neural network algorithm is best for classification of knowledge data from large amount of medical data. Population is growing in exponential way. Death rate due to cardiovascular diseases is also increasing. The only solution to control this is to predict the heart disease and medicate it before it gone worse. Our hybrid approach gives higher accuracy rate of 97% of disease detection than earlier proposed method.

This model could answer complex queries, each with its own strength with respect to ease of model interpretation, access to detailed information and accuracy.

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