HEART FAILURE PREDICTION USING MACHINE LEARNING TECHNIQUES

*Prasanta Kumar Sahoo, [2]Pravalika Jeripothula

[1] Professor, Dept. of CSE, Sreenidhi Institute of Science and Technology, Yamnampet, Hyderabad, Telangana.
[2] M. Tech Student, Dept. of CSE, Sreenidhi Institute of Science and Technology, Yamnampet, Hyderabad, Telangana.
[1]prasantakumars@sreenidhi.edu.in, [2]pravalika.3696@gmail.com

*Corresponding Author Prasanta Kumar Sahoo ORCID 0000-0002-5164-1010

ABSTRACT: **In this modern era people are very busy and working hard in order to satisfying their materialistic needs and not able to spend time for themselves which leads to physical stress and mental disorder. There are also reports that heart suffer because of global pandemic corona virus. Inflammation of the heart muscle can be caused by corona virus. Thus heart disease is very common now a day's particularly in urban areas because of excess mental stress due to corona virus. As a result Heart disease has become one of the most important factors for death of men and women in the so called material world. It has emerged as the top killer that has affected both urban and rural population. CAD (Coronary artery disease) is one of the most common types of heart disease. In the medical field predicting the heart disease has become a very complicated and challenging task, requires patient previous health records and in some cases they even need Genetic information as well. So, in this contemporary life style there is an urgent need of a system which will predict accurately the possibility getting heart disease. Predicting a Heart Disease in early stage will save many people's Life. There were many heart disease prediction systems available at present, the Authors have been researched well and proposed different Classification and prediction algorithms but each one has its own limitations. The main objective of this paper is to overcome the limitations and to design a robust system which works efficiently and will able to predict the possibility of heart failure accurately. This paper uses the data set from the UCI repository and having 13 important attributes. This work is implemented using many algorithms such as SVM, Naïve Bayes, Logistic Regression, Decision Tree and KNN. It is found that SVM gave the best result with accuracy up to 85.2%. A comparative statement of all the algorithms also presented in the implementation part of the paper. This research also uses model validation technique to design a best suitable model fitting in the current scenario.**

KEYWORDS: Heart Disease, machine learning, Prediction, Classification Algorithms.

I. INTRODUCTION

Heart is the essential organ of the human body. Human Life is completely depends on the efficient working of Heart. The heart pumps blood over blood vessels to the different body parts of the body, with enough oxygen and other essential nutritional components that are required for smooth functioning of the body. Healthy Heart leads a Healthy Life. But, in today's world Heart disease has become vital cause of death for both men and women in the world. Corona virus causes inflammation of the heart muscle leading to heart failure. Experimental evidences suggest that 1 in every five patient having heart injury due to Corona Virus irrespective of respiratory symptoms. Coronary heart disease is the most common type of heart disease. About 630,000 die from heart disease each year that's 1 in every 4 deaths. The diagnostic method for heart failure is generally based on the patient's medical and family histories, a physical examination, and test results [1]. Identification of heart disease is difficult because of various risk factors such as diabetes, high blood pressure, high cholesterol, abnormal pulse rate and many other factors [2]. Heart failure is a serious manifestation or late stage of various heart diseases. Generally, heart failure would result in insufficient cardiac ejection. Heart failure disease has the high mortality rate and it is not cost friendly. [3] Since heart disease is the most common, hence there is an urgent need of very accurate and early detection of heart disease which can save the life of many patients. There are many scanners to detect the heart disease but predicting a heart disease before it attacks can save many people. We are providing subsidiary information to the admin by using a tool in which can help the admin to analyze the patient's data

visually.[4] It is important to identify and analyze the presence of Arrhythmia in the early stage itself and prevent the people from getting affected with cardiac problems. The modest levels of heart rhythm may cause the presence of stroke or failure of heart in many cases.[5] Data mining holds great potential for the healthcare industry to enable health systems to use the data to analyze and predict the disease (identify) By using data mining. We can analyze the data and predict the disease and this reduces the cost, and saves the time. According to the World Health Organization it is estimated that till 2030, very nearly 23.6 million individuals will pass on because of Heart fragility. So to reduce the danger, expectation of coronary illness ought to be finished. [6] The risk factors of heart disease are classified into two main groups. The first group includes risk factors such as e.g., age, gender and family history, we cannot change them. The second group contains risk factors are e.g., smoking, eating habit and high cholesterol, we change this second group. Hence, the risk factors belonging to second class can be vanished or controlled by changing lifestyle and through medication [7] by using the medical data mining classification algorithms that is a vital part for identifying the possibility of heart attack before the occurrence. [8] the most commonly used method for diagnosis of CAD by medical experts is angiography but, the major side effects of angiography is high cost. [9] Blood pressure is also one of the most important factors affecting cardiovascular disease. According to previous studies, 13% of cardiovascular deaths are caused by raised blood pressure or hypertension. The objective is to reduce the number of incorrect decisions and increase the number of correct decisions [10] [11][13]. A paper published in JAMA cardiology report on heart problems among Corona Virus patients in Wuhan on Friday found that 20% of Covid-19 patients had some evidence of heart damage [14]. Initially it was thought that Corona Virus causes respiratory and lung problems but later on it was found that many patients infected with Corona Virus experiences cardiac issues. Now doctors are suggesting that one in every five deaths caused due to corona virus is because of heart distress.

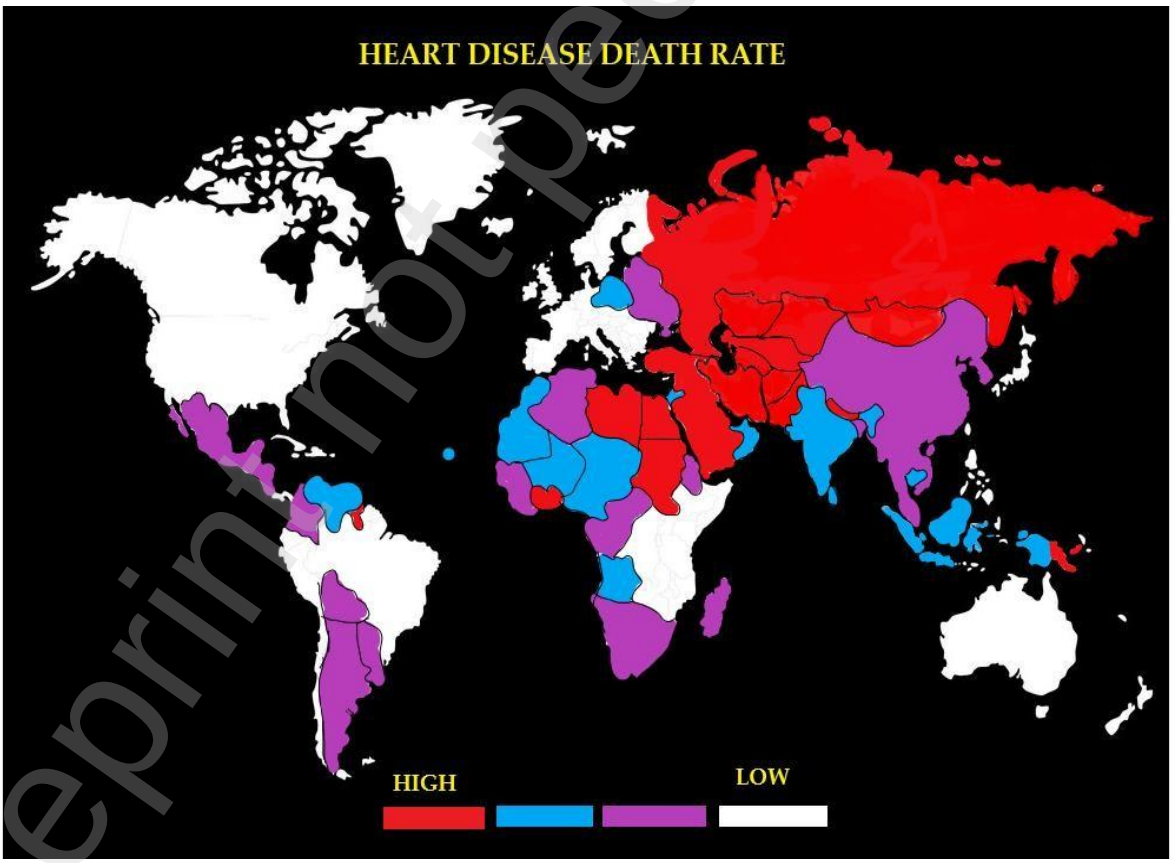


Fig 1: Death rate of highly effected countries, as per 2019.

Table 1: shows different types of heart diseases along with their symptoms.

TYPE	DESCRIPTION	SYMPTOMS
1.CORONARY ARTERY DISEASE	CAD restricts the blood flow to the heart, this affects the heart muscle and the heart muscle can't get enough oxygen.	Chest pain , Indigestion, Irregular heart beat
2. ARRHYTHMIA	Arrhythmia means peculiar heart beat which can be irregular, Arrhythmias are in two types Brady arrhythmia less heart rate and tachyarrhythmia higher heart rate.	Dizziness Fainting Shortness of breath
3.HEART FAILURE	It is technically known as congestive heart failure. It occurs when the heart does not have enough strength to pump blood to the entire body.	Swelling of your feet, ankles and legs.
4. HEART VALVE DISEASE	It occurs when one or more of the valves in the heart are not working properly.	Its main symptom is heart murmur which is an unusual sound heard between heartbeats.
5.HEART MUSCLE DISEASE	This is also known as CARDIOMYOPATHY. The muscle disease occurs when the heart becomes enlarged.	General weakness. Shortness of breath Light headedness. Fainting attacks
6. NGENITAL HEART DISEASE	Some children may be found to have been born with heart disease known as congenital heart disease.	It can occur in one out of every 100 live births.

A. ABOUT HEART DISEASE

CORONARY ARTERY DISEASE

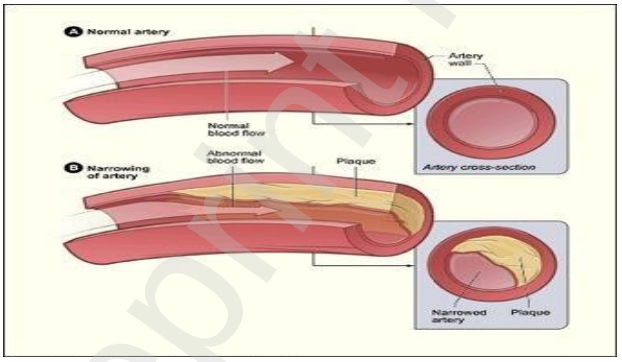
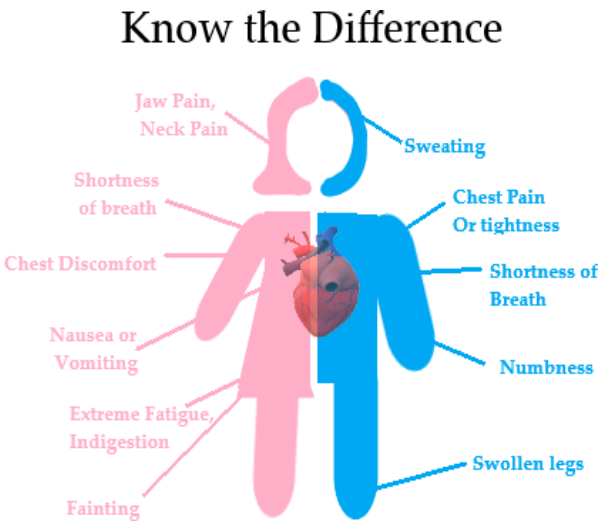


Fig: 2. Type of Coronary Artery disease

Here are some most common symptoms of heart diseases. Heart Disease symptoms might vary from men to women. Different kinds of symptoms mean different kinds of Heart Disease. This research analyzed most common Symptoms which vary from men to women and listed them below along with risk factors.



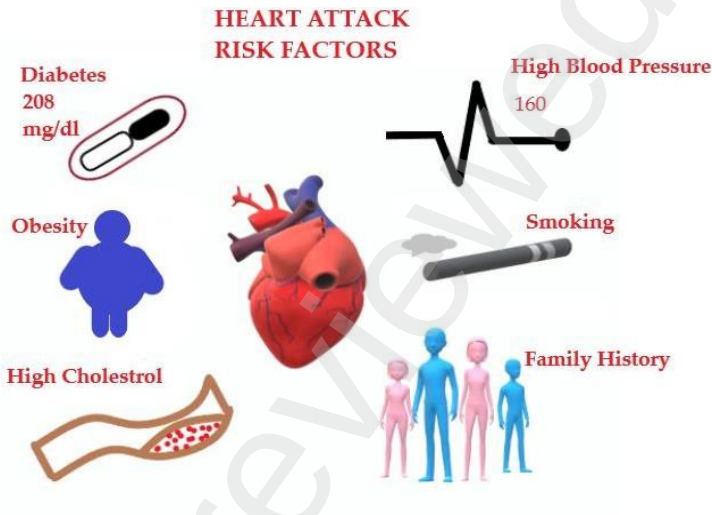


Fig: 3. Symptoms of Heart Disease for women/men

Fig:4 Major Risk factors

Here are some major **RISK FACTORS** of heart disease.
Risk factors are the warning signs for Heart Disease. Risk factors are divided as two factors such as

1. Modifiable Risk-factors
2. Non-Modifiable Risk factors
3.

The various risk factors are given below in the tabular form. We can change the modifiable risk factors by changing our food habits, life style and by participating in physical activities. Risk factors might also lead to Death in some serious cases.

NON-MODIFOABLE FACTORS	MODIFIABLE FACTORS
1. AGE	**1. Hypertension**
2. SEX	**2. Diabetes**
3. Family History	**3. Obesity**
–	**4. Cigarette Smoking**
–	**5. Physical Inactivity**
–	**6. Dyslipidemia**

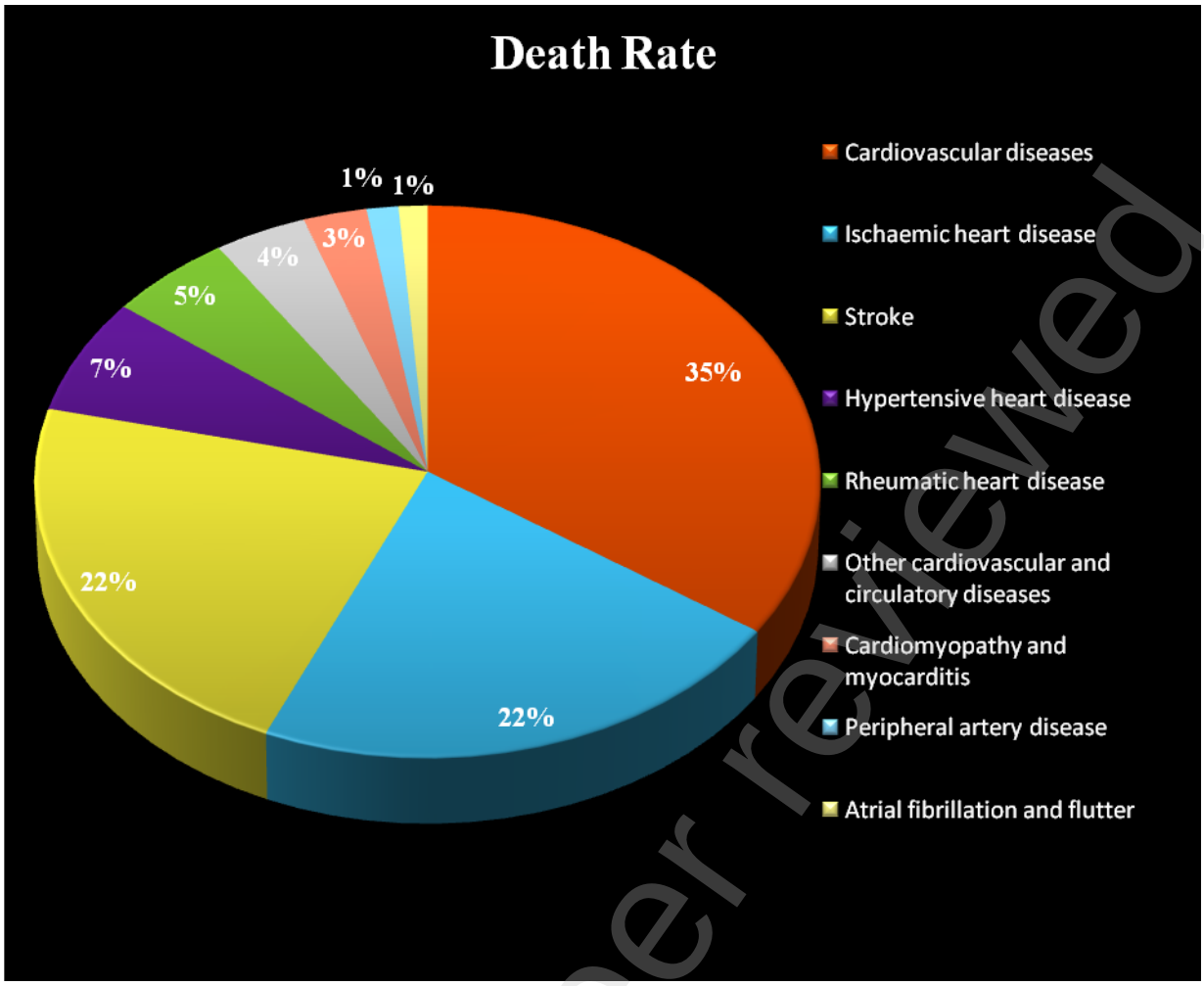


Fig:5. Death rate percentage of different types of heart disease, in 2019.

II. LITERATURE REVIEW

There were some existing prediction systems, the Authors have been researched well and proposed the predicting systems by applying different Classification and prediction algorithms. Some of the existing systems are Kaur K. proposed a method for the prediction of heart disease which is based on the principal of component analysis and SVM classification, and they proved that the method is suitable for disease prediction. Ren Y. proposed a hybrid neural network that combines two-way long-term memory and self-encoding network. Using the data of 35,332 hypertensive patients, the model was used to predict renal disease in hypertensive patients and the final prediction accuracy was 89.7%. [15]

Shashikant Ghumbre, Chetan Patil propsed, an intelligent system based support vector machine along with a radial basis function network which is used to represent the diagnosis of the patient. Based on clinical symptoms it will decide what type of heart disease is possible to appear for a patient, whether it is heart attack or not. The support vector machine with sequential minimal optimization algorithm is applied to India based patients" data set. Then, the Radial Basis Function (RBF) network structure trained by Orthogonal Least Square (OLS) algorithm is applied to same data set for predictions.

[16] CART uses Gini index as a measure to the contamination of a partition or a set of training tuples and can handle and process high dimensional categorical data. Decision Trees also handle continuous data (as in regression) but must be converted to categorical data before. [17] B. Jin, C. Che, Z. Liu, S. Zhang, X. Yin and X. Wei [1] the heart disease can be predicted with some attributes which are collected from the patient and they even collected patient‟s health records and previous patient history to predict the heart disease. They used the images from the (EHR) Electronic Health Records. EHR consists of patient diagnostic records, physician records, and hospital records. Based on the EHR records they got some output which is in image format unstructured data by identifying and analyzing the links between events they can ultimately predict when a patient will be diagnosed. Electronic health records data are sparse, we cannot analyze and predict with such data. Data which is obtained from EHR are unstructured and non-standardized. So, it will be difficult to use the existing data directly since they are sparse (dispersed).

Raj Kumar and Sophia have proposed by using the Data mining algorithm for heart disease diagnosis and they got with an accuracy of 52.33%. They have clubbed the ECG attributes and clinical symptoms to identify the heart disease. The algorithms used by this system are Naive Bayes algorithm, Decision list algorithm and KNN algorithm. This system lacks accuracy; it does not provide accurate results.

Genetic algorithm is also used in another approach by anbarasi et al. Where number of tests that are to be conducted by patient is reduced by determining the attributes that involved in the prediction of heart disease. In this approach three classifiers were used and these classifiers were fed with reduced attributes, this system takes more time for model construction.[18].

A system for diagnosis of heart disease that is based on support vector machine along with sequential minimal optimization algorithm is presented. In this system the network structure of Radial Basis Function is also used and it is trained using Orthogonal Least Square algorithm and applied to the dataset based on indian patients. The result shows that the SVM is equivalently as good as compared to Radial bias function in detection of heart disease with accuracy of 86.42% [19]

Gudadhe et al. proposed a system by using Support Vector Machine and multilayer perceptron neural network architecture for identifying the heart disease. They divided the database into two categories by using the Support Vector Machine to show the presence of heart disease or absence of heart disease. They achieved with an accuracy of 80.41%, whereas the artificial neural network classifies the heart disease data into 5 with an accuracy of 97.5% [20].

Kanika Pahwa and Ravinder Kumar proposed a method by applying the hybrid technique for selecting the features on the heart disease dataset for prediction. Author approached the feature selection technique using the SVM-RFE along with the gain ratio for removing the irrelevant and excessive features. Identifying the features is important for prediction. They have applied Naïve Bayes and Random Forest on the subset of features for classifying the data set into present or absence of heart disease. They achieved the results with better accuracy when applied with selected features. The accuracy achieved by Naïve Bayes is 84.15%, and the Random Forest achieved 84.16%, They got almost similar accuracy for both the methods[21] Auto regressive integral moving average model (ARIMA) is used to exhibit better performances with short-term time series data prediction and is thus suitable for numerical sequences. For non-numerical time series, a neural network can be constructed to solve the problem, this system lacks the efficiency and it does provide the accurate results.

Heart Disease Using Data Mining Techniques Identifying the Possibility of whether a person is having heart disease may take years of experience and intense medical tests This is a complicated process since it takes more time and money consuming since it requires many number of tests. We require a system which can predict the possibility more accurately.

A. MACHINE LEARNING

Machine learning is a process of exploring and modeling a huge amount of data. It sorts out the data through large sets to identify patterns and analyze the relationship between them. Machine Learning is the study of collecting, cleaning, pre-processing, analyzing, gaining useful insight information from data.

B. MACHINE LEARNING IN HEALTH CARE:

Machine learning in health care has achieved huge positive out-comes, which also save many lives. The usage of machine learning in Health care systems has increased in past years The purpose of data mining, is to identify useful and understandable patterns by analyzing large sets of data. These data patterns will help to predict information and then determine what to do about them. In the healthcare industry specifically, data mining can decrease cost of Tests, And It also increases efficiency and improves patient quality of life, and perhaps most importantly, save the lives of more patients. Data mining has potential to help to prevent in epidemics, diseases and to identify/ predict. This can also cut-own the costs and makes the out-come more accurate.

III. PROPOSED WORK (METHODOLOGY)

A. PROPOSED WORK: ALGORITHM

This research work used machine learning for prediction of heart disease. Machine learning has high scope in predicting and classification. Specifically in health care industries Data mining accuracy rate has been increased. Many Algorithms have been used and tested but SVM algorithm achieved high accuracy rate.

SVM Algorithm is a good classification approach for predicting. This prediction model will help people save their lives. The support vector machine (SVM) is a relatively new classification or prediction method developed by Cortes and Vapnik. Especially in the cases where sample sizes are small and a large number of features (variables) are involved. SVM is one of the most well-known supervised machine learning algorithms for classification. For a given set of training data, each marked as belonging to one of two categories, SVM training algorithm develops a model by finding a hyper plane, which classifies the given data as correctly as possible by maximizing the distance between two data clusters.

B. SVM PRINCIPLE:

Support Vector Machine is a linear model for classification problems. SVM is used to can solve linear and non-linear problems. The Support Vector Machine algorithm creates a line is called as hyper-plane which separates the different kinds of data into classes. The SVM algorithm will be trained

on a group of labeled data. Firstly, SVM will study the labeled training data then it classifies new data depending on what it learnt in the training phase. SVM has been used for many practical problems and it worked accurately.

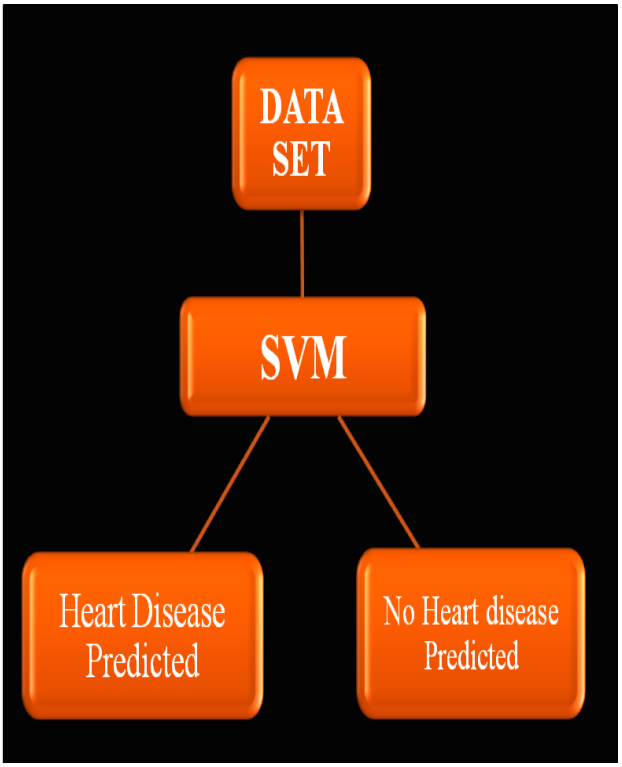


Fig:.6 SVM Example

C. DATA SET

i. DATA SET DESCRIPTION: The data set for this research work has been collected from the UCI repository. This data set consists of 13 significant attributes which plays key role in identifying the presence or absence of the heart disease. These 13 clinical attributes are preprocessed and trained to predict that there is the presence or absence of the heart disease. The attributes are in the form of numeric type which represents the age of the patient in the numeric values, Age is the most important risk factor in growing the heart diseases; it doubles the risk in ADOLENCE.

ii. Sex - Men are at greater risk of heart disease than women. The ender of the person is 1 represents the MALE; whereas 0 represents the female. Chest pain is an important attribute which is used for determining the type of the chest pain 1, 2, 3 and 4.Restbp is resting blood pressure which is measured in the numeric values. This differs from person to person. (Based upon the age and person health).FBS is fasting blood sugar which represents in the Boolean type either 1 or 0.Restecg is resting electrocardiogram results which results from 0, 1 and 2. Thalach is the Maximum heart rate achieved from 60-200. Exang is the exercise induced angina which is again in Boolean type 1 or 0. Slope is represents from 1-3. CA is coronary arteries count of the major vessels which ranges from 0-3. Thal is Thalassemia (defect type) value 3 is normal, 6 is fixed typed, 7 is reversible defect. The class label represents the result/ target which is in Boolean form 0 is absence of the heart disease 1 is presence of the heart disease.

D. PRE-PROCESSING: Data Pre-processing is one of the most important data mining task which includes preparation and transformation of data into suitable form for mining procedure. Data pre-processing reduces the size of the data and includes all techniques like data cleaning, integration relation between data and normalization of data. It also removes outliers and extracts features from data. It also involves removing feature noise from the data and suitable filling of missing features.

Table2: shows data set attributes

Attributes	Description	VALUES
1. Age	Patient Age in Years	Continuous
2. Sex	Gender of the Patient	1= Male; 0=Female
3. CP	Chest Pain type	1= Type I angina 2= Typical type Angina 3= Non-Angina 4= Asymptotic
4. Restbp	Resting Blood Pressure	BP mmHg [6=-200]
5. Chol	cholesterol	Measured in mm/dL
6. FBS	Fasting Blood Pressure	1= „>120 mg/dL" 0="<120 mg/dL"
7. Rest ECG	resting electrocardiogram results	0=normal; 1=Abnormal; 2= hypertrophy
8. Thalach	Maximum Heart rate achieved	60-200/bpm
9. exang	Exercise induced angina	1=Yes; 0=No
10. Old peak	ST curve (Depression induced by exercise relative to rest)	[0-6]
11. Slope	Slope of peak exercise ST segment	1=unslope; 2=flat; 3=Downslope
12. CA	No of major vessels coloured by Fluoroscopy	[0-3]
13. Thal	Thalassemia (defect type)	3=Normal; 6=Fixed; 7=Reversible defect
14. Class Label	Presence / Absence	0= Absence; 1= Presence

IV. ARCHITECTURE OF PROPOSED SYSTEM

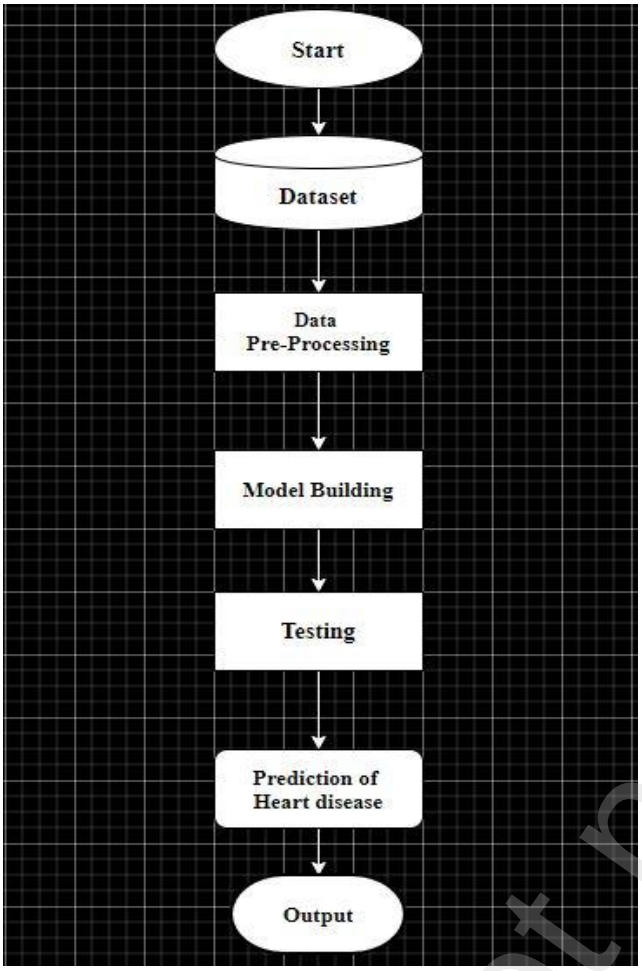


Fig: 7. Architectural Model of Proposed system

1. The initial procedure for this project is the collection of data. We have collected the data set from kaggle, which is available; it is an open-source.
2. The next step after data collection is data pre-processing. In this step, the data is cleansed by removing unnecessary values. It also removes the missing/ null/ corrupted values.
3. After Data is cleansed, the next step is dividing the data, we divide the data into two sets, Training data and testing data. The values have to dealt before we start to construct the training model. By using training data we build a model for prediction.
4. We chose SVM Algorithm as it achieved more accuracy and it is efficient. Now, we have to calculate the accuracy of the model.
5. The final step is predicting the disease. The final output will be in numerical 1= Yes; 0= No.

V. IMPLEMENTATION

This work used Python programming for this project, as it is a high level programming language and it has vast libraries and Python automates tasks and makes it efficient. Firstly, we need to install Python then we need to import some libraries, they are:

1 Numpy: Numpy is used for multi-dimensional arrays, It does element to element operations and it also has different methods for processing arrays.

2. Panda: Pandas is one of the highly used python library, it provides high performance. It manipulates data and it makes data analysis fast and easy.

3. Sklearn: It is most useful library, This library contains lot of efficient tools, It is used to build models like statistical modeling including classification, regression, clustering. After loading required packages, we divide dataset as training and testing as follows, here 70 % of dataset is taken as training and remaining 30 % as to perform test.

PERFOMANCE METRICS ANALYSIS

ACCURACY: Accuracy is used to find the correct values; it is the sum of all true values divided by total values (True Positive + True Positive) / (True Positive +True Negative +False Positive +False Negative)

$$\text{ACCURACY} = \frac{(TP + TN)}{(TP + TN + FP + FN)}$$

PRECISION: How often a model predicts a positive value is correct? It is all the true positives divided by the total number of predicted positive values. True Positive/True Positive + False Positive

$$\text{PRECISION} = \frac{(TP)}{(TP + FP)}$$

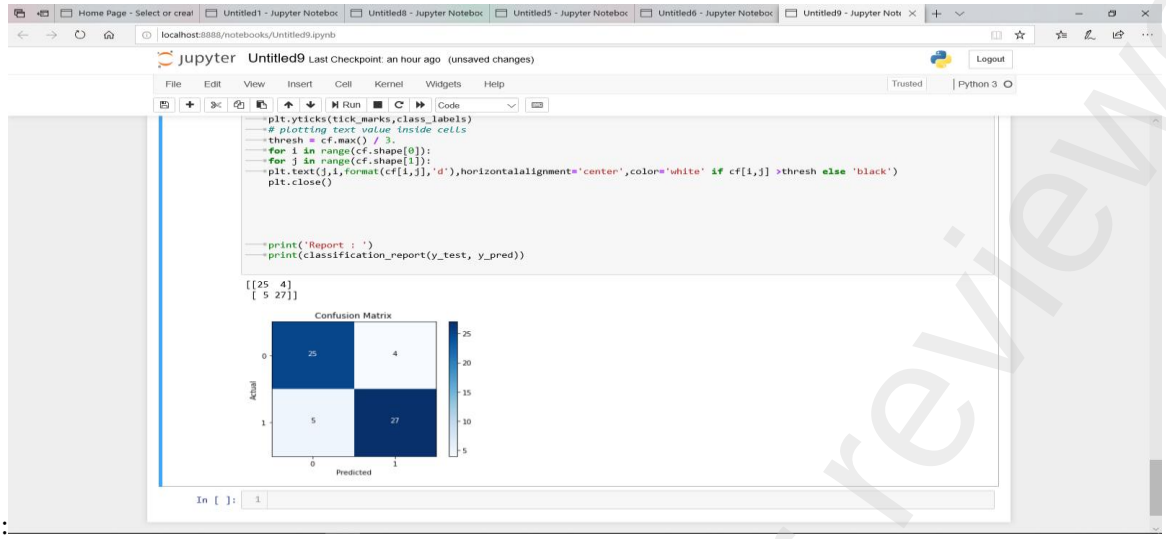
RECALL: It used to calculate the models ability to predict positive values. How often does the model actually predict the correct positive values? It is true positives divided by the total number of actual positive values.
True Positive/True Positive + False Negative

$$\text{RECALL} = \frac{(TP)}{(TP + FN)}$$

F-1 SCORE: F1 measure is used when we need to take both Precision and recall.

$$\text{F1} = \frac{2 \times PRECISION \times RECALL}{(PRECISION + RECALL)}$$

SVM CONFUSION MATRIX



:

Fig 8: shows SVM confusion matrix.

$$\text{ACCURACY} = \frac{(TP + TN)}{(TP + TN + FP + FN)}$$

=25+27/(25+27+4+5) =0.852 means 85.2%.

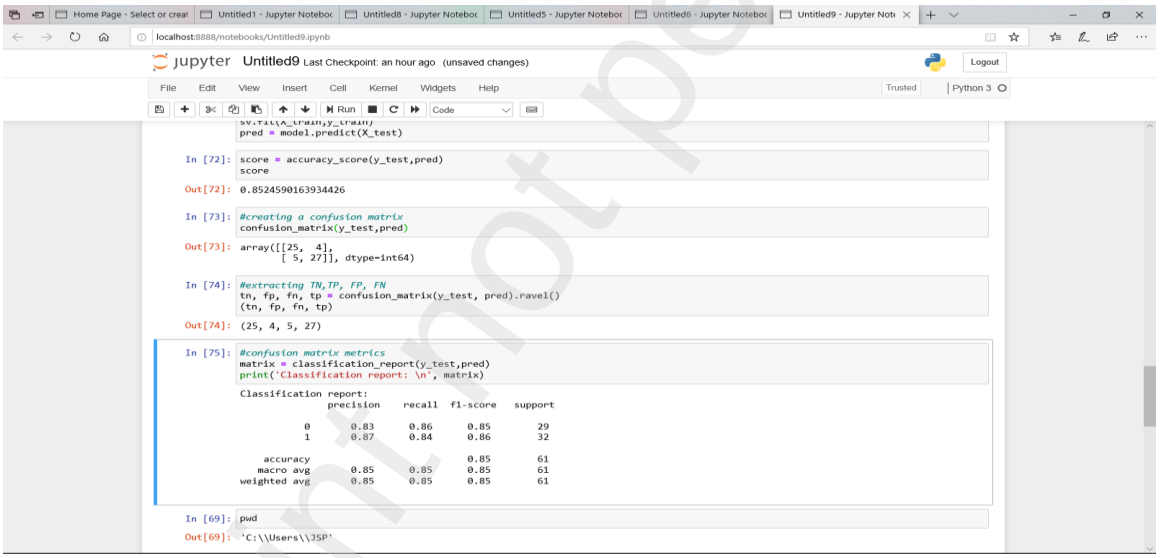


Fig 9: shows implementation using Naïve Bayes.

NAÏVE BAYES CONFUSION MATRIX:

11	7
3	19

$$\text{ACCURACY} = \frac{(TP + TN)}{(TP + TN + FP + FN)}$$

$= ((11 + 19))/((11 + 19 + 7 + 3))$ = 0.75

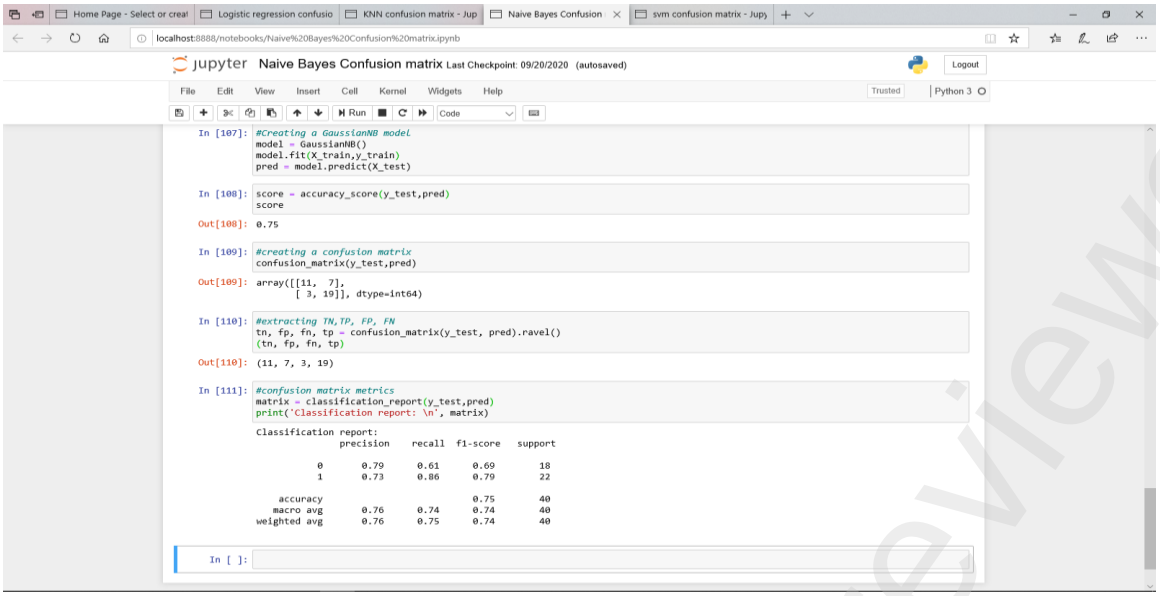


Fig 10: shows implementation using Logistic Regression.

LOGISTIC REGRESSION MATRIX:

16	11
4	30

$$\text{ACCURACY} = \frac{(TP+TN)}{(TP+TN+FP+FN)} = \frac{(16+30)}{(16+30+11+4)} = 0.83$$

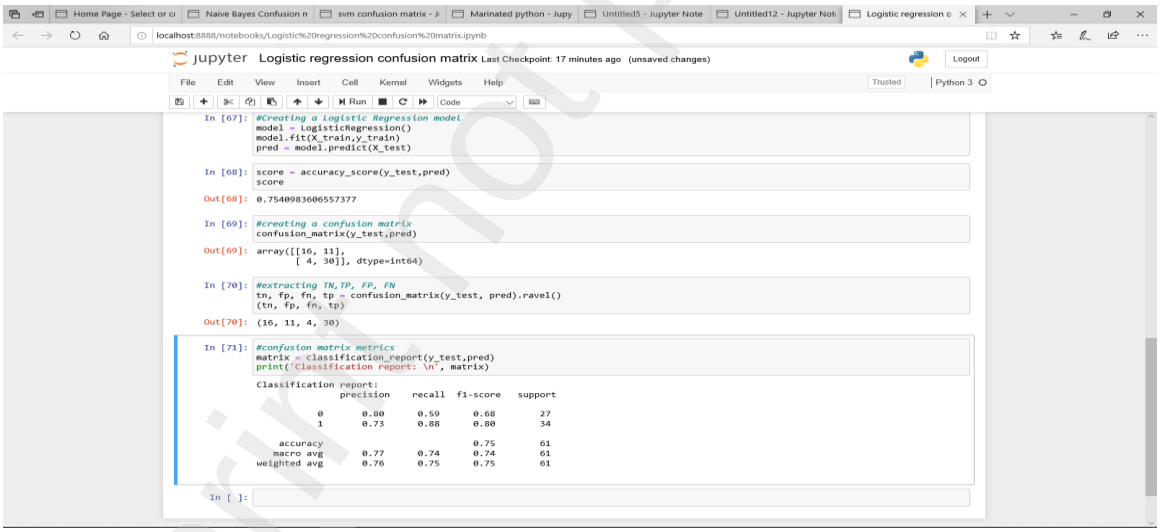


Fig 11: shows implementation using Decision Tree.

DECISION TREE CONFUSION MATRIX:

4	6
5	5

$$\text{ACCURACY} = \frac{(TP+TN)}{(TP+TN+FP+FN)} = \frac{(4+5)}{(4+5+6+5)} = 0.68$$

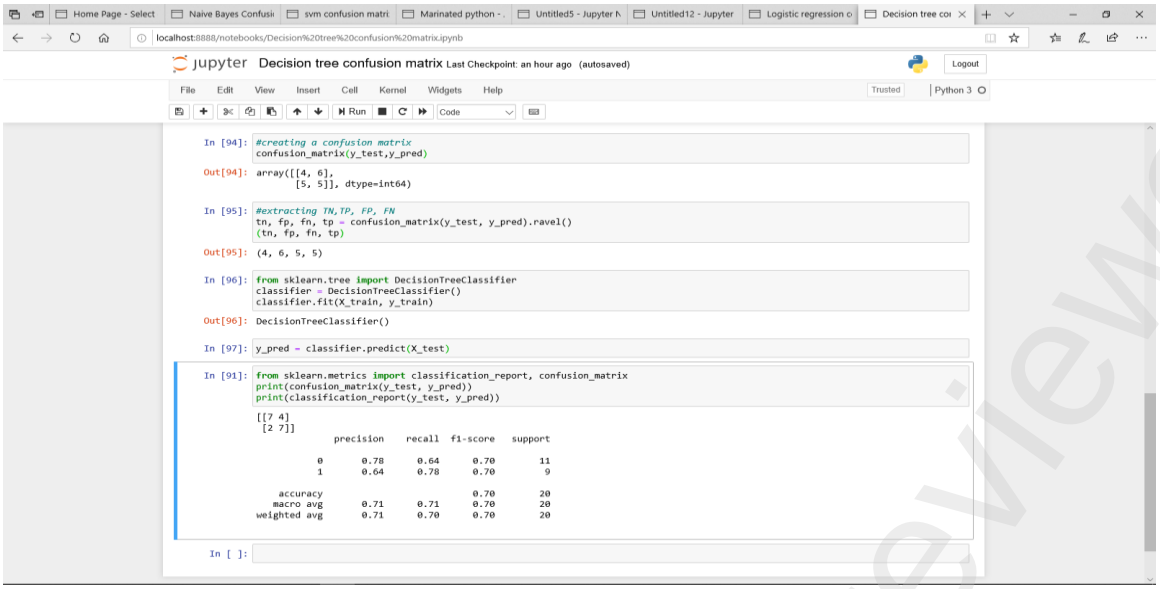
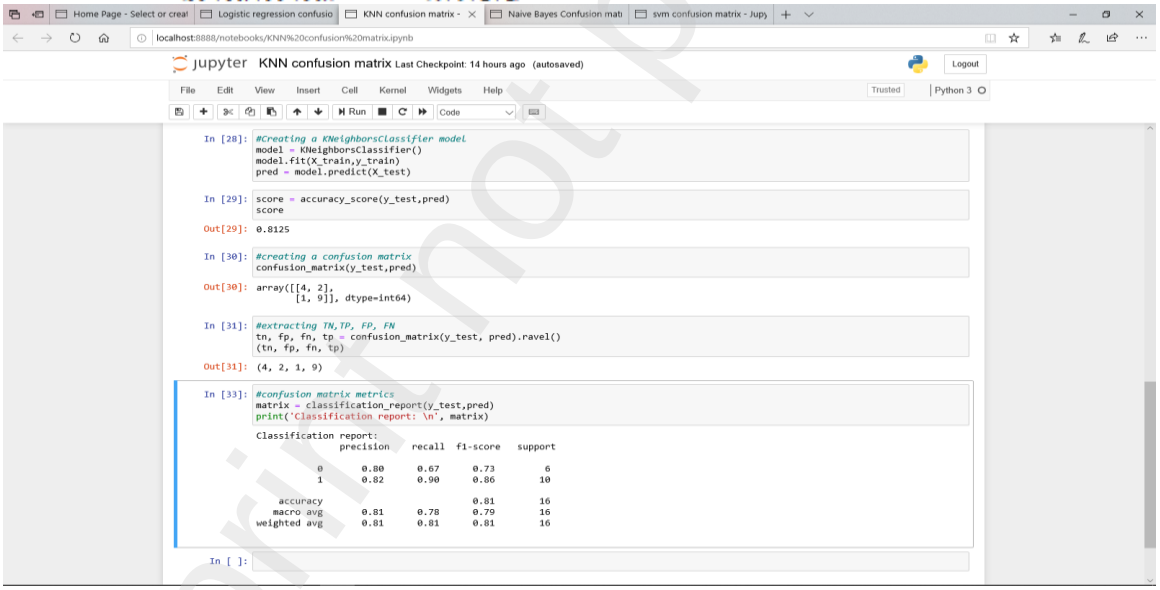


Fig 12: shows implementation using KNN.

KNN CONFUSION MATRIX:

4	2
1	9

ACCURACY $= \frac{(TP+TN)}{(TP+TN+FP+FN)} = \frac{(4+9)}{(4+9+2+1)} = 0.81$



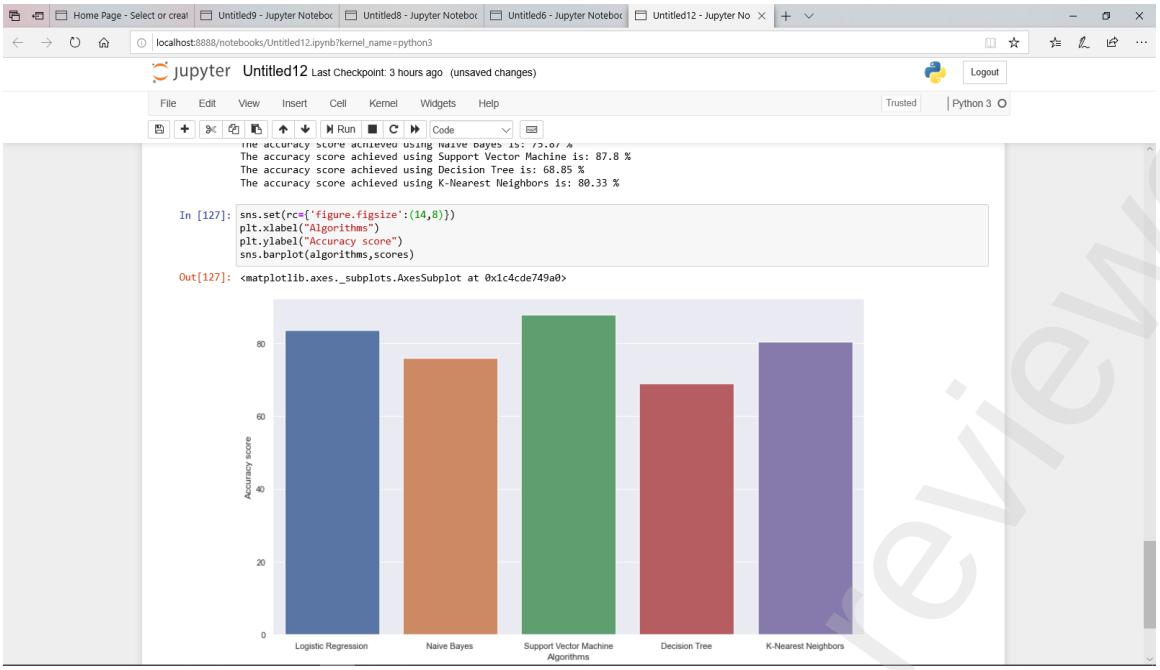


Fig 13: shows comparison of all algorithms.

VI. RESULT ANALYSIS:

This research work use the data set consists of various clinical attributes like patient Age, Sex, Chest pain, Fbs and etc as shown in table 2. Next step is to divide the data set into two sets, Training set is 70% and testing set is 30%. Training set is used to construct the model and testing to evaluate the correctness of the model. This research work is carried out by implementing the data set over five different algorithms and results are compared. By using this method this research work could able to predict whether a patient is suffering from heart disease or not (0 is absence and 1 is presence) with 85.2% accuracy. By using the Support vector machine this model could able to predict with an accuracy of about 85.2% which is highest as compared to other algorithms.

VII. CONCLUSION

Heart is the most essential organ of the human body and day by day the loss of Human Life is increasing exponentially due to heart failure. It was experimentally found that the Global pandemic Corona Virus causes heart injury among a lot of patients. Hence there is an urgent need for research to focus into the causes for heart failure and to design a robust prediction system to detect at early stage so that loss of life can be avoided. Even though there were many heart diseases prediction systems available at present but each one has its own limitations. The main objective of this research work is to overcome the difficulty faced by other researchers and to build a robust system which works efficiently and will able to predict accurately the possibility of heart attack at very early stage. This research work could able to design a very robust and accurate model to predict the possibility of heart failure in the current scenario. By using the Support vector machine this model could able to predict with an accuracy of about 85.2% which is highest as compared to other algorithms.

VIII. COMPLIANCE WITH ETHICAL STANDARD

We the author of "HEART FAILURE PREDICTION USING MACHINE LEARNING TECHNIQUES" states that this research work fully compile with ethical standards as per the Journal.

We have no direct or potential influence or impart bias on this research work.

We have no conflict conflicts of interests that are directly or indirectly related to this research work.

We have no funding from any funding agency or financial support from any organization.

This research work only involves human beings and for Ladies and Gents only.

IX. REFERENCES

[1]. B. Jin, C. Che, Z. Liu, S. Zhang, X. Yin and X. Wei, "Predicting the Risk of Heart Failure with EHR Sequential Data Modeling," in IEEE Access, vol. 6, pp. 9256-9261, 2018.

[2]. S. Mohan, C. Thirumalai and G. Srivastava, "Effective Heart Disease Prediction Using Hybrid Machine Learning Techniques," in IEEE Access, vol. 7, pp. 81542-81554, 2019.

[3]. B. Wang et al., "A Multi-Task Neural Network Architecture for Renal Dysfunction Prediction in Heart Failure Patients With Electronic Health Records," in IEEE Access, vol. 7, pp. 178392-178400, 2019.

[4]. S.Adithya Varun, G.Mounika, Dr. P.K. Sahoo, K. Eswaran, "Efficient system for Heart disease prediction by applying Logistic regression. ijcst vol 10, issue 1, march 2019.

[5]. Rajalakshmi, S., & Madhav, K. V., A Collaborative Prediction of Presence of Arrhythmia in Human Heart with Electrocardiogram Data using Machine Learning Algorithms with Analytics. 278 287. doi:10.3844/jcssp.2019.278.287, 2019.

[6]. Purushottam, Saxena, K., & Sharma, R, "Efficient Heart Disease Prediction System". Procedia Computer Science Published by Elsevier 85, 962–969. doi:10.1016/j.procs.2016.05.288.

[7]. A. Javeed, S. Zhou, L. Yongjian, I. Qasim, A. Noor and R. Nour, "An **Intelligent** Learning System Based on Random Search Algorithm and Optimized Random Forest Model for Improved Heart Disease Detection," in *IEEE Access*, vol. 7, pp. 180235-180243, 2019.

[8]. H. Benjamin Fredrick David and S. Antony Belcy, "heart disease prediction using data mining techniques". ICTACT JOURNAL, oct 2018, volume: 09, issue: 01, DOI: 10.21917/ijsc.2018.0253.

[9]. L. Ali, A. Rahman, A. Khan, M. Zhou, A. Javeed and J. A. Khan, "An Automated Diagnostic System for Heart Disease Prediction Based on ${\chi^{2}}$ Statistical Model and Optimally Configured Deep Neural Network," in IEEE Access, vol. 7, pp. 34938-34945, 2019.

[10]. Alaa Elsayad and Mahmoud Fakhr, "Diagnosis of Cardiovascular Diseases with Bayesian Classifiers" Journal of Computer Sciences 2015, 11 (2): 274.282 DOI: 10.3844/jcssp.2015.274.282.

[11]. W. Chang, Y. Liu, X. Wu, Y. Xiao, S. Zhou and W. Cao, "A New Hybrid XGBSVM Model: Application for Hypertensive Heart Disease," in *IEEE Access*, vol. 7, pp. 175248-175258, 2019.

[12]. J. Chen, A. Valehi and A. Razi, "Smart Heart Monitoring: Early Prediction of Heart Problems Through Predictive Analysis of ECG Signals," in *IEEE Access*, vol. 7, pp. 120831-120839, 2019.

[13]. M.D.Anto Praveena, B. Bharathi, "Cognitive Learning Based Missing Value Computation in Cardiovascular Heart Disease Prediction Data". Procedia Computer Science 165 742–750, (2019).

[14].https://health.economictimes.indiatimes.com/news/diagnostics/a-heart-attack-no-it-was-coronavirus/74869291.

[15]. W. Chang, Y. Liu, X. Wu, Y. Xiao, S. Zhou and W. Cao, "A New Hybrid XGBSVM Model: Application for Hypertensive Heart Disease," in *IEEE Access*, vol. 7, pp. 175248-175258, 2019.

[16]. Ghumbre, S., C. Patil and A. Ghatol, 2011. Heart disease diagnosis using support vector machine. Proceedings of the International Conference on Computer Science and Information Technology, (SIT, 11), Pattaya, pp: 84-88. Dec. 2011.

[17]. S. Palaniappan, R. Awang, "Intelligent heart disease prediction system using data mining techniques", IEEE/ ACS International Conference on Computer Systems and Applications, Doha, pp. 108-115, 2008.

[18]. J. S. Sonawane and D. R. Patil, "Prediction of heart disease using multilayer perceptron neural network" *International Conference (ICICES2014)*, pp. 1-6, 2014.

[19]. Kalyani Kondalkar and Vaishali Sahare, "A Survey On Different Methods For Disease Diagnosis In Health Care System", (IJIFR) Volume - 3, Issue -8, April 2016.

[20]. M. Gudadhe, K. Wankhade and S. Dongre, "Decision support system for heart disease based on support vector machine and Artificial Neural Network," *2010 International Conference on Computer and Communication Technology (ICCCT)*, Allahabad, Uttar Pradesh, 2010, pp. 741-745.

[21]. K. Pahwa and R. Kumar, "Prediction of heart disease using hybrid technique for selecting features," *2017 4th IEEE Uttar Pradesh Section International Conference on Electrical, Computer and Electronics (UPCON)*, Mathura, 2017, pp. 500-504.

X. Authors Biography

Dr. Prasanta Kumar Sahoo currently working as a Professor, Department of Computer Science and Engineering, Sreenidhi Institute of Science & Technology, Hyderabad. His ORCID 0000-0002-5164-1010. He has completed his Ph.D. from Fakir Mohan University, Odisha in Computer Science Engineering. He has 19 years of teaching, research, and administrative experience. His Research Interest includes Cyber Security, Information Security, Machine Learning and Data Mining. He has published around 60 research papers in various reputed journals both at national and international levels. His research papers were cited both at the national and international levels, so far by 51 citations and 4567 reads as per Google Scholar and Research Gate report. Many times Dr. Prasanta Kumar Sahoo won the best teacher award in various colleges for his contribution to the teaching and learning process. He is Certified Professional from BalaBit, completed Electronic Contextual Security Intelligence exam Intermediate Level (ECSI). He has guided more than 50 projects both at UG and PG levels. He has delivered more than 15 guest lecturers. He has organized three national conferences and twelve faculty development program with immense success.

Pravalika Jeripothula received her Bachelor's degree in computer science and engineering from ACE Engineering College (JNTUH). Now she is pursuing a Master of technology in Sreenidhi institute of science and technology in Computer Science and Engineering.