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HEART DISEASE PREDICTION USING VARIOUS MACHINES LEARNING APPROACH

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Abstract

In health sector computer aided diagnosis (CAD) system is rapidly growing area because medical diagnostic systems make huge change as compare to traditional system. Now a day huge availability of medical data and it need proper system to extract them in to useful knowledge. Machine learning has been exposed to be operative in supporting in making decision and predication from the large quantity of data produce by the healthcare sector. Classification is a prevailing machine leaning approach which are commonly used for predication some classification algorithm predict accurate result according to the marks whereas some others exhibit a limited accuracy. So in this paper investigates some of classification approaches and also combining multiple classifiers for single approaches are used. A reasonable analytical of these technique was done to conclude how the cooperative techniques can be applied for improving prediction accuracy in heart disease. Five main classifiers used to construct heart disease prediction base on the experimental results demonstrate that support vector machine, naive bayes, logistic regression, decision tree and memory-based learner provide reliable and accurate result.

Keywords: Classifiers, Machine learning technique, prediction, Healthcare sector

Introduction

Medical data design in healthcare is one of the important and complicated tasks because as a result it must show accuracy and efficiency in his performance. Computer aided diagnosis (CAD) becomes very useful tool that attempts to solve real world health problems in diagnosis treatment of disease. The feature of machine learning is high accuracy and learning rate in this field. Normally, many health care organizations are encrustation a major defy to offer high quality provisions, like analyzing patients appropriately and management treatment at sensible costs [1]. Machine learning methods have been widely used to mine information from medical databases. In machine learning, classification (e.g. is this specific patient sick or healthy) is a supervised form of learning that can be used to design models describing important data classes. Using those machines learning methods can provision researchers or physicians in making medical verdicts and they can answer significant and connected questions regarding health care. It is problematic to recognize heart disease because of several con- tributary risk issues such as diabetes, high blood pressure, high cholesterol, abnormal pulse rate and many other factors [2]. Various methods in machine learning approach have been engaged to find out the severity of heart disease among humans. 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 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)[3]. Machine learning is made up of several types of learning that have been classified into some popular families, figure 1 shows the taxonomy of popular techniques which are supervised learning, unsupervised learning, semi-supervised learning, and reinforcement learning, which are categorized as the figure 1 below.

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

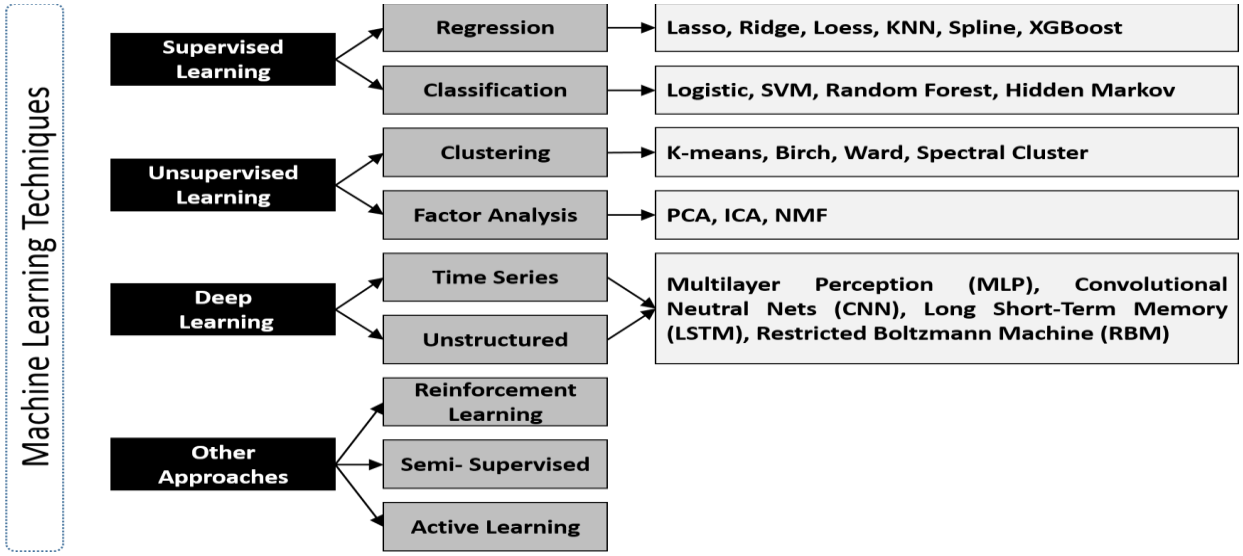


Fig 1: Type of machine learning technique

In malice of immense scientific growth in healthcare sector, evolving countries and all around the world, there are still in need of providing quality healthcare services at a reasonable cost that is easily affordable by their population. While such countries have seen large scale enlargement in terms of provided that well health care amenities, yet there is still a huge request in terms of creation these lavatories inexpensive[4].The rest of this paper is organized as: The necessary background for the heart disease is discussed in section 2. In section 3, present the related work in this section. In section 4, the statistical analysis and limitations are presented. In Section 5, we present the outstanding issues of ML-based algorithms for heart disease predication and their result. Section 6, present conclusion. For the comfort of readers we provided a list of the most frequently used acronyms in the paper are mention in table 1.

Table.1. list Acronyms

Acronyms	Meaning	Acronyms	Meaning
HD	Heart diseases	LR	Linear regression
PH	Predication approach	NN	Neural networks
MLG	Machine learning algorithm	DP	Deep learning
SL	Supervised learning	SVM	Support Vector Machine
WHO	world, Heath Organization	UCI	University of California Irvine
CAD	Computer aided diagnosis	MBL	Memory-Based Learner

Diseases

Disease is a particular term that is used for abnormal condition, or this term used in healthcare condition that part of organism. Various diseases are known by their symptoms, signs and knowledge and therefore it is necessary to optimize disease forecaster. According to the survey of world, heath organization (WHO), heart disease

has been the main cause of death in the world. Heart attack in different countries due to exertion ,work overload ,mental stress ,food and so on the treatment and diagnosis is complicated therefore it important

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

step designed systematic system for diagnoses. The main prevention of this disease is to make early prediction[5,6].Figure 2 show the main diseases of humanity affected from them are.

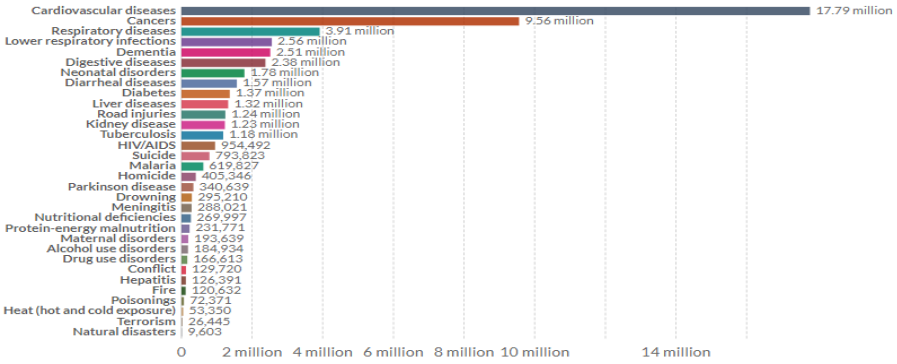


Fig 2: Main disease affected by human (WHO 2020)[7]

Heart disease risk factors the main elements which make a person risk factor of this disease are. Age factors: Normally men face heart attack in age of 65 and women face this kind of attack after. Climacteric but as compare to women man face more heart attack. Family history; normally its see that family faces this kind of problems and it inherits from family to family heart disease cause[8]. Smoking factor; the chemical in tobacco smoke developed of blood clots and also increase the cause of heart attacks and now a day's its more in young generation due to use of smoke weight; if the body increases then it make the chance of heart disease. These people who carry extra body fact it give chance to these diseases. To reduce this kind of numerous problems many kind of factor can be used[9,10]. Blood pressure is the power of the blood that go through inner wall of heat and other vessels when heart pumps the blood. Hypertension is that person which arteries are under increased pressure and the heart has to pump harder and this process make the artery wall arthrosclerosis and make heart problems. Cholesterol; cholesterol is the blood building in the walls of the arteries this process is called atherosclerosis, if this process affects then it makes heart disease[11]. Diabetes; diabetes also makes the heart disease when growing the risk of high blood pressure and make high cholesterol in the blood. This makes injury to the artery wall and formation of the blood clots when the heart make pumps the blood it make vessels generated inner problems to the fellow of the blood. When a person facing this kind of problems that is known as hypertension under increased pressure and the heart jump harder and which make affect the inner system and destroy the system[12,13].Figure 3 shows the ratio of causes heart attack in men and women.

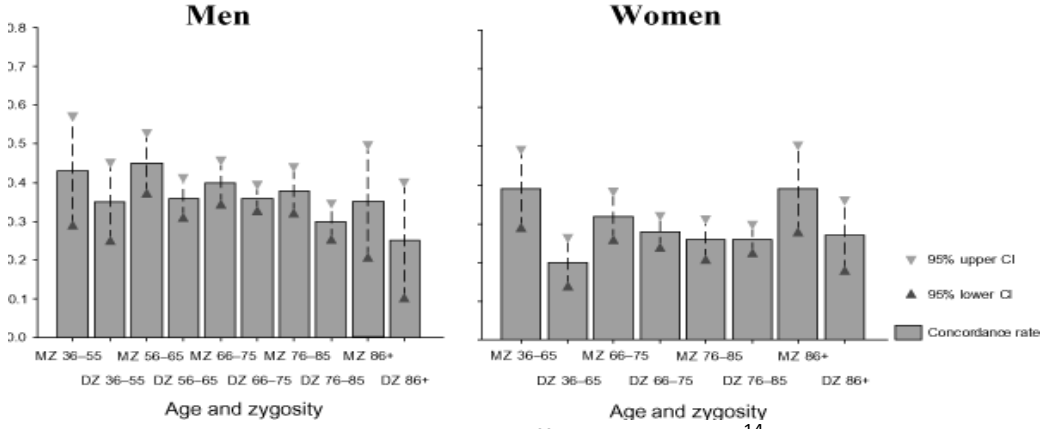


Fig 3: Main disease affected by human[14]

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

Related Work : Different researchers have proposed several ML algorithms and technique to prediction heart disease accurately some of them are. Tzavaras,[15],design a neural network algorithm knows as self -organizing piecewise aggregate approximate (SOPAA). This algorithm used for electrocardiogram (ECG) signal classification and performed to diagnose heart disease. According to their result 97 % better than other technique used. Researcher Implement genetic algorithm in neural network for heart disease prediction. They use 12 parameters such as sex, age, blood, cholesterol etc. The algorithms calculate the number of hidden layer nodes and architecture to calculate the parameter result. According to their result it gives up to 98% accuracy[16].According to Khan,et al., ,design a scheme that is known as prototype Intelligent heart disease prediction system (IHDPS) using deep learning technique, namely, decision Trees i.e. ID3.By using medical profiles of patients such as age, gender, blood pressure and blood sugar, chest pain, ECG graph etc, it can predict the likelihood of patients getting a heart disease or not and make 82 % effectively working in requirement[17]. According to Seixas, et al., design multilayer Perceptron model for predictive detection of heart disease severity based on various parameters. The author also deploys a novel principle attribute analysis to understand the orientation of the attributes affecting the results. The final outcome of this work is to analyses the heart disease severity based on proposed multilayer perceptron model according to the result it 97 % accurate [18]. Author [19], design a scheme known as decision tree and bagging algorithm used for the reduction of blood and oxygen supply to the heart leads to heart disease. Used different attribute to compare with other algorithm and the result show 96 % increment in this scheme. Devi, and Anto [20], proposed for the diagnosis of the coronary artery disease the decision tree is used to select the most significant attributes and the output is converted into crisp if-then rules. The crisp sets of rules are transformed into the fuzzy rules and these rules constitute the fuzzy rule base. The performance of the proposed system is analyzed using various parameters like classification accuracy, sensitivity and specificity and it is observed that that this system achieves better accuracy about 98% than the existing systems. Author applied and compared several data mining techniques to predict heart diseases. They used models based upon five algorithms including C5.0, neural network, support vector machine (SVM), k nearest neighborhood (KNN) and logistic regression. C5.0 decision tree was able to build a model with greatest accuracy of 93.02% whereas KNN, SVM, neural network had the accuracy of 88.37%, 86.05% and 80.23% respectively[21].Summary of the related work are mention in table2.

Table.2. Related work summary

ML.Technique	Year	Disease	Dataset	Simulation	Accuracy rate
Bayes Net/ FT 84.5% Naive Bayes/SVM	2015	Coronary artery disease	UCI	WEKA	84.5%
Naive Bayes/ J48	2015	Heart Disease	UCI	WEKA	85.1
Bagging/ SVM	2018	Heart Disease	UCI	WEKA	84.2
UCI	2019	Heart disease	UCI	WEKA	84.95
ANN	2019	Dengue Disease	UCI	WEKA	85.56
MFNN	2019	Dengue Disease	UCI	WEKA	84.56
C4.5	2019	Dengue Disease	UCI	WEKA	84.56
Feed forward NN with Back propagation	2019	Dengue Disease	UCI	WEKA	84.56
CART	2019	Dengue Disease	UCI	WEKA	82.56
K Star	2019	Dengue Disease	UCI	WEKA	83.56

Proposed approaches

In this section we present all those classifiers of machine learning algorithm which are used for heart disease prediction in this paper. Clevel and UCI repository data set for heart disease classification process it offers an easy-to-use visual representation of the dataset, working situation and building the analytical analytics. For applying machine leaning technique start from pre-processing phase followed by post-processing steps. Figure 4 present the proposed approaches.

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

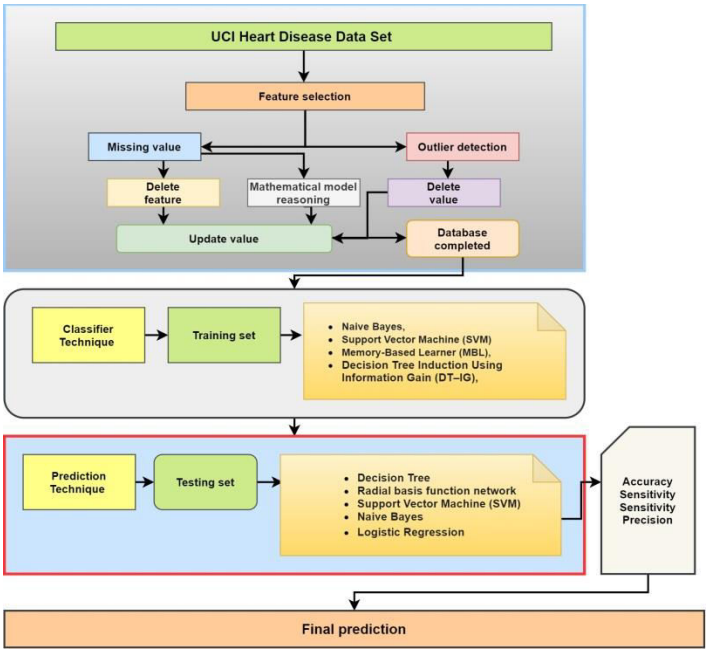


Fig 4: Proposed approaches structure

Figure 4 present the proposed approach structure where it starts from data pre- processing and post-processing steps. The different ML approaches are used in post- processing where classification and predication section are used where we implements these algorithms.

Logistic Regression

Logistic Regression is one of the main classification techniques of machine learning approach based on the probabilistic of the data. It used for predict of binary response from a binary predications let us assume our hypothesis is given as hθ(x) [22].

$$h\phi(x) = g(\phi^T x) = \frac{1}{1+e^{-\phi Tx}} \qquad (1)$$

$$g(z) = \frac{1}{1+e^{-z}} \qquad (2)$$

Naive Bayes

Naïve Bayes is a technique that depends on bayes' theorem; mainly used for grouping and classification purposes, its working principle could be presented as a naive bayes classifier, which assumes that a particular characteristic of a class is not exactly directly related to another characteristic. In other words, naïve bayes is a very important tool for understanding the dependence between events and assigning probabilities to them, to determine how much, or what is the change of occurrence of one event relative to another [23].

$$P(C_X / Y) = \frac{P(Y / C_X)P(C_X)}{P(Y)} \qquad (3)$$

Where Y is the dataset that need to classify and class label is denoted as C_X and the probability of belonging of Y to C_X as $P(C_X / Y)$

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

Support Vector Machine (SVM)

Support vector machine (SVM) has proven to be a supervised machine learning method, commonly used to provide data analysis for regression and classification problems. Generally, this method is used as a classifier, based on the principle of making a plot of n dimensions in space, where the value of each entity also presents the value of the specified coordinate. Subsequently, find the ideal hyper plane that made it possible to differentiate the two created classes. Like other machines, the SVM takes input, performs input manipulation, and then provides an output, which can later categorize new examples [24].Support vector machine (SVM) classifier used for binary classification of feature space by hyperplane -based linear separation of data. Normally it used for nonlinear regression and pattern classification purposes, SVM work on the following base rule [25].

$$Sgn(f(x,wb)$$
$$f(x,w,b) = (w.x) + b \qquad \textbf{(4)}$$

Where x is the example to be classified and maximum margin with hyperplane (w,b) represent the complex problem and w within the specified constraints [26].

$$yi(w.xi) + b) \geq 1 \qquad \textbf{(5)}$$
$$(w.x) + b) = 0 \;\; \omega \alpha R^n, b\varepsilon\, R$$

Memory-Based Learner (MBL)

Memory based learner also known as instance-based this approach work on the nearest neighbor that classifier the attributes based on training labels (K) is the neighbor in the feature space. A distance function is used to identify the nearest neighbors. The type of distance function is contingent on the datatype of nominated attributes [27].

$$d(xi,xj) = \sum_{q\alpha Q}(X_{iq} - X_{iq})^2 + \sum_{C\varepsilon c} L_c(X_{ic} - X_{jc}) \qquad (6)$$

Where Lc represents the M × M matrix used to describe the distance between two categorical attributes, Let Ni represents the set of k nearest neighbors for an instance xi having the distance d. T

$$V_i(t) = \sum K\varepsilon N_i(t, yk))$$

Decision Tree Induction Using Information Gain (DT–IG)

The decision tree erected on information gain defines the entropy approach whose eventual purpose is to minimize the entropy by identifying a split attribute. As a result, the information gain will be exploited [28].

$$E = -\sum_{I=1}^{K} Pi \log_2 P_i \qquad \textbf{(7)}$$

Radial basis function network

RBFN is the alternative of the more widely used MLP network and it less computer time consuming for network training system. RBFN consist of three layers these are input layer hidden layer and output layer and the node are fully connected with each other fully [29].

$$Y_k(k) = \sum_{i=1}^{H} W_{ki} \exp(\frac{//X - \mu^2)}{\sigma_I^{\,2}} \qquad \textbf{(8)}$$

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

Decision Tree

Decision trees are those three types that group attributes by sorting them according to their values. The decision tree is mainly used for classification purposes. Each tree is made up of nodes and branches. Each node represents attributes in a group to be classified and each branch represents a value that the node can take[30].For the training purpose of data set (D) the trees are constructed base on the level of entropy inputs and the trees are simple and fast for construction in a top down recursive divided and conquer technique (DAC) so for removing the irrelevant samples on data set [31].

$$Entropy = \sum_{j=1}^{m} P_{IJ} \log_2 p_{ij} \qquad (9)$$

Data Pre-Processing

Dataset for this study cleveland dataset ((UCI, 2016) used which are under the control of University of California Irvine (UCI) machine learning repository used for heart disease dataset. The data set consist of 303 instance of patient but 6 of them are conation missing value and table 3 shows the data set attributes with their definition.

Table.3. Dataset Features information and description

Feature name	Feature code	Description	Domain of values (minimax)
Age	AGE	Age in yrea	20<age>80
sex	SEX	Female =1,Male 0,	0,1
Resting blood pressure	RBP	mm Hg admitted at the hospital	94–200
Type of chest pain	CPT	1. atypical angina	1
		2. typical angina	2
		3. asymptomatic	3
		4. nonagonal pain	4
Fasting blood sugar >120 mg/dl	FBS	Fasting blood sugar >120 mg/dl (1 _ true; 0 _ false)	10 00 12
Serum cholesterol	SCH	In mg/dl	120–564
Resting electrocardiographic results	RES	having ST-T 1 hypertrophy 2	1 2
Maximum heart rate achieved	MHR	-	71–202
Exercise-induced angina	EIA	1 _ yes	1
		0 _ no	0
Old peak _ ST depression induced by exercise relative to rest	OPK	-	0–6.2
Slope of the peak exercise ST segment	PES	1. up sloping 1	1
		2. .at 2	2
		3. down sloping	3
Number of major vessels (0–3) colored by horoscope	VCA	-	1 2 3
Thallium scan	THA	3.normal	3
		6.£xed defect	6
		7. reversible defect	7

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

Results and Discussion

In this section we present the result of different proposed classifier in ML algorithm taking UCI data set. Before discussing the result these result are evaluated by using evaluation measures which are as:
This study we evaluated the accuracy rate of predication of proposed different models on heart disease datasets are mention below.

(1) Classification error: it is used for the measurement of incorrect classification in the classification model which is measured as:
(2) Classification accuracy: used to check the overall result of the performance of different classification and it will be measured as:
(3) Accuracy = $\frac{(TP + TN)}{(TP + FP + TN + FN)} * 100$
(4) Sensitivity is the process which shows the positive fraction or confirms that diagnostic test is
(5) positive and the test result for which process has find and it can be written as:
(6) Sensitivity/rec call /true positive rate =Sensitivity = $\frac{TP}{(TP + FN)} * 100$
(7) Specificity is diagnostic test is negative and person is healthy and can be present as: $\frac{TN}{(TN + FP)} * 100$
(8) Precision can be : $\frac{TP}{(TP + FN)} * 100$
(9) True Positive rate= TP / (TP + FN)
(10) False Positive rate = FP / (FP + TN)

Experiments

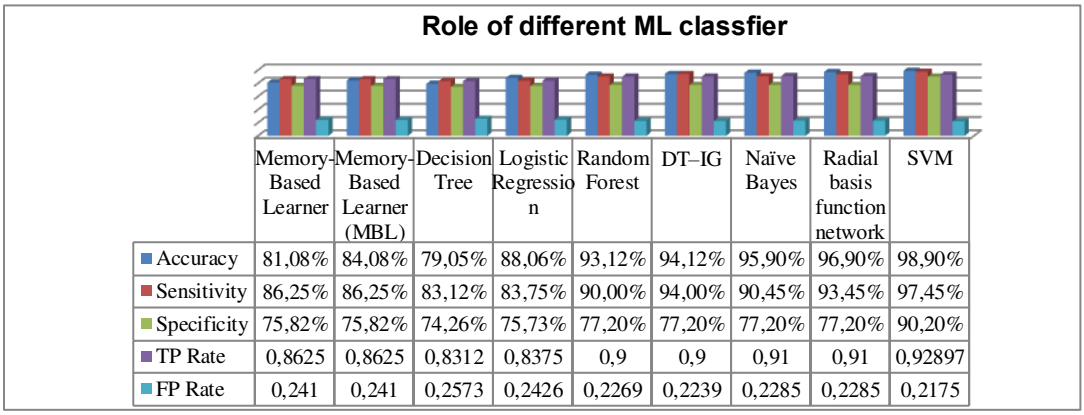
In this study Jupyter notebook software used for heart disease prediction taking, cleveland heart disease dataset. Here, the diagnostic performance is evaluated in terms of accuracy, precision, sensitivity, specificity, taking different ML algorithm. The factors contributing to these are discussed below.

Tabl.4. Assessment of ML Approach for heart disease prediction

Parameter	Accuracy	Sensitivity	Specificity	TP Rate	FP Rate
Memory-Based Learner	81.08%	86.25%	75.82%	0.8625	0.2410
Memory-Based Learner (MBL)	84.08%	86.25%	75.82%	0.8625	0.2410
Decision Tree	79.05%	83.12%	74.26%	0.8312	0.2573
Logistic Regression	88.06%	83.75%	75.73%	0.8375	0.2426
Random Forest	93.12%	90.00%	77.20%	0.9000	0.2269
DT–IG	94.12%	94.00%	77.20%	0.9000	0.2239
Naïve Bayes	95.90%	90.45%	77.20%	0.91000	0.2285
Radial basis function network	96.90%	93.45%	77.20%	0.91000	0.2285
SVM	**98.90%**	**97.45%**	**90.20%**	**0.92897**	**0.2175**

Table 4 present the result of all ML technique for accuracy, specificity, sensitivity, True positive and false positive based on those result SVM provide best result in term of accuracy and specificity and figure 5 presets these result. Figure 5 present the result of accuracy, specificity, sensitivity of different ML approach and based on the result of SVM accuracy rate is 98.90% and specificity, 90.20%, sensitivity rate are the best case. In this situation SVM help full in the overfitting issue also and provide good result as compare other classifier has some limitation.

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021



	Memory-Based Learner	Memory-Based Learner (MBL)	Decision Tree	Logistic Regression	Random Forest	DT–IG	Naïve Bayes	Radial basis function network	SVM
Accuracy	81,08%	84,08%	79,05%	88,06%	93,12%	94,12%	95,90%	96,90%	98,90%
Sensitivity	86,25%	86,25%	83,12%	83,75%	90,00%	94,00%	90,45%	93,45%	97,45%
Specificity	75,82%	75,82%	74,26%	75,73%	77,20%	77,20%	77,20%	77,20%	90,20%
TP Rate	0,8625	0,8625	0,8312	0,8375	0,9	0,9	0,91	0,91	0,92897
FP Rate	0,241	0,241	0,2573	0,2426	0,2269	0,2239	0,2285	0,2285	0,2175

Fig.5.ML models presentation of TP and FP rate

Figure.5. Present the TP and FP rate of ML approach and table 5 show the depicts of the outcome of all ML approach in term of performance are mention.

Table .5. Result of different classifier

Classifiers	Performance
Memory-Based Learner	90.74%
Memory-Based Learner	93.62%
Decision Tree	98.089%
Logistic Regression	95.88%
Random Forest	96.78%
DT–IG	97.89%
Naïve Bayes	97.95%
Radial basis function network	98.90%
SVM	98.91%

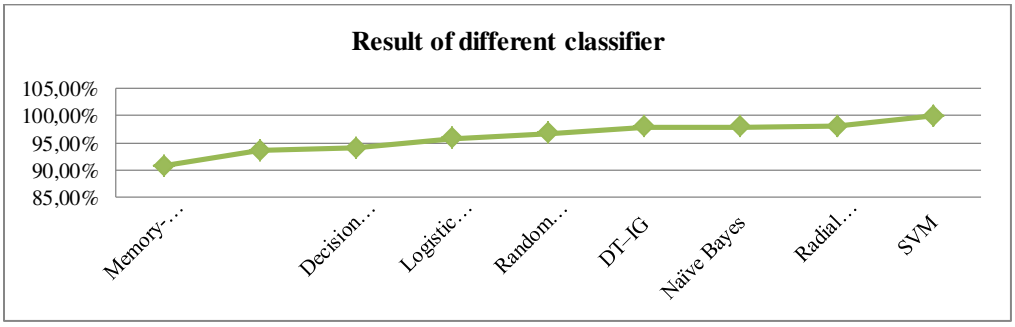


Fig.6. Rust of different classifier

Figure 6 show the result of different machine learning approach in term of accuracy performance for heart disease prediction. Based on the result SVM classifier provide best result and it accuracy rate is 98.91% best case and worst case. Memory-based learner and it result was 93.62%. Table 6 present the result of proposed technique (Classification) result in term of instances.

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

Table .6. Proposed classifier rest

	TP Rate	FP Rate	Precision	Recall	F-Measure	ROC Area
Incorrectly Classified Instances	0.312	0.092	0.571	0.312	0.404	**0.695**
Correctly Classified Instances	0.908	0.688	0.571	0.908	0.834	**0.695**
Weighted Average	**0.74**	**0.52**	**0.714**	**0.74**	**0.712**	**0.695**

Table 6 shows the training section of proposed classifier approaches where different instances are check based on missing or incorrect and correct form. To measure these instance different element are used to check which are Recall ,and ROC Area based of all parameter the correctly classified instances value are better and proved good result by the different classifier during simulation process. Figure 7 present their result based on each classifier.

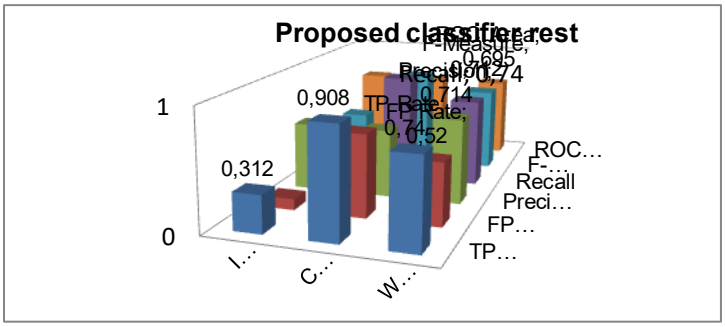


Fig.7.Show the result of classifier

Figure 7 present the result of all ML classifier which are used in training and testing section of the study. Taking different element three main section of the data set are check which are correct instances and correct, average instance based on the result the different proposed approach provide good result and most of instance are correct. Table 7 show the result of classifier in term of time.

Table .7. Time comparison of Classifier

Classifiers	Performance	Time of construction	MAE
Memory-Based Learner	90.5	0.02	0.044
Memory-Based Learner	91.2	0.08	0.00019
Decision Tree	88.3	0.06	0.117
Logistic Regression	89.3	0.06	0.117
Random Forest	96.5	0.02	0.044
DT–IG	96.2	0.09	0.013
Naïve Bayes	97.3	0.06	0.112
Radial basis function network	97.3	0.06	0.114
SVM	**99.2**	**0.02**	**0.044**

Table 7 present the one of most important parameter of classification which is time consumption based on the table SVM and Radial basis function network are the best case in term of time and accuracy using

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

MAE section for time measurement in the process system. This is primarily because it takes only few milliseconds to calculate the accuracy purpose. Figure 8 present the result of accuracy in term of accuracy in predication of heart disease.

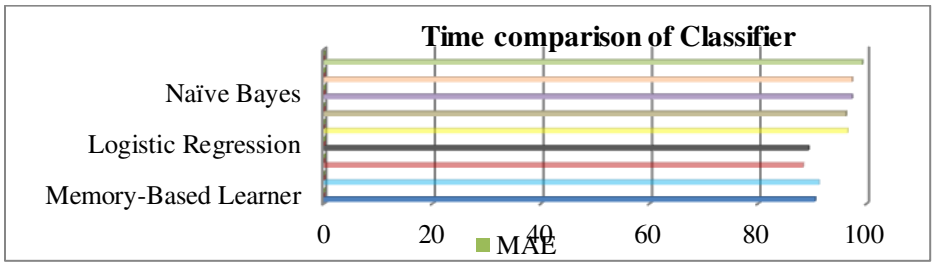


Fig.8. Time based comparison of classifier

Figure 8 present the time consumption of different machine learning classifier during the process system and table 8 present the overall time of all classifier taking different data range.

Table .8. Overall time consumption

Classifiers	Performance	Time for construction
Memory-Based Learner	52.33%	**609ms**
Memory-Based Learner	52%	**719ms**
Decision Tree	45.67%	**700ms**
Logistic Regression	62.33%	**850ms**
Random Forest	78.23%	**680ms**
DT–IG	85.67%	**608ms**
Naïve Bayes	70.33%	**850ms**
Radial basis function network	88.23%	**840ms**
SVM	**97.67%**	**600ms**

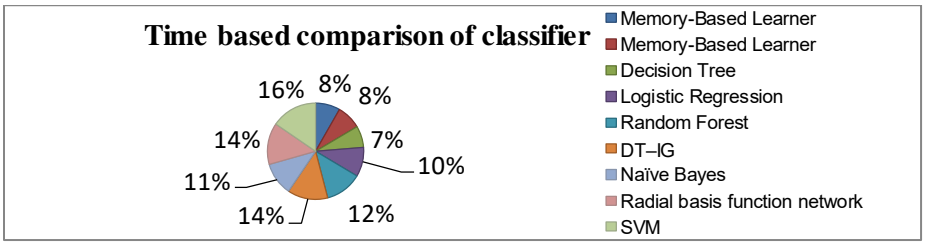


Fig.9. Overall time consumption of ML algorithm

Figure 9 and table 8 present the overall time consumption of ML technique all the model are good and improve the performance of each and every base classifier by providing accurate predictions of heart diseases. The overall time was good based on the classifier result so are at the position we can say machine learning approach are good for medical data set.

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

Conclusion

In this paper we analysis the accuracy of predication of heart disease using machine learning algorithm classifiers taking dataset from UCI. The different classifiers of machine leaning algorithm exploited for training and testing purposes. The main classifier are used are ,Support Vector Machine, Naive Bayes, Logistic Regression, Decision Tree and Memory-Based Learner based on these result has achieved an accuracy of SVM 97.90% with 90.96% sensitivity, 98.83% specificity are the most accurate classifier among all of them. Future research directions include weighted voting-based classifier ensemble and application of the proposed algorithm on different diseases like diabetes and cancer for classification and prediction.

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