Predictive analytics of heart disease presence with feature importance based on machine learning algorithms

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ABSTRACT

Heart failure disease is a complex clinical issue which has more impact on life of human begins. Hospitals and cardiac centers frequently employ electrocardiogram (ECG) tool to assess and to identify heart failure at early stages. Healthcare professionals are very concerned about the early identification of heart disease. In this research paper we have focused on predictive analysis of cardiac disease by using machine learning algorithms. We have developed python-based software for healthcare research in this paper. This research has more significant work for tracking and establishing numerous health monitoring apps. We have demonstrated information handling that requires adjusting clear-cut portions and working with absolute factors. A quick overview of the various machine learning technologies based on heart disease diagnosis is described clearly in this research. A more reliable way for diagnosing cardiac problems is the random forest (RF) classification algorithm. This application needs data analysis, which is crucial owing to its about 95% accuracy rate across training data. We have discussed the tests and findings of the RF classifier method, which improves the accuracy of heart disease research diagnosis.

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1. INTRODUCTION

Heart diseases are frequently used as a substitute for cardiovascular diseases. The majority of these conditions are brought on by constricted or blocked plasma arteries, which can induce a heart attack, a stroke, or chest pain known as angina. Heart conditions can take many different forms, including those that affect the muscle, valve, or rhythm of the heart. On the other hand, machine learning is essential for determining who has cardiac disease [1]. In any scenario, if critical information for treating and diagnosing patients was foreseen in advance, clinicians would have a lot simpler time collecting it. Heart illness is frequently misdiagnosed as coronary artery disease [2], [3].

The main contribution of the paper is as follows:

– This research has more significant work for tracking and establishing numerous health monitoring apps.
– A quick overview of the various machine learning technologies based on heart disease diagnosis is described clearly in this research [4]–[6]. First, a weighted variant of logistic regression is employed to predict cardiac disease. The second one is automated and examines the location and diagnosis of ischemic heart disease, according to information theory, frequency domain, and temporal domain properties.

– We have also implemented the major stages of usage progress: analyzing dataset properties, performing logistic regression, and gathering databases.

The following is how the paper is set up: The theoretical and mathematical foundations of feature selection and classification methods in machine learning are briefly discussed in section 2's background material on the heart disease dataset. Proposed work is presented in section 3. Remaining sections are the Training datasets, cross-validation approach and measures for performance evaluation under results and discussion section.

2. RELATED WORK

The American College of Cardiology/American Heart Association (ACC/AHA) models for cardiovascular disease (CVD) finding and forecast perform better when artificial intelligence is applied in disease detection systems, particularly cardiac disease detection systems [7]–[9]. Examination of the possibilities of offering advanced services through a humanoid healthiness administration system, and they also suggested an investigation path for medical technology on the internet of things (IoT) [10]–[12]. They have investigated a variety of health-related technologies and sensors. They have discovered a few issues that must be addressed [13]. Prior researchers created the home-based checking system and conclusion support system [14], [15]. The wireless health monitoring system (WHMS) has attracted a lot of interest from both the academic and corporate communities during the last 10 years [16]–[18]. A few AI computations and classifier demonstrations, such as weighted cooperative classifier, were accounted for in the discovery of cardiac anomalies [19]–[21].

A present mobile healthcare system which was exhibited elderly individuals and also monitored from inside or outside [22]–[24]. The main components of the system were a smartphone and a signal sensor. The data from the bio-signals sensor was delivered to a brainy server for data collecting over the GPRS/UMTS network [25]. The device may monitor the old patient's flexibility, energetic signs, location, and illness from a remote place. A fully operational wireless body area network (WBAN) system was planned [26], [27]. Medical bands were utilized to collect physiological data from devices in the developed system. The author chooses several medical bands to prevent interference between the sensors and other existing equipment [28]. A medical gateway wireless board was utilized to widen the functioning area using the multi-hopping approach.

In recent years, data mining and machine learning have made tremendous advances in the healthcare business [29]. These treatments have been widely accepted and have demonstrated feasibility in a variety of medical care applications, particularly in the field of clinical cardiology. Researchers currently have an unrivalled opportunity to create and test novel algorithms in this field because of the enormous body of medical data [30].

3. PROPOSED WORK

The proposed system starts with data collection and feature selection. The main part is data preprocessing and exploratory data analysis (EDA) [31]. Utilise this to analyse the data and then convert it to the appropriate format. The machine learning algorithm may be trained using training data, and then it can be tested using test data. Finally find the accuracy using test data. Our proposed system is implemented based on following modules:

a) Dataset collection.
b) Feature selections.
c) Data pre-processing method.
d) Handling imbalanced data.
e) Disease prediction.

3.1. Proposed algorithms

3.1.1. Logistic regression

Logistic regression as shown in (1) is most extensively used supervised machine learning algorithms. It is used to predict the category reliant on features using a specific collection of independent factors. Strategic relapse forecasts the result of an all-out subordinate feature. As an outcome, the output necessity is moreover separate or definite set of data categorically. It can be true or false, and zero or one. Precise number is in between zero and one [32], it offers probabilistic values among zero and one:

$$Log\ loss\ = \sum (x,y) € D\ -\ y\ log(y1) - (1-y\ )\ log(1-y1) \quad (1)$$

(x,y) € D is a large data collection that includes numerous labelled pairs of instances.
y is the actual label it must be 0 or 1.
y^1 is predicted value for input data.

In the Figure 1 shows that machine learning algorithms, logistic regression delivers excellent training efficiency in specific cases while staying easy to apply. Because of the same principles, this technique may be used to train a model without requiring a lot of processing resources [33].

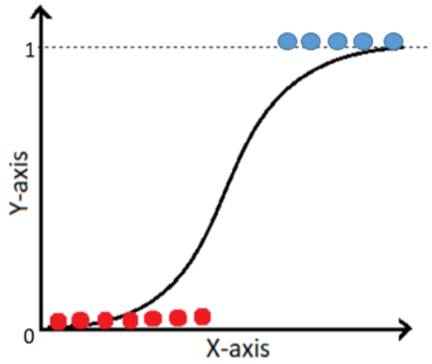

Figure 1. Logistic regression

3.1.2. Support vector machine

In machine learning, support vector machine is one of the mostly used supervised machine learning technique. It is useful for solving regression and classification issues with the help of (2). However, in machine learning, it is mostly used to crack all types of classification problems [34]. The support vector machine method's objective is to identify the best line or decision boundary for classifying n-dimensional space so that subsequent data points can be quickly assigned to the appropriate group. This optimal choice frontier is known as a hyperplane [35]. Figure 2 represents how support vector machine works.

$$\text{Los function} = \frac{1}{2}\|W\|^2 + C\sum_i \max(0,1 - y_i\,(W^T X_i + b)) \quad (2)$$

$\|W\|^2$ term regularize and the max (0,1-$y_i(W^T X_i + b)$) term loss function.

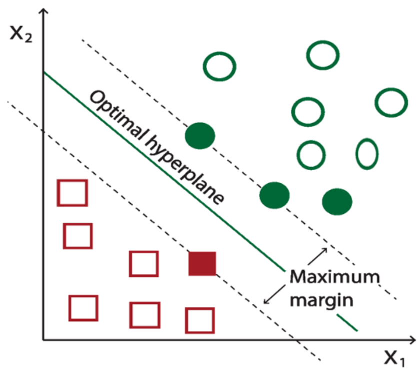

Figure 2. Support vector machine

3.1.3. Random forest (RF) algorithm approach

RF is an ensemble learning system. It is an enhancement to a machine learning classifier that uses bagging to boost decision tree performance. Trees are reliant on a random vector that is individually tried, and it combines tree predictors. Each tree is dispersed in the same manner [36]. RF splits nodes based on the best prediction subset chosen at random from the node itself, as opposed to splitting nodes based on factors. When employing RF, the worst-case temporal complexity of knowledge is O (M ($d_n log_n$)), where M is the number of maximum trees, n is the number of occurrences, and d is the number of features or columns. Regression and classification are two possible uses for it.
Random Forest = Bootstrap Samples + Decision Tree + Column Sampling + Aggregation

4. RESULTS AND DISCUSSION

Dataset description: The following dataset value are age, sex, cp, trestbps, chol, fbs, restecg, thalach, exang, oldpeak, slope, ca, thal, target. Table 1 shows the features and the values in the dataset. Train describe (): after training process by using the above datasets, the following values are shown below. It includes with count, mean, std, min and max values. Table 1 shows the original datasets with mentioned attributes and Table 2 shows that Training values with the datasets. In Figure 3 shows Chest pain type can be classified based on sex. Pie chart is displayed below for Female, male, overall details of chest pain type. Age v/s resting blood pressure and Maximum heart rate is also shown. The Figure 4 shows the age v/s resting blood pressure. The Figure 5 shows the age v/s Maximum heart rate achieved. In Figure 6 it is represented machine learning models comparison. Using RF model, we got 98.6% accuracy. In this case out of 300 test data points only 2 positive and 2 negative data points' misclassified remaining 296 data points are correctly classified. We can find that output results in Figure 6. Compared 3 model RF giving best accuracy compared to logistic regression and linear support vector machine models. Misclassified data points are also less and precision, recall and F-1 score values are also better. We can see the comparison in Figure 6 and Table 3 shows the machine learning models comparison table.

Table 1. Original dataset feature description

S.No	age	sex	cp	trestbps	Chol	Fbs	Restecg	thalach	Exang	Oldpeak	Slope	Ca	thal	target
0	64	1	2	146	234	1	0	150.5	0	2.45	0	0	1	1
1	38	1	3	131	251	0	1	187.5	0	3.55	0	0	2	1
2	42	0	1	130.5	205	1	1	173	1	1.42	2	0	2	1
3	57	1	0	120.4	237	0	0	179	0	0.81	0	0	1	1
4	58	0	1	120.5	355	1	1	163.2	0	0.60	2	0	2	1

Table 2. Training values with the datasets

Attributes	Count	Mean	std	min	25%	50%	75%	Max
age	300	54.5	9.09	28.5	48.1	55	62	78
sex	300	0.68	0.45	0.00	0.00	1.00	1.00	1.00
Cp	300	0.96	1.04	0.00	0.00	1.05	1.05	312
Trest bps	300	132	17.56	94.5	120.56	130.7	145.0	200.0
Chol	300	246.25	51.89	126.7	212.01	241.2	274.52	565.000
fbs	300	0.1543	0.3562	0.0000	0.0000	0.0000	0.0000	1.0002
restecg	300	0.534	0.532	0.000	0.000	1.001	1.001	2.000
thalach	300	149.67	23.01	71.53	132.99	153.15	166.05	201.99
exang	300	0.323	0.464	0.000	0.000	0.000	1.001	1.001
Old Peak	300.00	1.034	1.060	0.000	0.000	0.8000	1.605	61999
Slope	300	1.401	0.607	0.000	1.001	1.001	2.0001	2.0001
Ca	300	0.7287	1.0333	0.0000	0.0000	0.000	1.000	4.0101
thal	300.00	231.241	0.6123	0.000	2.0001	2.0001	3.0012	3.0012
target	300.00	0.545	0.499	0.000	0.000	1.001	1.005	1.005

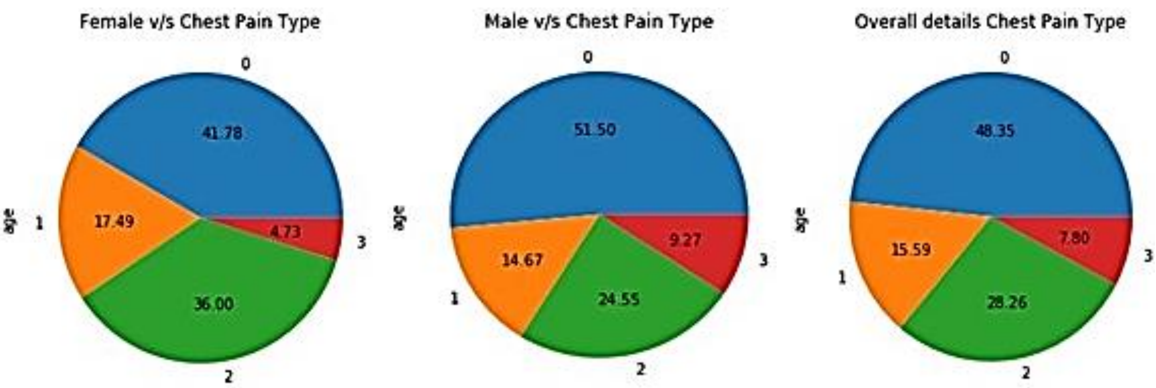

Figure 3. Pie chart for chest pain type

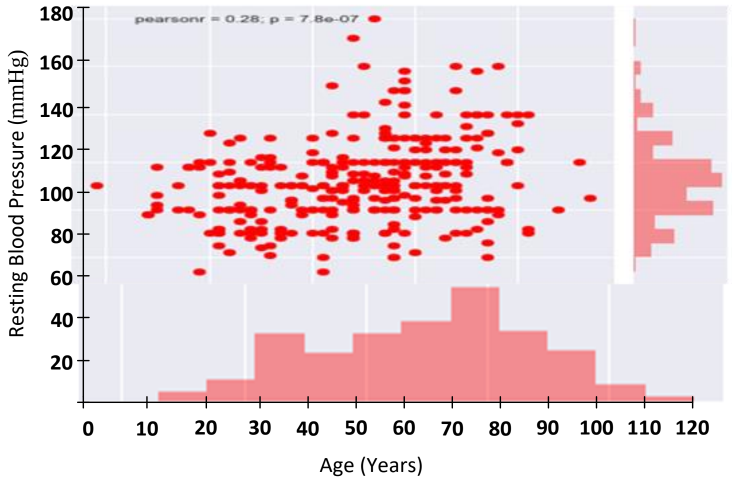

Figure 4. Age v/s resting blood pressure (in mmHg) on admission to the hospital

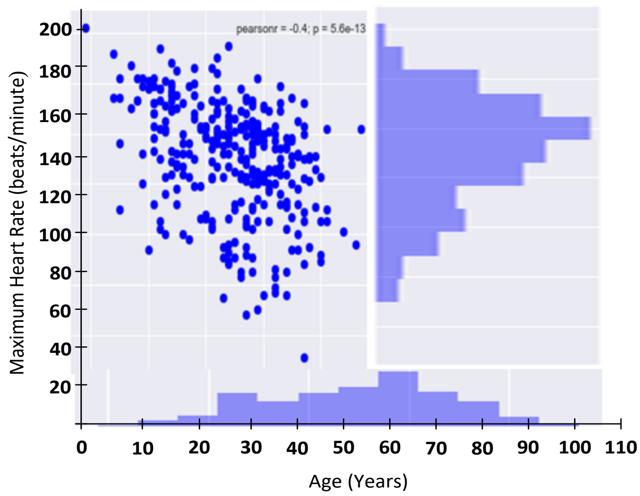

Figure 5. Age v/s maximum heart rate (beats/minute) achieved

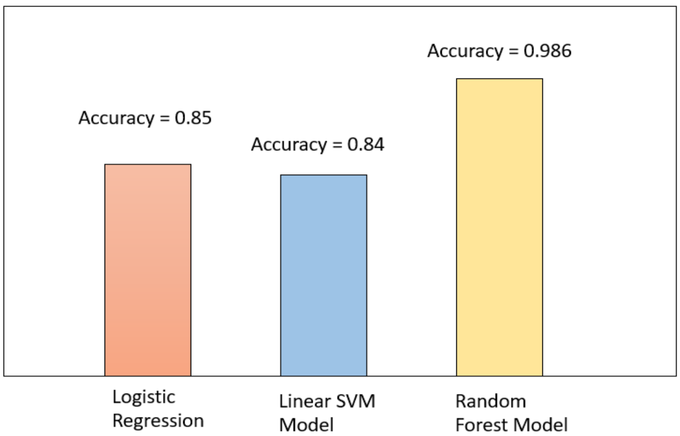

Figure 6. Machine learning models comparison plot

Table 3. Machine learning models comparison table

Models	Accuracy	Precision	Recall	F-1 score
Logistic regression	0.85	0.82	0.84	0.845
Linear support vector machine	0.84	0.83	0.83	0.840
RF classifier	0.986	0.978	0.981	0.984

5. CONCLUSION

The transfer of promising information, such as machine learning, to the early prognosis of heart disorders would have a huge impact on mankind because heart ailments are a prominent cause of mortality in India and throughout the world. Early diagnosis of cardiac disease can help high-risk patients alter their lifestyles to lessen the effects, which can be a significant development in medicine. Every year, the number of persons suffering from heart disease increases. As a result, it may be recognized and treated early.

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