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HEART DISEASE PREDICTION USING MACHINE LEARNING TECHNIQUES

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ABSTRACT

Heart plays significant role in living organisms. Diagnosis and prediction of heart related diseases requires more precision, perfection and correctness because a little mistake can cause fatigue problem or death of the person, there are numerous death cases related to heart and their counting is increasing exponentially day by day. To deal with the problem there is essential need of prediction system for awareness about diseases. Machine learning is the branch of Artificial Intelligence(AI), it provides prestigious support in predicting any kind of event which take training from natural events. This research paper presents various attributes related to heart disease, and the model on basis of supervised learning algorithms as Logistic Regression , Decision Tree , Random Forest , Support Vector Machine , Gaussian Naive Bayes , Multinomial Naive Bayes and Gradient Boosting Classifier algorithm. It uses the existing dataset from the Cleveland database of UCI repository of heart disease patients. The dataset comprises 303 instances and 76 attributes. Of these 76 attributes, only 14 attributes are considered for testing, important to substantiate the performance of different algorithms. This research paper aims to envision the probability of developing heart disease in the patients. The results portray that the highest accuracy score is achieved with KNN.

INDEX TERMS:- Machine learning, Artificial Intelligence(AI), heart disease prediction, Diagnosis, prediction, UCI repository, Python programming.

I.INTRODUCTION

It is difficult to identify heart disease because of several contributory risk factors such as diabetes, high blood pressure, high cholesterol, abnormal pulse rate and many other factors. Various techniques in data mining and neural networks have been employed to find out the severity of heart disease among humans. The severity of the disease is classified based on various methods like K-Nearest Neighbor Algorithm (KNN), Decision Trees (DT), Genetic algorithm (GA), and Naive Bayes (NB) [11], [13]. The nature of heart disease is complex and hence, the disease must be handled carefully. 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 have also seen decision trees be used in predicting the accuracy of events related to heart disease [1]. Various methods have been used for knowledge abstraction by using known methods of data mining for prediction of heart disease. In this work, numerous readings have been carried out to produce a prediction model using not only distinct techniques but also by relating two or more techniques. These amalgamated new techniques are commonly known as hybrid methods [14]. We introduce neural networks using heart rate time series. This method uses various clinical records for prediction such as Left bundle branch block (LBBB), Right bundle branch block (RBBB), Atrial fibrillation (AFIB), Normal Sinus Rhythm (NSR), Sinus bradycardia (SBR), Atrial flutter (AFL), Premature Ventricular Contraction (PVC)), and Second degree block (BII) to find out the exact condition of the patient in relation to heart disease. The dataset with a radial basis function network (RBFN) is used for classification, where 70% of the data is used for training and the remaining 30% is used for classification [4], [15]. We also introduce Computer Aided Decision Support System (CADSS) in the field of medicine and research. In previous work, the usage of data mining techniques in the healthcare industry has been shown to take less time for the prediction of disease with more accurate results [16]. We propose the diagnosis of heart disease using the GA. This method uses effective association rules inferred with the GA for tournament selection, crossover and the mutation which results in the new proposed fitness function. For experimental validation, we use the well-known

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Cleveland dataset which is collected from a UCI machine learning repository. We will see later on how our results prove to be prominent when compared to some of the known supervised learning techniques [5], [17]. The most powerful evolutionary algorithm Particle Swarm Optimization (PSO) is introduced and some rules are generated for heart disease. The rules have been applied randomly with encoding techniques which result in improvement of the accuracy overall [2]. Heart disease is predicted based on symptoms namely, pulse rate, sex, age, and many others. The ML algorithm with Neural Networks is introduced, whose results are more accurate and reliable as we have seen in [8], [12]. Neural networks are generally regarded as the best tool for prediction of diseases like heart disease and brain disease. The proposed method which we use has 13 attributes for heart disease prediction. The results show an enhanced level of performance compared to the existing methods in works like [3]. The Carotid Artery Stenting (CAS) has also become a prevalent treatment mode in the medical field during these recent years. The CAS prompts the occurrence of major adverse cardiovascular events (MACE) of heart disease patients that are elderly. Their evaluation becomes very important. We generate results using a Artificial Neural Network ANN, which produces good performance in the prediction of heart disease [6], [18]. Neural network methods are introduced, which combine not only posterior probabilities but also predicted values from multiple predecessor techniques. This model achieves an accuracy level of up to 89.01% which is a strong results compared to previous works. For all experiments, the Cleveland heart dataset is used with a Neural Network NN to improve the performance of heart disease as we have seen previously in [9], [19]. We have also seen recent developments in machine learning ML techniques used for Internet of Things (IoT) as well [43]. ML algorithms on network traffic data has been shown to provide accurate identification of IoT devices connected to a network. Meidan et al. collected and labeled network traffic data from nine distinct IoT devices, PCs and smartphones. Using supervised learning, they trained a multi-stage meta classifier. In the first stage, the classifier can distinguish between traffic generated by IoT and non-IoT devices. In the second stage, each IoT device is associated with a specific IoT device class. Deep learning is a promising approach for extracting accurate information from raw sensor data from IoT devices deployed in complex environments [44]–[47]. Because of its multilayer structure, deep learning is also appropriate for the edge computing environment [48], [49]. In this work, we introduce a technique we call the Hybrid Random Forest with Linear Model (HRFLM). The main objective of this research is to improve the performance accuracy of heart disease prediction. Many studies have been conducted that results in restrictions of feature selection for algorithmic use. In contrast, the HRFLM method uses all features without any restrictions of feature selection. Here we conduct experiments used to identify the features of a machine learning algorithm with a hybrid method. The experiment results show that our proposed hybrid method has stronger capability to predict heart disease compared to existing methods.

II.LITERATURE SURVEY

A data mining model for predicting the coronary heart disease using random forest classifier

Authors: A. S. Abdullah and R. R. Rajalaxmi.

Abstract: Cardiovascular system diseases are an important health problem. These diseases are very common also responsible for many deaths. With this study, it is aimed to analyze factors that cause Coronary Artery Disease using Random Forests Classifier. According to the analysis, we observed correct classification ratio and performance measure that creates susceptibility to Coronary Artery Disease for each factor. The performance measure results clearly show the impact of demographic characteristics on CAD. Additionally, this study shows that random forests algorithm can be used to the processing and classification of medical data such as CAD.

Using PSO algorithm for producing best rules in diagnosis of heart disease

Authors: A. H. Alkeshuosh, M. Z. Moghadam, I. Al Mansoori, and M. Abdar

Abstract: Heart disease is still a growing global health issue. In the health care system, limiting human experience and expertise in manual diagnosis leads to inaccurate diagnosis, and the information about various illnesses is either inadequate or lacking in accuracy as they are collected from various types of medical equipment.

Since the correct prediction of a person's condition is of great importance, equipping medical science with intelligent tools for diagnosing and treating illness can reduce doctors' mistakes and financial losses. In this paper, the Particle Swarm Optimization (PSO) algorithm, which is one of the most powerful evolutionary algorithms, is used to generate rules for heart disease. First the random rules are encoded and then they are optimized based on their accuracy using PSO algorithm. Finally we compare our results with the C4.5 algorithm.

Backpropogation neural network for prediction of heart disease

Authors: N. Al-milli,

Abstract: Recently, several software's, tools and various algorithms have been proposed by the researchers for developing effective medical decision support systems. Moreover, new algorithms and new tools are continued to develop and represent day by day. Diagnosing of heart disease is one of the important issue and many researchers investigated to develop intelligent medical decision support systems to improve the ability of the physicians. Neural network is widely used tool for predicting heart disease diagnosis. In this research paper, a heart disease prediction system is developed using neural network. The proposed system used 13 medical attributes for heart disease predictions. The experiments conducted in this work have shown the good performance of the proposed algorithm compared to similar approaches of the state of the art.

Clinical decision support system: Risk level prediction of heart disease using weighted fuzzy rules

Authors: P. K. Anooj

Abstract: The development of medical domain applications has been one of the most active research areas recently. One example of a medical domain application is a detection system for heart disease based on computer-aided diagnosis methods, where the data is obtained from some other sources and is evaluated by computer based applications. Up to now, computers have usually been used to build knowledge based clinical decision support systems which used the knowledge from medical experts, and transferring this knowledge into computer algorithms was done manually. This process is time consuming and really depends on the medical expert's opinion, which may be subjective. To handle this problem, machine learning techniques have been developed to gain knowledge automatically from examples or raw data. Here, a weighted fuzzy rule-based clinical decision support system (CDSS) is presented for the diagnosis of heart disease, automatically obtaining the knowledge from the patient's clinical data. The proposed clinical decision support system for risk prediction of heart patients consists of two phases, (1) automated approach for generation of weighted fuzzy rules and decision tree rules, and, (2) developing a fuzzy rule-based decision support system. In the first phase, we have used the mining technique, attribute selection and attribute weightage method to obtain the weighted fuzzy rules. Then, the fuzzy system is constructed in accordance with the weighted fuzzy rules and chosen attributes. Finally, the experimentation is carried out on the proposed system using the datasets obtained from the UCI repository and the performance of the system is compared with the neural network-based system utilizing accuracy, sensitivity and specificity.

III. EXISTING SYSTEM

ANN has been introduced to produce the highest accuracy prediction in the medical field [6]. The back propagation multilayer perception (MLP) of ANN is used to predict heart disease. The obtained results are compared with the results of existing models within the same domain and found to be improved [10]. The data of heart disease patients collected from the UCI laboratory is used to discover patterns with NN, DT, Support Vector machines SVM, and Naive Bayes. The results are compared for performance and accuracy with these algorithms. The proposed hybrid method returns results of 86.8% for F-measure, competing with the other existing methods [7]. The classification without segmentation of Convolution Neural Networks (CNN) is introduced. This method considers the heart cycles with various start positions from the Electrocardiogram (ECG) signals in the training phase.

DISADVANTAGES OF EXISTING SYSTEM:

- Existing approaches are low accuracy and high computation time and these might be due the use of irrelevant features in dataset. In order to tackle these problems new methods are needed to detect HD correctly. The improvement in prediction accuracy is a big challenge and research gap.
- Accuracy is very low

- ❖ Computationally complex
- ❖ More execution time required to generate results

IV PROPOSED SYSTEM:

This project presents various attributes related to heart disease, and the model on basis of supervised learning algorithms as Logistic Regression , Decision Tree , Random Forest , Support Vector Machine , Gaussian Naive Bayes , Multinomial Naive Bayes and Gradient Boosting Classifier algorithm. It uses the existing dataset from the Cleveland database of UCI repository of heart disease patients. The dataset comprises 303 instances and 76 attributes. Of these 76 attributes, only 14 attributes are considered for testing, important to substantiate the performance of different algorithms. This research paper aims to envision the probability of developing heart disease in the patients.

ADVANTAGES OF PROPOSED SYSTEM:

- ❖ There is essential need of prediction system for awareness about diseases.
- ❖ The results portray that the highest accuracy score is achieved with Gaussian Naive Bayes.

PROJECT FEATURES

Machine Learning is one of the efficient technology for the testing, which is based on training and testing. It is the branch of Artificial Intelligence(AI) which is one of broad area of learning where machines emulating human abilities, machine learning is a specific branch of AI. On the other hand machines learning systems are trained to learn how to process and make use of data hence the combination of both technology is also called as Machine Intelligence. As the definition of machine learning, it learns from the natural phenomenon, natural things so in this project we uses the biological parameter as testing data such as cholesterol, Blood pressure, sex, age, etc. and on the basis of these, comparison is done in the terms of accuracy of algorithms such as in this project we have used four algorithms which are decision tree, linear regression, Support Vector Machine , Gaussian Naive Bayes , Multinomial Naive Bayes and Gradient Boosting Classifier algorithm.

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V. SYSTEM DESIGN

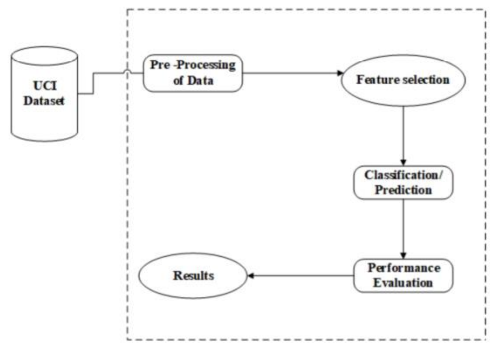

Fig1: Architecture of system.

MODULE DESCRIPTION:

To develop an effective heart disease prediction model using machine learning techniques, you can follow the module description outlined below. This description provides an overview of the various components and steps involved in the process.

1).Data Collection: Gather a comprehensive dataset that includes relevant features related to heart disease, such as age, gender, blood pressure, cholesterol levels, family history, smoking habits, and medical test results (e.g., ECG readings). Ensure that the dataset is representative and contains a sufficient number of positive and negative heart disease instances.

2).Data Preprocessing: Perform necessary preprocessing steps to clean and prepare the dataset for training the machine learning model. This may include handling missing values, dealing with outliers, normalizing or standardizing numerical features, and encoding categorical variables.

3).Feature Selection: Analyze the dataset to identify the most informative features for heart disease prediction. Consider using techniques like correlation analysis, feature importance ranking, or dimensionality reduction methods (e.g., principal component analysis) to select the subset of features that have the highest predictive power.

4).Model Selection: Explore different machine learning algorithms suitable for classification tasks, particularly for heart disease prediction. Commonly used algorithms include logistic regression, decision trees, random forests, support vector machines, naive Bayes, and K-nearest neighbors. Evaluate and compare the performance of these models using appropriate evaluation metrics and techniques like cross-validation.

5).Model Training: Split the preprocessed dataset into training and validation sets. Use the training set to train the selected machine learning model(s) on the data. During the training process, the model learns patterns and relationships between the features and the target variable (heart disease presence or absence).

6).Model Evaluation: Assess the performance of the trained model(s) using the validation set. Calculate evaluation metrics such as accuracy, precision, recall, F1 score, and area under the ROC curve (AUC-ROC) to measure the model's predictive capabilities. Compare the performance of different models and select the one with the highest accuracy and desirable trade-offs in terms of other evaluation metrics.

7).Hyperparameter Tuning: Optimize the hyperparameters of the chosen model to enhance its performance. Utilize techniques like grid search, random search, or Bayesian optimization to explore different combinations of hyperparameter values and find the optimal configuration.

8).Model Validation: Validate the final trained model(s) on an independent test set to obtain an unbiased estimation of its performance. This step helps assess how well the model generalizes to unseen data and provides confidence in its predictive ability.

9).Model Deployment: Once the model has been validated and deemed effective, it can be deployed for heart disease prediction in real-world scenarios. This may involve integrating the model into a software application, web service, or healthcare system to make predictions on new, unseen data.

10).Continuous Improvement: Monitor the performance of the deployed model and collect feedback from users and domain experts. Continuously update and retrain the model as new data becomes available to ensure its accuracy and reliability over time.

VI. EVALUATION MEASURES

The trained models are evaluated by computing their accuracy, precision, recall, and f1-score values for their predictions on the test data alongside the receiver operating characteristic (ROC) curve and the area under curve (AUC). Firstly, these values can be explained by denoting the model predictions fit in one of four categories: (1) True positive (T.P.). (2) True negative (T.N.). (3) False positive (F.P.). (4) False negative (F.N.), which is referred to as the confusion matrix. When there’s only two possible classes in the classification problem at hand (e.g., healthy vs unhealthy), the

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actual class of concern is denoted as the positive class and anything else as the negative class. T.P. is when the models' prediction, for instance, is positive, and the instance is positive. T.N. is when the models' prediction, for instance, is negative, and the instance is negative. F.P. is when the model falsely predicts an instance as positive while it should be negative, and F.N. is when the model predicts an instance as negative while it should be positive. This can be visualized as in Fig. 9. In multi-class classification problems, T.P., T.N., F.P., and F.N. are treated as a one-vs-all problem. Thus, to a specific class of concern, the positive class is the class of concern, and the negative class is all other classes. In this context, accuracy is the overall predictive accuracy of a model, which is the number of correctly predicted samples divided by the total number of predictions presented by .

$$accuracy = \frac{T.P. + T.N.}{T.P. + T.N. + F.P. + F.N.}$$

In contrast, precision is the ratio between the numbers of correctly predicted positives for a class to the total number of positive predictions for that class, calculated by using

$$precision = \frac{T.P.}{T.P. + F.P.}$$

Recall gives a measurement for what fraction of all positive samples are correctly predicted as positive, calculated by

$$recall = \frac{T.P.}{T.P. + F.N.}$$

And the f1-score is computed as the weighted average of Precision and Recall as in

$$f1 - score = \frac{2 \times precision \times recall}{precision + recall}$$

The ROC curve is a graphical plot that illustrates the diagnostic ability of a binary classifier as its discrimination threshold varies. It is created by plotting the recall value against the false positive rate (F.P.R.) value at different threshold levels as in Fig. 10 where the F.P.R. can be represented by (20)

$$F.P.R. = \frac{F.P.}{F.P. + T.N.}$$

In a multi-class classification problem, the ROC curve for each class can be plotted as a one-vs-all problem as well, where the class

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of concern is considered a positive class, and every other class is considered a negative class. The AUC is the area under the ROC curve that denotes the probability that a classifier would rank a randomly chosen positive instance higher than a randomly chosen negative one.

VII. RESULT:

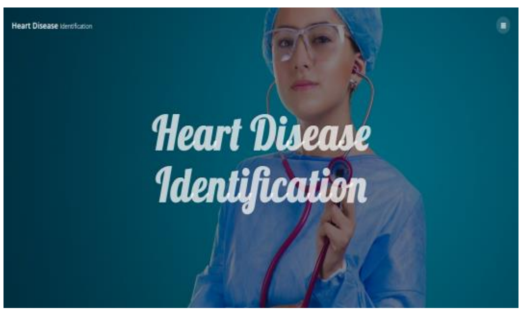

fig: 1: Home page of Heart disease identification

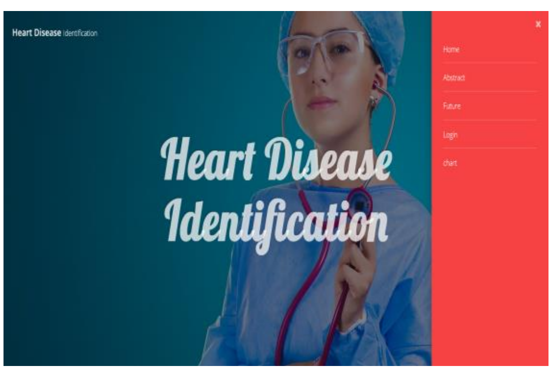

fig: 2: Screen page of Heart Disease Prediction

fig: 3: Login page of Heart Disease prediction

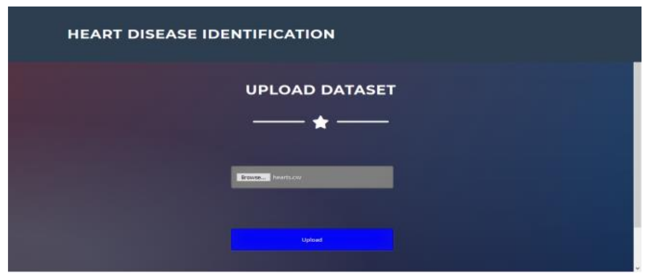

fig: 4: Insertion of dataset

	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	target
Id														
1	52	1	0	125	212	0	1	168	0	1.0	2	2	3	0
2	53	1	0	140	203	1	0	155	1	3.1	0	0	3	0
3	70	1	0	145	174	0	1	125	1	2.6	0	0	3	0

fig:5: Preview page

1023	47	1	0	110	275	0	0	118	1	1.0	1	1	2	0
1024	50	0	0	110	254	0	0	159	0	0.0	2	0	2	1
1025	54	1	0	120	188	0	1	113	0	1.4	1	1	3	0

fig:6: Prediction table

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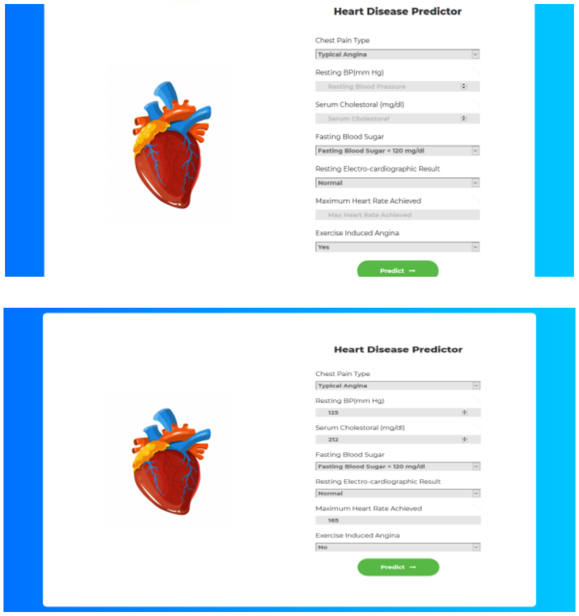

fig: 7: Patient's Health Details

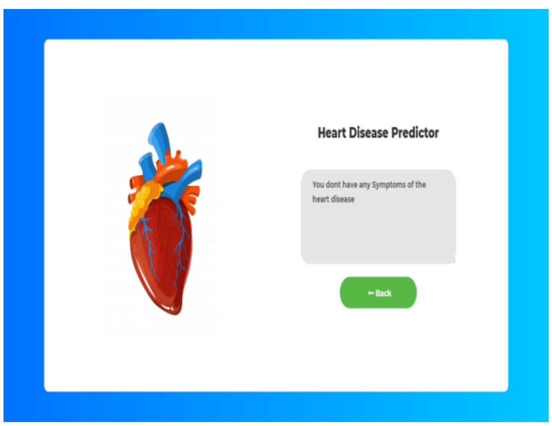

fig:8: Medical checkup results

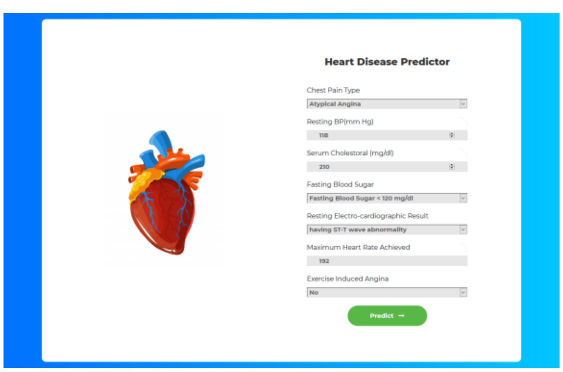

fig:9: Description of Heart condition

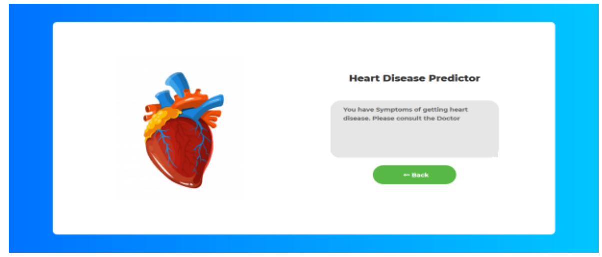

fig:10: Results

ALGORITHMS	ACCURACY
LINEAR REGRESSION	80.3
RANDOM FOREST	75.4
DECISION TREE	78.6
SUPPORT VECTOR MACHINE	62.2
MULTINOMIAL NAIVE BAYES	68.8
GRADIENT BOOSTING CLASSIFIER	73.7
GAUSSIAN NAIVE BAYES	81.9

Table 1. Accuracy of all algorithms

VIII. CONCLUSION

Identifying the processing of raw healthcare data of heart information will help in the long term saving of human lives and early detection of abnormalities in heart conditions. Machine learning techniques were used in this work to process raw data and provide a new and novel discernment towards heart disease. Heart disease prediction is challenging and very important in the medical field. However, the mortality rate can be drastically controlled if the disease is detected at the early stages and preventative measures are adopted as soon as possible. The overall aim is to define various data mining techniques useful in effective heart disease prediction. Efficient and accurate prediction with a lesser number of attributes and tests is our goal. In this study, I consider only 14 essential attributes. I applied four data mining classification techniques, Logistic Regression , Decision Tree , Random Forest , Support Vector Machine , Gaussian Naive Bayes , Multinomial Naive Bayes and Gradient Boosting Classifier. The data were pre-processed and then used in the model. Logistic Regression, Gaussian Naive Bayes , and Decision Tree are the algorithms showing the best results in this model. I found the accuracy after implementing four algorithms to be highest in Gaussian Naive Bayes. We can further expand this research incorporating other data mining techniques such as time series, clustering and association rules, support vector machine, and genetic algorithm. Considering the limitations of this study, there is a need to implement more complex and combination of models to get higher accuracy for early prediction of heart disease.

IX. FUTURE ENHANCEMENT

For the Future Scope more machine learning approach will be used for best analysis of the heart diseases and for earlier prediction of diseases so that the rate of the death cases can be minimized by the awareness about the diseases.

X. REFERENCES

[1] A. S. Abdullah and R. R. Rajalaxmi, ''A data mining model for predicting the coronary heart disease using random forest classifier,'' in Proc. Int. Conf. Recent Trends Comput. Methods, Commun. Controls, Apr. 2012, pp. 22–25.

[2] A. H. Alkeshuosh, M. Z. Moghadam, I. Al Mansoori, and M. Abdar, ''Using PSO algorithm for producing best rules in

diagnosis of heart disease,'' in Proc. Int. Conf. Comput. Appl. (ICCA), Sep. 2017, pp. 306– 311.

[3] N. Al-milli, ''Backpropogation neural network for prediction of heart disease,'' J. Theor. Appl.Inf. Technol., vol. 56, no. 1, pp. 131–135, 2013.

[4] C. A. Devi, S. P. Rajamhoana, K. Umamaheswari, R. Kiruba, K. Karunya, and R. Deepika, ''Analysis of neural networks based heart disease prediction system,'' in Proc. 11th Int. Conf. Hum. Syst. Interact. (HSI), Gdansk, Poland, Jul. 2018, pp. 233–239.

[5] P. K. Anooj, ''Clinical decision support system: Risk level prediction of heart disease using weighted fuzzy rules,'' J. King Saud Univ.-Comput. Inf. Sci., vol. 24, no. 1, pp. 27–40, Jan. 2012. doi: 10.1016/j.jksuci.2011.09.002.

[6] L. Baccour, ''Amended fused TOPSIS-VIKOR for classification (ATOVIC) applied to some UCI data sets,'' Expert Syst. Appl., vol. 99, pp. 115–125, Jun. 2018. doi: 10.1016/j.eswa.2018.01.025.

[7] C.-A. Cheng and H.-W. Chiu, ''An artificial neural network model for the evaluation of carotid artery stenting prognosis using a national-wide database,'' in Proc. 39th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. (EMBC), Jul. 2017, pp. 2566–2569.

[8] H. A. Esfahani and M. Ghazanfari, ''Cardiovascular disease detection using a new ensemble classifier,'' in Proc. IEEE 4th Int. Conf. Knowl.- Based Eng. Innov. (KBEI), Dec. 2017, pp. 1011–1014. [9] F. Dammak, L. Baccour, and A. M. Alimi, ''The impact of criterion weights techniques in TOPSIS method of multi-criteria decision making in crisp and intuitionistic fuzzy domains,'' in Proc. IEEE Int. Conf. Fuzzy Syst. (FUZZ-IEEE), vol. 9, Aug. 2015, pp. 1–8.

[10] R. Das, I. Turkoglu, and A. Sengur, ''Effective diagnosis of heart disease through neural networks ensembles,'' Expert Syst. Appl., vol. 36, no. 4, pp. 7675–7680, May 2009. doi: 10.1016/j.eswa.2008.09.013.

[11] M. Durairaj and V. Revathi, ''Prediction of heart disease using back propagation MLP algorithm,'' Int. J. Sci. Technol. Res., vol. 4, no. 8, pp. 235–239, 2015.

[12] M. Gandhi and S. N. Singh, ''Predictions in heart disease using

International Journal For Advanced Research In Science & Technology
A peer reviewed international journal www.ijarst.in
IJARST ISSN: 2457-0362

techniques of data mining,'' in Proc. Int. Conf. Futuristic Trends Comput. Anal. Knowl. Manage. (ABLAZE), Feb. 2015, pp. 520–525.

[13] A. Gavhane, G. Kokkula, I. Pandya, and K. Devadkar, ''Prediction of heart disease using machine learning,'' in Proc. 2nd Int. Conf. Electron., Commun. Aerosp. Technol. (ICECA), Mar. 2018, pp. 1275–1278.

[14] B. S. S. Rathnayakc and G. U. Ganegoda, ''Heart diseases prediction with data mining and neural network techniques,'' in Proc. 3rd Int. Conf. Converg. Technol. (I2CT), Apr. 2018, pp. 1–6.

[15] N. K. S. Banu and S. Swamy, ''Prediction of heart disease at early stage using data mining and big data analytics: A survey,'' in Proc. Int. Conf. Elect., Electron., Commun., Comput. Optim. Techn. (ICEECCOT), Dec. 2016, pp. 256–261.