Alinteri J. of Agr. Sci. (2021) 36(1): 609-615
e-ISSN: 2587-2249
info@alinteridergisi.com

http://dergipark.gov.tr/alinterizbd
http://www.alinteridergisi.com/
DOI:10.47059/alinteri/V36I1/AJAS21086

RESEARCH ARTICLE

An Innovative Method for Predicting and Classifying Inadequate Accuracy in Heart Disease by Using Decision Tree with K-Nearest Neighbors Algorithm

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ARTICLE INFO

Article History:
Received: 08.04.2021
Accepted: 15.05.2021
Available Online: 21.06.2021

Keywords:
Heart Disease
Innovative Decision Tree
K-Nearest Neighbors
Accuracy Rate
Medical Parameters
Machine Learning

ABSTRACT

Aim: Predicting the Heartdiseases using medical parameters of cardiac patients to get a good accuracy rate using machine learning methods like innovative Decision Tree (DT) algorithm. **Materials and Methods:** Supervised Machine learning Techniques with innovative Decision Tree (N = 20) and K Nearest Neighbour (KNN) (N = 20) are performed with five different datasets at each time to record five samples. **Results:** The Decision Tree is used to predict heart disease with the help of various medical conditions, the accuracy is achieved for DT is 98% and KNN is 72.2%. The two algorithms Decision Tree and KNN are statistically insignificant (=.737) with the independent sample T-Test value (p<0.005) with a confidence level of 95%. **Conclusion:** Prediction and classification of heart disease significantly seem to be better in DT than KNN.

Please cite this paper as follows:

Rajesh, M. and Dr. Malathi, K. (2021). An Innovative Method for Predicting and Classifying Inadequate Accuracy in Heart Disease by Using Decision Tree with K-Nearest Neighbors Algorithm. *Alinteri Journal of Agriculture Sciences, 36*(1): 609-615.
doi: 10.47059/alinteri/V36I1/AJAS21086

Introduction

To develop a risk prediction and accurate model of heart disease with classification algorithms over various medical attributes of cardiac patients like age, chest pain, fasting blood sugar, etc. (Sultana, Haider, and Uddin 2016). Over 17.9 million people are losing their lives every year because of heart problems. The main reasons for these heart diseases are illness, stress, depression, overthinking, excess fat growth in the body. This can be overcome when those symptoms are predicted in advance. (Marimuthu et al. 2018). These proposed systems can be replaced in medical areas so that it becomes easier to classify the patients with symptoms (Khateeb and Usman 2017).

There are several papers published to overcome these problems. Only a few of them were successful in predicting accurate results. 26 papers from IEEE Xplore and 15 from google scholar have been selected and referred to in this paper. (Rani et al. 2018) implemented multiple regression models with 70% training data and 30% testing data. with 13 different heart disease medical parameters, he concludes that his proposed algorithm is better than other algorithms. (Sultana, Haider, and Uddin 2016) discussed heart disease prediction using Kstar, SMO, and Bayes net, using WEKA tool. After performing cross-validation with proposed techniques he stated that those prediction results will not be enough to classify the heart disease patients with limited datasets. (Pahwa and Kumar 2017) proposed a data mining technique for heart disease prediction with effective results. where his system helps in making effective decisions with specific parameters. In the proposed model accuracy in training is

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87.3% and accuracy in testing is 86.3%. (Mokhlessi, Mehrshad, and Rad 2010; Cako, Njeguš, and Matić 2017) developed artificial neural network models with Feedforward backpropagation. Based on the literature survey, which helps in predicting heart disease with 88% accuracy and 20 neutrons in a hidden layer from the above survey the ANN model is named as the best model in the prediction of heart disease. In Fig.1 the architecture of heart disease prediction is mentioned.

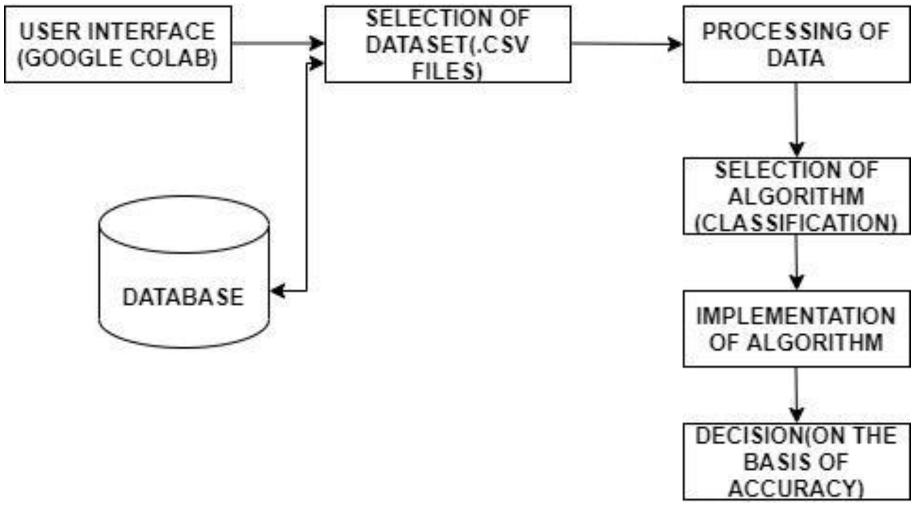

Fig. 1. Architecture Diagram for Heart Disease Prediction

Previously our team has a rich experience in working on various research projects across multiple disciplines (Sathish and Karthick 2020; Varghese, Ramesh, and Veeraiyan 2019; S.R. Samuel, Acharya, and Rao 2020; Venu, Raju, and Subramani 2019; M. S. Samuel et al. 2019; Venu, Subramani, and Raju 2019; Mehta et al. 2019; Sharma et al. 2019; Malli Sureshbabu et al. 2019; Krishnaswamy et al. 2020; Muthukrishnan et al. 2020; Gheena and Ezhilarasan 2019; Vignesh et al. 2019; Ke et al. 2019; Vijayakumar Jain et al. 2019; Jose, Ajitha, and Subbaiyan 2020). Now the growing trend in this area motivated us to pursue this project.

The existing system fails in predicting when there is a variation in the number of medical parameters. The aim of the study is to predict the accuracy of heart disease.

Materials and Methods

The study setting of the proposed work is done in our university. The study setting of the proposed work is done in our university laboratory. The sample size was calculated by using clincalc.com by keeping G Power (Kane, Phar, and BCPS n.d.) and the minimum power of the analysis is fixed as 0.8 and the maximum accepted error is fixed as 0.5 with a threshold value of 0.05% and Confidence Interval is 95%. Mean and standard deviation has been calculated based on the previous literature for size calculation. In this methodology, two groups are used. The group1 (N = 20) is the K-nearest neighbor which is an existing system and group 2 (N = 20) is the Decision tree.

Dataset Preparation

The collection of various medical parameters which are responsible for cardiac diseases is listed out. Only 13 parameters are considered for predicting heart disease. Dataset has been collected from the Kaggle repository (https:/www.kaggle.com/ronitf/heart-disease-uci). The dataset includes 1024 instances, in which 80% of the training set and 20% of the test set. The parameters are

1. Age: age
2. Sex: male/female
3. Cp: Chest pain
4. Trestbps: Resting blood pressure
5. Chol: Serum cholesterol
6. FBS: Fasting blood sugar
7. Restecg: Resting electrocardiographic results
8. Thalach: Maximum heart rate achieved
9. Exang: Exercise-induced angina
10. Oldpeak: ST depression induced by exercise relative to rest
11. Slope: Represent exercise ST segment
12. Ca: Total number of major vessels
13. Thal

Datasets are preprocessed by the removal of attributes and normalization. In heart_disease data sets specified in Table 1.

Table 1. Five Random samples from Dataset, the attributes painexer, relrest which are independent attributes are removed from the .csv file and do not affect the results

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
236	63	0	0	108	269	0	0	169	1	1.8	1	2	2	0
79	58	1	2	105	240	0	1	154	1	0.6	1	0	3	1
160	56	1	1	120	240	0	0	169	0	0.0	0	0	2	1
63	41	1	1	135	203	0	1	132	0	0.0	1	0	1	1
211	61	1	0	120	260	0	0	140	1	3.6	1	1	3	0

K-Nearest Neighbors Algorithm

Machine learning method KNN is a supervised machine learning algorithm that is used for both classification and regression problems. It is easy to understand and also for implementation. The Classification is based on the K value which is a distance parameter. This parameter will be applied to find new data points and cluster them based on their properties and features.

In the existing system, the K value is used as 7 for classifying the features in medical parameters. 80% of the data used for training the system and 20% of the data used for testing. Finally, 72.2% accuracy has been achieved for heart disease prediction using the existing KNN.

Pseudocode

Initially assign K value as 7.
KNN (dataset, sample)

1. Go through each item of the dataset and calculate the distance from the data item to a specific sample.
2. Cluster the samples of the majority classes between K-samples in the dataset having the smallest distance to the sample.
3. Every new item will be classified based on its properties and assigned to existing groups.
4. Repeat step 3 and return the results.

Decision Tree Algorithm

A Decision Tree is a classification and supervised machine technique where the main attribute will be placed as a root node and continues to divide the root node into branches. This will continue in both left and right nodes of the tree till it reaches the end of all parameters. Based on yes or no type split will take place in every level of the tree.

Root Node = Decision Node
Leaf Node = Child Node

Once it completes this process decision will be taken in a classification manner to give output. The whole data will be split into two parts. One part consists of 80% which is for training and another set with 20% of the testing data set. In Fig.2 the decision tree process flow has been mentioned.

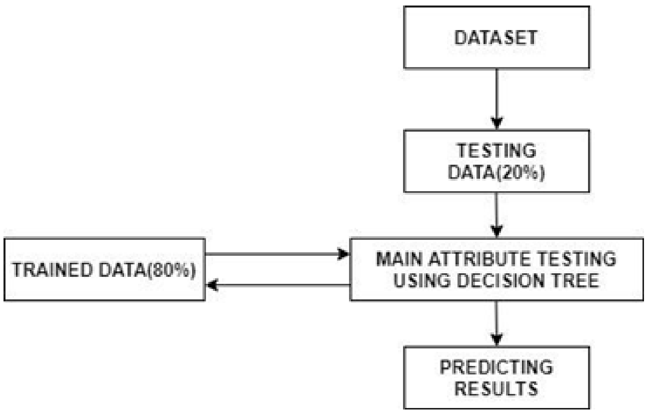

Fig. 2. Process diagram Decision Tree Algorithm

Pseudocode

1. Place the best attribute at the root node
2. Split the training set into two subsets
3. Repeat both 1 and 2 on both left and right side of a tree till you find leaf nodes in all branches of the tree
4. Consider all the branches which reach the leaf node from the root node.
5. Cluster the features using step 4.
6. Repeat from step 2 to step 5 for testing data until clustering into existing groups.
7. Perform accuracy function on major groups and return the value.

Both proposed and existing algorithms are executed in Google colab, which is an online platform with python as an integrated development environment and open source to access. The hardware and software specifications include a 64-bit windows system with 4GB RAM and intel core i3 as a processor.

Each dataset is split into two groups. first group as the training set (80% of the dataset) and the second group as testing set (20% of the dataset). Built-in training package which is imported from sklearn package will default train the system based on the training dataset. The testing procedure will be based on the classification algorithm we select. In this paper, 20% of the testing set will be assigned to the Decision Tree as a parameter. As a result, the testing set will be compared with the Training set and cluster the similar property data points into groups.

Results

Each group is executed with five different numbers of datasets at different times to obtain five sample groups. These sample groups will be used in the IBM SPSS tool to calculate the independent sample T-Test which gives significant value for comparing the Decision Tree (DT) and K Nearest Neighbors (KNN) Algorithm. For comparing both models, five different input datasets are used and respective accuracy values are recorded below. Decision Tree has been classified as a better algorithm than K-Nearest Neighbors in the prediction of Heart Disease due to automatic feature interaction in the dataset. Where KNN has no scope to reach every attribute automatically. The time complexity of KNN is greater than DT in real-time execution. In Table 2 Data collection from N=20 sample datasets for KNN and Decision Tree using target variable as Independent variable.

Table 2. Data collection from N=5 sample datasets for KNN and Decision Tree using target variable as Independent variable.

Samples (N)	**KNN (Accuracy%)**	**Decision Tree (Accuracy%)**
270	62.5%	85.19%
299	58.33%	81.67%
303	67.21%	81.67%
1025	72.2%	98.80%
760	57.24%	77.24%

Statistical Analysis

The statistical comparison of the Heart Disease prediction using two sample groups was done through SPSS version 21. target and accuracy are Dependent variables and the remaining are independent variables. Analysis was done for mean, standard deviation, independent T-test.

Table 3. Group Statistics T-Test for K-Nearest Neighbors with Standard Error Mean (2.789) and for Decision Tree (3.867)

groups	N	Mean	Std. Deviation	Std.Error Mean
accuracy KNN	5	63.588	6.237	2.789
Decision Tree	5	85.292	8.648	3.867

Table 4. Independent Sample T-Test is applied with the sample collections by fixing the level of significance as ($p<0.05$) with confidence interval as 95% after applying the SPSS calculation to Decision Tree Algorithm

	Levene's Test for equality of variance		T-Test for Equality of Means						
	F	Sig	1	df	sig (2-tailed)	Mean difference	std. error difference	95% confidence interval of the difference	
								Lower	Upper
equal variance assumed	.121	.737	-4.551	8	.002	-21.704	4.768	-32.700	-10.707
equal variance not assumed			-4.551	7.275	.002	-21.70	4.768	-32.894	-10.513

Table 3: Group Statistics T-Test for K-Nearest Neighbors with Standard Error Mean (2.789) and for Decision Tree (3.867). Table 4: Independent Sample T-Test is applied with the sample collections by fixing the level of significance as ($p<0.05$) with confidence interval as 95% after applying the SPSS calculation to Decision Tree Algorithm.

In Fig.3: Bar chart representing the comparison of Mean Accuracy of Heart Disease Prediction computed with Decision Tree and KNN algorithms. Decision Tree appears to produce the most consistent results with minimal standard deviation. KNN appears to produce the most variable results with its standard deviation ranging from the lower 70's to the upper 90's. There is a significant difference between KNN and Decision Tree algorithms. ($p< 0.05$ Independent Sample T-Test).

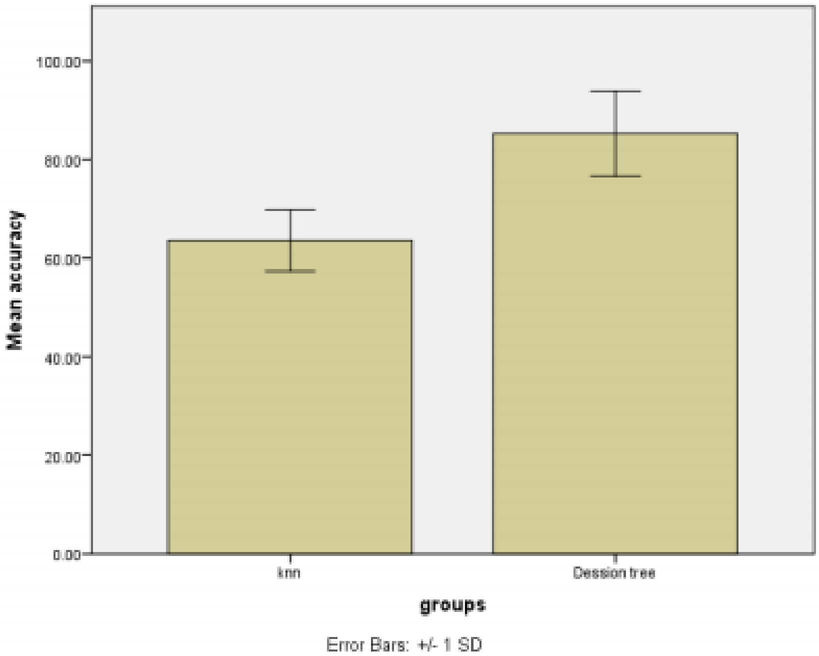

Fig. 3. Bar graph between KNN and Decision Tree. Comparison of KNN algorithm and Decision Tree algorithm in terms of mean accuracy. The mean accuracy of KNN is better than Decision Tree and the standard deviation of KNN is slightly better than Decision Tree. X-Axis: KNN vs Decision Tree Y-Axis: Mean accuracy of detection ± 1 SD

Discussion

Our overall results obtained by performing SPSS tool calculations state that the proposed Decision Tree (98%) algorithm is best suited for Heart Disease prediction which satisfies significantly ($p<0.05$) compared to the K-Nearest Neighbors algorithm (72.2%). (Chauhan et al. 2018) states that the Support Vector Machine with linear model shows 85% accuracy and concluded more instants are needed to classify the data. But in the proposed model the results varied with the same instances with decision trees, and the classification led to high accuracy of 98%. (Kaur and Gupta 2018) used 303 instants with limited attributes using Random Forest and showed a positive prediction of 98.45% accuracy with extended classification in the training set but in the proposed model, less accuracy which is 98% because the collection of decision trees in random forest performs better than single decision trees. However, the difference was not statistically significant ($p<0.05$).

(Rani et al. 2018) who reported that the dependent variable value varies by the total number of instants and parameters considered in the dataset and proves 78% accuracy using nonlinear methods in logistic regression. Non-linear logistic may normalize some of the key attributes in preprocessing where decision trees train the system with each attribute in the form of the tree structure and give more (98%) accuracy than the logistic regression. Some of the previous studies by (Prabakaran and Kannadasan 2018), who states that deep learning technology has more accuracy of about 80% due to hidden layer classification among specific medical parameters out of 64 but the results were identified in the proposed model based on the contrast with Decision tree algorithm, which has the highest accuracy of 98% due to top-down classification during preprocessing. The image processing is involved in the detection of images on a heart disease predict relevant details based on the detection by different classification process ((“Recognition and Classification of Diabetic Retinopathy Utilizing Digital Fundus Image with Hybrid Algorithms” 2019; Malathi and Nedunchelian 2018). The findings in this paper were almost similar to the above-cited papers. Only the number of parameters and instances of data will decide the accuracy because classification becomes stronger when the data provided in preprocessing is directly related. The accuracy is always dependent on the total number of medical parameters and the number of instants. From the overall literature, many authors have cited proposed better accuracy compared to existing methods.

Our institution is passionate about high quality evidence based research and has excelled in various fields ((Vijayashree Priyadharsini 2019; Ezhilarasan, Apoorva, and Ashok Vardhan 2019; Ramesh et al. 2018; Mathew et al. 2020; Sridharan et al. 2019; Pc, Marimuthu, and Devadoss 2018; Ramadurai et al. 2019). We hope this study adds to this rich legacy.

For this study, data has been taken from medical centers which are stored one year before the database and there will be a chance for data collision. So these manual entries will not exist for a long time. The range differs a lot in future times. To overcome this, the system has not been fully automated and needs data from users for a full diagnosis. The Decision Tree algorithm is more sensitive to noisy data and outliers. Application developers can work with medical experts to convert this into a real-time application.

Conclusion

In this research, the Heart disease prediction using an innovative Decision Tree is performed with the heart disease dataset found with an accuracy of 98% using Decision Tree which is a promising result than the existing K Nearest Neighbors Algorithm of 72.2%. This proposed model can be used in clinical areas.

Declarations

Conflict of Interests

No conflicts of interest in this manuscript.

Authors Contributions

Author Mandhapati Rajesh was involved in conceptualization, data collection, data analysis, manuscript writing. Author Dr.K. Malathi was involved in conceptualization, guidance, and critical review of the manuscript.

Acknowledgments

The authors would like to express their gratitude towards Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (Formerly known as Saveetha University) for providing the necessary infrastructure to carry out this work successfully.

Funding: We thank the following organizations for providing financial support that enabled us to complete the study.

1. I pharmed Services, Bangalore.
2. Saveetha University.
3. Saveetha Institute of Medical and Technical Sciences.
4. Saveetha School of Engineering.

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