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Enhancing Heart Disease Prediction Accuracy Through Hybrid Machine Learning Methods

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Abstract

INTRODUCTION: Over the past few decades, heart disorders have been the leading cause of mortality worldwide. People over 55 must get a thorough cardiovascular examination to prevent heart disease or coronary sickness and identify early warning signs. To increase the ability of healthcare providers to recognize cardiovascular illness, researchers and experts have devised a variety of clever ways.
OBJECTIVES: The goal of this research was to propose a robust strategy for cardiac issue prediction utilizing machine learning methods. The healthcare industry generates a massive quantity of data and machine learning has proved effective in making decisions and generating predictions with this data.
METHODS: Al has been exhibited to be useful in helping with forecast and decision-production because of the tremendous measure of information made by the medical services a 20 Few explorers have inspected the capability of Al to figure out heart disease. In this article, we suggest a creative strategy. to improve the exactness of cardiovascular sickness forecasts by finding basic highlights utilizing Al systems.
CONCLUSION: There is a lot of promise and possibility in using machine learning techniques to forecast cardiac disease. By means of examining a range of datasets and applying multiple machine-learning methods. Alongside various element blends and not able arrangement procedures, the expectation model is presented. We accomplish a better exhibition level with a Crossbreed Irregular Woods, with a Direct Model as our coronary illness forecast model.

Keywords: Cardiovascular disease, Hybrid Random Forest, Hybrid Random Forest with Linear Model, Support Vector Machines, Artificial Neural Network, Naive Bayes

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1. Introduction

Numerous issues, including diabetes, hypertension, excessive cholesterol, and irregular heartbeat all contribute to the high mortality rate among explorers. Much different the extent of human cardiac disease is to be determined using data mining and neural network techniques. Decision Trees, Logistic Regression, the K-Nearest Neighbour Algorithm, and Support Vector Machine are some of the techniques utilized to classify the severity of the disease. Developing a neural network model that forecasts the spread of the coronavirus is the goal of the research project. This research describes the use of artificial neural networks (ANN) in the transmission of Covid-19 [1].

Special consideration must be given to the condition's treatment due to its intricacy. The potential for mortality from heart disease or other causes if you don't do so is high.

Metabolic diseases are classified using methods from both medical research and data mining. Monstrous volumes of realities are handled utilizing techniques like grouping, bunching, and alliances you can conjecture or decipher current realities. The methodology in question is mining. Choice wood is utilized to conclude how accurately sports related to coronary heart disorder happen. Not too long after, many types of structural heart anomalies were identified. Cardiac examination was limited to pregnancies at high risk of congenital heart disease (CHD) at this period, such as those where extracardiac abnormalities had been found or when a family history of CHD existed [2].

To choose the patient's particular situation almost about coronary respiratory failure, clinical specialists are searching for exhortation from medical facts that integrates the Left Group There are several different types of atrial fibrillation, including second-confirmation block (BII), atrial utter (AFL), uncomfortable ventricular withdrawal (PVC), sinus bradycardia (SBR), Left bundle branch block (LBBB), Right bundle branch block (RBBB), normal sinus rhythm (NSR), and atrial utter (AFL). 30 percent of current realities from a dataset for outspread foundation feature networks (RBFN) are performed grouping, even as 70 percent of the realities are utilized for preparing. Utilizing the popular Clevel and dataset for exploratory approval may be located in a UCI device readings to rehouse. The execution of the Brain Organizations ML approach outcomes in common average overall all performance is extra specific and solid. The suggested method made predictions about heart disease based on 13 medical characteristics. The work's studies demonstrate that the suggested algorithm performs well when compared to comparable state-of-the-art methods [3].
The recommended approach for coronary heart contamination expectation includes thirteen attributes. The outcomes display a higher degree of average overall performance in correlation with the by-utilized approaches. Brain community fashions are utilized, which comprise each destiny probabilities and predictable convictions from some of the antecedent method gathering will begin with recognizing among net internet site online website traffic created with the guide of utilizing IoT contraptions and region website online traffic delivered with the guide of utilizing non-IoT devices. Each IoT device is led out to a definition tool spent inside the 2nd step. This paper aims to evaluate several machine learning and deep learning approaches used in the prediction and classification of cardiac illnesses to determine which approaches are reliable and efficient [4]. Automated learning methods based on examples or unprocessed data have been developed to address this issue [5]. Our objective is to as fast and precisely as possible predict in real-time the gender, age, and expression of a human face [6]

1.1 Problem Statement

Because of several risk factors that contribute to heart disease, including diabetes, high blood pressure, excessive cholesterol, an irregular pulse rate, and many more, diagnosing heart disease can be challenging. To determine the severity of human heart disease, several data mining and neural network algorithms have been used. The severity of the disease is classified based on various methods like the K-nearest neighbor Algorithm (KNN), Decision Trees (DT), and Genetic algorithm. Since cardiac illness has a complicated character, it requires cautious management. Not doing so may affect the heart or cause premature death. The perspective of medical science and data mining are used for discovering various sorts of metabolic syndromes. Data mining with classification plays a significant role in the prediction of heart disease and data investigation. We propose a clever strategy to improve the exactness of cardiovascular sickness forecasts by finding basic highlights utilizing AI systems. Alongside various element blends and not able arrangement procedures, the expectation model is presented. We accomplish a better exhibition level with a Crossbreed Irregular Woods, with a Direct Model as our coronary illness forecast model.

1.2 Motivation

Over the past few decades, heart disorders have been the leading cause of mortality worldwide. People over 55 must get a thorough cardiovascular examination to prevent heart disease or coronary sickness and identify early warning signs. To increase the ability of healthcare providers to recognize cardiovascular- lar illness, researchers and experts have devised a variety of clever ways. The goal of this research was to propose a robust strategy for cardiac issue prediction utilizing machine learning methods. The healthcare industry generates a massive quantity of data and machine learning has proved effective in making decisions and generating predictions with this data.

2. Literature Review

The fields properly applicable to this examination have a wealth of associated work. In the sector of medicine, ANN has been advanced to supply predictions with the highest diploma of accuracy [6]. An ANN is carried out with a lower decrease again propagation specifically, Support Vector Machines and Supportive layer perception (MLP). A coronary heart infection forecast. The ensuing findings are contrasted with the ones of diverse fashions which have both been employed in the same field, although it is argued that [10] the former is superior. Naive Bayes, Decision Trees, Specifically, Support Vector Machines and Support Regression are used to find patterns within the UCI heart disease patient data. The regular universal overall performance and accuracy of the output through the use of numerous techniques are compared. The suggested hybrid technique competes with the possibility-identified techniques, yielding effects for an F-degree of 86.8 percent. This research compares the accuracy and prediction of several discovery pattern algorithms, such as Decision Tree, Neural Networks, Rough Set, SVM, and Naive Bayes, using

data on cardiovascular patients gathered from the UCI Laboratory. [8,9]. In this work, a novel technique for classifying breast cancer using histopathological images—ensemble learning with symbiotic organism search and optimization algorithm—is developed for the first time [11].

Convolutional Neural Networks (CNN) elegance without segmentation is introduced. In the education phase, this method takes an interest in the coronary heart cycles with numerous beginning places from the electrocardiogram (ECG) signals. In the patient's finding out phase, CNN can offer talents with numerous positions. The clinical vicinity generates loads of statistics; however, it hasn't normally been handled well. The novel techniques referred to right here make coronary heart disorder extra without troubles and correctly predictable at same time as reducing costs. In this study, we present an approach for diagnosing cardiac disease using SAS Base software 9.1.3 [12]. The many studies techniques considered the use of machine learning (ML) and deep learning (DL) algorithms in this artwork for the kind and forecast of coronary pollution is quite accurate in determining the efficacy of those techniques. The current methods discussed here are an easy and beneficial way to cut costs and increase the projection of heart disease. Several different studies the methods for projecting and classifying cardiac illness are being considered in this work using machine learning. The utility may be accurately determined using Deep learning (DL) and machine learning (ML) techniques. The Intelligent Heart Disease Prediction System (IHDPS) was developed in this study using data mining techniques. These comprised Networks, Support Vector Machines, Naive Bayes, Decision Trees, and Bayes. Results show that a coach has distinct benefits for understanding the stated mining targets. A solution for the creation of automatic cardiac disease diagnostic systems employing electrocardiogram (ECG) signals was the proposed novel neural architecture, which was based on the recent popularity of convolutional neural networks (CNN) [13].

The accuracy of events connected to heart disease has also been predicted using decision trees. The use of well-established ways of data mining for cardiac prediction illness has led to the employment of a variety of techniques for knowledge abstraction. Numerous readings have been conducted in this study to develop a prediction model by fusing several methodologies and linking two or more of them. The maximum prediction accuracy over medical data has also been made possible by the innovative approaches of Artificial Neural Network concepts. This study uses an artificial neural network's backpropagation MLP (multilayer perceptron) to forecast the presence of heart disease [14]. This work aims to provide an overview of the many approaches to knowledge abstraction that are employed in current heart disease prediction research through the use of data mining tools. The survey of various data mining and neural network classification technologies utilized in risk factor-based heart disease prediction is presented in this research. [15,16,17]. These combined new techniques are sometimes referred to as hybrid methods. We present neural networks with the use of heart rate time data. When developing an intelligent model to identify heart disease (HD) in patients utilizing patient data sets that include heart disease risk factors, data mining is a crucial component [18]. In this work, the use of machine learning to determine a person's risk of heart disease is discussed. Cardiovascular diseases (CVDs) are common and can be fatal for people everywhere in the world. A person's age, cholesterol level, chest pain, and other characteristics can all be taken into account using machine learning to determine if they have a cardiovascular disease [19]. This technique can be automated to provide medical diagnostic processes in a rapid, accurate, objective, and logical manner [20]. This method uses a range of clinical records, such as Left Bundle Branch Block (LBBB), Right Bundle Atrial Fibrillation (AFIB), Right Bundle Branch Block (RBBB), Sinus Bradycardia (SBR), Normal Sinus Rhythm (NSR), Left Bundle Branch Block (LBBB), Atrial Flutter, Premature Ventricular Contraction (PVC), and Second-degree block (BII) to determine the patient's precise state concerning the cardiac disease. To classify the data, a radial basis function network (RBFN) is utilized. Where 70 we recommend utilizing the GA to identify cardiac disease. The method uses the GA selection's effective association criteria, which are tournament specific. The new fitness function is the result of mutation and crossover. Experimental validation makes use of the renowned Cleveland model. dataset obtained from a machine learning resource at UCI. We will ultimately compare our results to some of the well-known supervised learning techniques to evaluate how they compare Particle Swarm Optimisation (PSO), the most potent evolutionary algorithm, is presented, and some rules are produced for heart disease. The criteria have been implemented arbitrarily while utilizing encoding techniques that increase accuracy overall. Pulse rate, sex, age, and several other symptoms are used to predict heart disease. Ghosh et al.'s 2023 study focuses on "Water Quality Assessment Through Predictive Machine Learning", highlighting the [21] use of machine learning for analyzing and predicting water quality parameters.

In Unraveling the Heterogeneity of Lower-Grade Gliomas Rahat, Ghosh, and colleagues (2023) [22] delve into deep learning-assisted segmentation and genomic analysis of brain MR images, offering new insights into this medical condition. Potato Leaf Disease Recognition and Prediction using Convolutional Neural Networks by Ghosh, Rahat, and team (2023),[23] showcases the application of convolutional neural networks in accurately identifying diseases in potato leaves. Mandava, Vinta, Ghosh, and Rahat's [24] research presents "An All-Inclusive Machine Learning and Deep Learning Method for Forecasting Cardiovascular Disease in Bangladeshi Population", integrating advanced AI techniques for health predictions. The 2023 study by Mandava et al., titled "Identification and Categorization of Yellow Rust Infection in Wheat [25] through Deep Learning Techniques", applies deep learning methods to detect and categorize wheat infections effectively. Khasim, Rahat, Ghosh, and colleagues' 2023

article, "Using Deep Learning and Machine Learning: Real-Time [26] Discernment and Diagnostics of Rice-Leaf Diseases in Bangladesh", explores AI-based solutions for diagnosing rice-leaf diseases. Deciphering Microorganisms through Intelligent Image Recognition",[27] authored by Khasim, Ghosh, Rahat, and others in 2023, discusses the use of machine learning and deep learning in identifying microorganisms through advanced image recognition techniques. The 2023 study by Mohanty, Ghosh, Rahat,[28] and Reddy, "Advanced Deep Learning Models for Corn Leaf Disease Classification", focuses on the application of deep learning in classifying diseases in corn leaves based on a field study. Alenezi and team's 2021 research, "Block-Greedy and CNN Based Underwater Image Dehazing for Novel Depth Estimation and[29] Optimal Ambient Light", investigates novel CNN-based methods for enhancing underwater image clarity and depth estimation.

As we've seen, the ML method using neural networks produces results that are more precise and dependable. Typically, neural networks are said to be the most accurate way to foretell illnesses, such as heart and brain disorders. 13 factors for heart disease prediction are included in the suggested method that we use. Comparing the outcomes to the conventional approaches in works like this, the results demonstrate improved performance. The popularity of Carotid Artery Stenting (CAS) has also increased as a treatment approach in the medical sector for the past few years. Major adverse cardiovascular events (MACE) in senior heart disease patients are triggered by the CAS. Their assessment becomes crucial. We provide findings utilizing an Artificial Neural Network (ANN), which performs well for heart disease prediction. We have compiled the data showing the significance of each aspect of RFM in the prevention and treatment of AF in this narrative review. We also discuss new findings about the role that cardiovascular activity and weight loss have in the therapy and prevention of atrial fibrillation [30].

There is an introduction of neural network approaches that include predicted values from several earlier techniques in addition to posterior probability. This model is up to 89.01 percent accurate. In this paper, we present the Hybrid Random Forest with Linear Model (HRFLM) approach. The major goal of this study is to increase heart disease prediction performance accuracy. The selection of features for use in algorithms has been constrained as a consequence of several research that has been done. However, the HRFLM method uses every feature without any restrictions on feature selection. Here, we undertake tests to determine the characteristics of a hybrid machine learning algorithm. The outcomes of the experiment demonstrate that in comparison to current approaches, the hybrid strategy offers a stronger capacity to predict heart disease.

3. Proposed Methodology

We provide a unique approach that uses machine learning approaches to uncover key characteristics, resulting in increasing the predictability of cardiovascular illness. The prediction model is provided with several feature combinations and several well-known classification methods. The advocated studies use libraries like sci-kit-learn, pandas, matplotlib, and others and are built in Python 3.6.4. Their cords consist of binary classifications of cardiac disorder. The hybrid version is blended with algorithms like random forests and desired trees. Considerations of Seniority, Genital Gender, Pain in the Chest, BP, and Cholesterol Measurements of glucose and insulin levels while fasting; electrocardiograms were taken at rest; and peak heart rates Angina Pectoris During Exercise, Age of Peak, Decline, Total Number of Severe Attacks Vessels, Thala, and Pred variables had been all blanketed with inside the dataset. The project is to determine if an affected character must be recognized with coronary heart ailment or not which is a binary outcome (0 – Heart disorder doesn't exist, 1-Heart disorder exists). The pre-processing of information is done by changing medical information into evaluation values. The suggested hybrid HRFLM method combines advancements in Random Forest (RF) and the Linear Method into a single framework (LM). HRFLM's diagnosis of a coronary condition was quite accurate. Classification problems have resolved the use of a decision tree (DT), a Supervised Learning Algorithm. Support is provided for every unique and non-prevent input and output variable. The pattern is cut up into further steady devices by the most significant splitter or discriminate or inside the enter variables. This approach. An assessment of the feature is represented via the inner node, the very last consequences are represented via the arm, and the perception is represented via the leaf inside the choice tree when estimating a category grade for a report in desire trees, starting at the tree's base. Next, the values of the report's characteristics are contrasted with the ones of the muse function.

3.1. Random Forest Model

1. Let's assume there are n occurrences in the training dataset. Random sub-samples are drawn by substituting some of the n occurrences. The training dataset is partitioned randomly, and it is from those partitions that individual trees are built.
2. In a system with k entry variables, more than a handful of m is selected such that m k. There are k possible variables, and at each node, m are picked at random. The m variables are narrowed down to the one that best represents the reduction of the node. Despite the expanding forest, Figure 1 shows that the rate of m remains constant.
3. Every tree is allowed to reach its full potential in terms of size, with no trimming or other limiting techniques being used. If the new item receives enough votes from several decision trees, its predicted class will be determined by the results.

3.2. Hybrid Model

The blended model incorporates the random woodland location probabilities to amass a hybrid approach. The training record lists were combined with the random forest placement probabilities and adapted to the selection tree model. As a comparison, the preference tree possibility is commonly discussed and serves as a tool for analyzing test results.

3.3. Data Pre-Processing

After collecting a couple of statistics, pre-processing of coronary heart sickness statistics occurs. There are 303 affected person statistics inside the dataset overall. There are a few lacking statistics in 6 entries. The ultimate 297 affected person statistics are applied for pre-processing after the 6 statistics have been removed from the dataset. For their residences of the provided dataset, multiclass variables and binary type are introduced. The presence or absence of cardiac desires is decided by the usage of the multi-magnificence variables. If the affected person has a coronary heart there are, the cost is about 1, in any other case, it's far set to zero to suggest that the affected person is coronary heart sickness-free. Data pre-processing is carried out. Fig.1 and Fig.2 illustrate the experiment's workflow using the UCI dataset to demonstrate how it was phased in for evaluation. The UCI dataset loading prepares the data for pre-processing in the first stage and the diagnosis of cardiovascular disease using HRFLM. In this instance, we select a collection of 13 characteristics to investigate using a pre-processed dataset on heart disease (Age, sex, cp, thalach, exang, olpeak, slope, ca, that, chol, FBS, restecg, cp, treetops, olpeak, that, and goal). To create the classification, the three pre-existing models (DT, RM, and LM) are employed.

3.4. Datasets

The UCI device studying repository changed into used to accumulate records on coronary heart illness. Four databases (together with Cleveland, Switzerland, Hungary, and the VALongBeach). Because it is a famous beneficial useful resource for ML researchers and has extremely good and complete records, the Cleveland database changed into a determined for this study. There are 303 entries inside the collection. Although there are seventy-six attributes inside the Cleveland dataset, only 14 of them are blanketed through the records set this is to be had inside the repository. The Cleveland Clinic Foundation is the dataset's records source. The description and form of homes are proven in Table 1. One feature acts because of the reality of the output or the projected feature to the lifestyles of coronary heart disease in an affected individual out of the thirteen attributes which are probably protected inside the prediction of coronary heart disease.

3.5. Performance Evaluation

This model's performance has been determined using several common performance metrics, such as accuracy, precision, and classification error, in this scenario, accuracy would refer to the percentage of instances that properly predicted out of all the available examples. Precision is defined as the proportion of accurate predictions in the instances that fall into the positive category. The percentage of missing or inaccurate accuracy in these instances, we have what is called a categorization mistake. There are three acts. Indicators that help comprehend the nature of the many feature-selection combinations are used to identify the most important features of heart disease. Most machine learning approaches seek to identify the model with the highest performance.

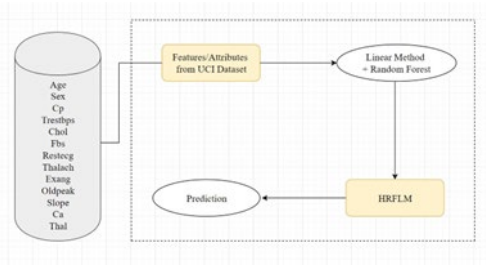

Figure 1. Heart disease prediction with HRFLM

4. Result Analysis

The reliability is measured by the percentage of expected function selections that the model produces. As for which skills may be used, HRFLM doesn't put any limits on you. The features chosen for this release all provide top-notch outcomes.

Table 1 Data from the overall error rate and overall classification error rate result table

Data Split	Overall error rate				Best Model Overall Classification error rate Best Model			
	DT	RF	LM		DT	RF	LM	
1	14.9	4	6.7	RF	14.9	14.9	16.2	DT/RF
2	34.9	12.2	22.6	RF	39.6	37.7	38.2	RF
3	50	4	11.1	RF	50	27.8	50	RF
4	62.5	20.9	29.2	RF	62.5	54.2	54.2	RF
5	60	13.3	13.3	RF/LM	60	53.3	53.3	LM
6	54.6	12	18.1	RF	60.6	54.6	54.6	LM
7	57.1	0	28.7	RF	57.1	42.8	42.8	RF
8	36.4	18.2	9.1	LM	36.4	27.3	27.3	RF/LM

There are no limitations on the functionalities that can be used with HRFLM. The best results are achieved by all the features that were chosen for this model. Table 1 compares various models using the approach we provide. Figure 2 and Figure 3 show, respectively, the performance comparison of several models of the suggested method.

$$Sensitivity = \frac{TP}{TP + FN} \quad (1)$$

$$Specificity = \frac{TN}{TN + FP} \quad (2)$$

$$Precision = \frac{TP}{TP + FP} \quad (3)$$

$$F - Measure = \frac{2TP}{2TP + FP + FN} \quad (4)$$

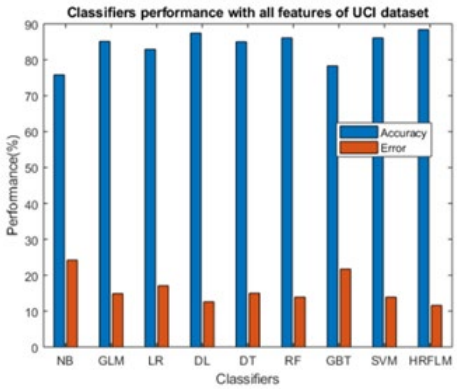

Figure 2. Performance evaluations of several models about the suggested methodology

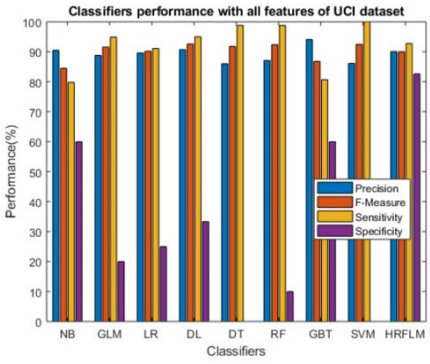

Figure 3. Performance evaluations of several models about the suggested methodology

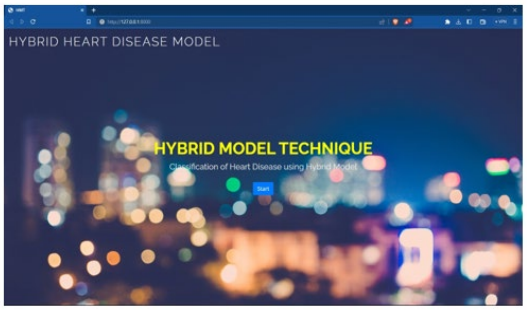

Figure 4. Interface of the designed model

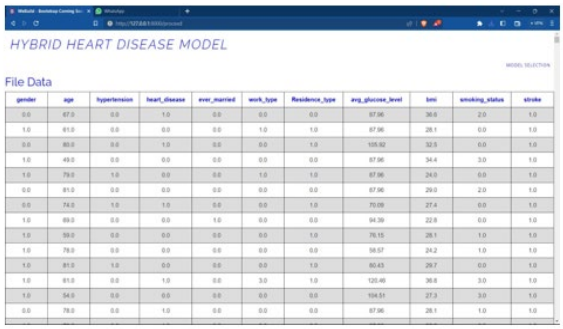

Figure 5. Dataset that contains the risk factors for heart disease and stroke

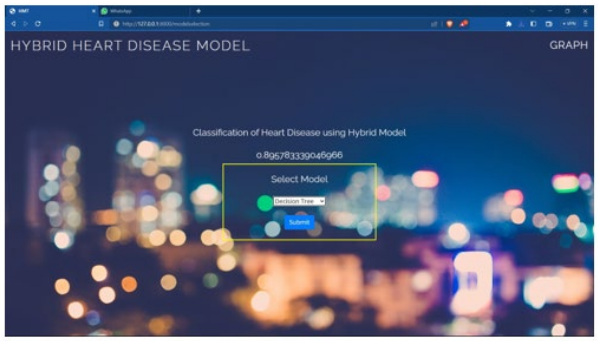

Figure 6. Performance evaluation of existing models on a given dataset

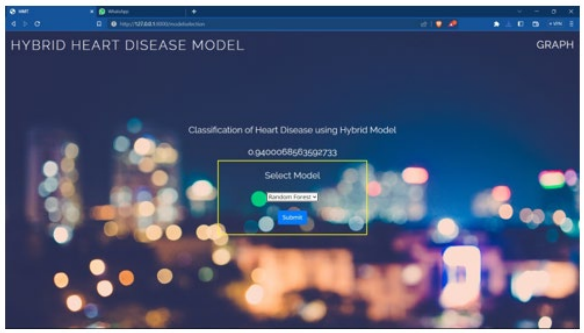

Figure 7. Performance evaluation of hybrid model on given data set

5. Conclusion

Identifying the coronary heart's raw healthcare facts and processing Information is crucial for the long-term preservation of human life. As properly due 19 the fact early identification of aberrant cardiac diseases. In this work, tools and techniques for tearing were carried out to approach raw facts and offer a glowing and modern mindset on coronary heart contamination predicting coronary heart illness is difficult, and especially extensive within the clinical industry. Identifying the coronary heart's raw healthcare facts and processing Information is crucial for the long-term preservation of human life. As properly due 19 the fact early identification of aberrant cardiac diseases. In this work, tools and techniques for tearing were carried out to approach raw facts and offer a glowing and modern mindset on coronary heart contamination predicting coronary heart illness is difficult, and especially extensive within the clinical industry.

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