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Efficient Diagnosis of Atherosclerosis Through Combined Machine Learning And K-Means Clustering Methods

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Abstract *– The prediction of atherosclerosis disease is a very complex process. The complexity of prediction faces a problem of multiple attributes of heart disease-related symptoms. The machine learning algorithm plays an essential role in the prediction of atherosclerosis disease. The various authors and research scholar proposed various algorithms based on machine learning and artificial intelligence. This paper presents the study of machine learning algorithms for the prediction of atherosclerosis disease. The analysis of atherosclerosis disease applied four machine learning algorithms such as support vector machine, KNN, decision tree and naive Bayes. For the validation of algorithms applied four datasets: the applied dataset obtained from the UCI machine learning repository. For the evaluation of performance, measure three significant parameters like accuracy, specificity and sensitivity. I used MATLAB tools for all experimental research. MATLAB is algorithm analysis software. The analysis of performance suggests that a hybrid approach to integrate machine learning and k-means clustering is better than other machine learning algorithms. Coronary artery disease (CAD) is caused by atherosclerosis in coronary arteries and results in cardiac arrest and heart attack. For diagnosis of CAD, angiography is used which is a costly time consuming and highly technical invasive method. Researchers are, therefore, prompted for alternative methods such as machine learning algorithms that could use noninvasive clinical data for the disease diagnosis and assessing its severity. In this study, we present a novel hybrid method for CAD diagnosis; including risk factor identification using correlation-based feature subset (CFS) selection with particle swam optimization (PSO) search method and K- means clustering algorithms. Supervised learning algorithms such as multi- layer perceptron (MLP), multinomial logistic regression (MLR), fuzzy unordered rule induction algorithm (FURIA) and C4.5 are then used to model CAD cases.*

Keywords *– Atherosclerosis, Coronary Artery Disease, Machine Learning, K-Means Clustering, Particle Swarm Optimization, Feature Selection, Support Vector Machine, Clinical Decision Support System, Predictive Modeling, Artificial Intelligence in Healthcare.*

I.INTRODUCTION

The World Health Organization (WHO) reports that around 17.9 million people die each year from cardiovascular disease, and one-third of all premature deaths occur in people under the age of 70 [1]. The report also found that of the 17.3 million deaths from heart disease in 2020, approximately 6.2 million were from stroke and an estimated 7.3 million from coronary heart disease. The WHO predicted that around 23.6 million people would die from heart disease and stroke by 2030 [2]. Cardiovascular disease shows a number of symptoms including chest tightness, chest pressure, chest discomfort (angina), chest pain, shortness of breath, numbness, weakness or coldness in the legs or arms, if the blood vessels are constricted these parts of the body. Some other symptoms of this disease include nausea, fatigue, cold sweats, and discomfort in the neck, elbow, throat, jaw, left shoulder, upper abdomen, or back. However, the main causes of cardiovascular disease are age, smoking, sugar, obesity, depression, high blood pressure, high blood pressure, cholesterol, poor diet and lack of exercise [3]. Cardiovascular disease is also caused by damage to the coronary arteries, damage to all or part of the heart, or inadequate supply of nutrients and oxygen to the heart. There are various types of cardiovascular diseases, such as coronary artery disease, stroke, hypertensive heart disease, inflammatory heart disease, rheumatic heart disease, etc. [4]. Some types of cardiovascular disease, such as hypertrophic cardiomyopathy, dilated cardiomyopathy, and arrhythmogenic right ventricular cardiomyopathy, are genetically inherited. It is necessary to monitor a patient's cardiovascular symptoms to obtain medical advice from a healthcare professional. If cardiovascular disease is diagnosed at an early stage, the risk of death from the disease may be reduced. However, analyzing symptoms manually is difficult due to redundancy, multiple mapping, incompleteness, and a close relationship to

time in medical data. Additionally, finding the right medication for a patient after manually analyzing massive amounts of heart disease data is a significant challenge. To address this problem, machine learning (ML) technology helps create predictive models that can process and analyses large amounts of complex medical data and predict the absence or presence of cardiovascular disease for a patient with more accurate results. In the ML approach, a computer program is trained to perform a specific task in order to learn from its previous experience and predict the outcome of the test data based on the training data [5]. Machine learning techniques allow a machine to make correct decisions based on a built- in analytical model when it provides invisible data. Machine learning techniques take relatively less time to accurately predict. Therefore, an intelligent ML-based cardiovascular disease prediction system can help doctors make faster decisions so that they can offer medical treatments to a large number of patients in a short period of time; therefore, the ML model potentially saves millions of lives. Machine learning techniques have already achieved a significantly higher level of precision for classification-based problems [6]. Information abstraction has been achieved using several machines learning techniques, including feature selection, classification, and grouping [7], [8].

II.MOTIVATION

The main motivation of doing this research is to present a heart disease prediction model for the prediction of occurrence of heart disease. Further, this research work is aimed towards identifying the best classification algorithm for identifying the possibility of heart disease in a patient. This work is justified by performing a comparative study and analysis using three classification algorithms namely Naïve Bayes, Decision Tree, and Random Forest are used at different levels of evaluations. Although these are commonly used machine learning algorithms, the heart disease prediction is a vital task involving highest possible accuracy. Hence, the three algorithms are evaluated at numerous levels and types of evaluation strategies. This will provide researchers and medical practitioners to establish a better understanding and help them identify a solution to identify the best method for predicting the heart diseases.

III. OBJECTIVES OF THE STUDY

The report of WHO related to death in concern of heart disease is very scaring, the community of medical society and engineers put effort to predict early stage of heart disease for survival of human life. In the process of proposed methodology set objective given below

- Extensive analysis of different parameters of cardi vesicular disease using machine learning algorithms.
- Feature optimization for better processing of data using GSO and evaluation algorithms.
- Design ensemble-based classifier for the predication of CVD disease.
- Reduces training error during the sampling of data
- Reduces the feature separation process by principle of decomposition.
- To design and implement inter-features variance function for the processing of CVD data.

MACHINE LEARNING ALGORITHMS:

Data mining is a developing technique that is a direct result of the growing usage of computer databases to efficiently store and retrieve information. It involves the non-trivial extraction of innovative, implicit, and usable knowledge from big data sets. It also goes by the name Knowledge Discovery in Databases (KDD) and allows for the high- level, hypothesis-free data exploration, analysis, and visualization of enormous databases. By making predictions using a technique called modelling, it is possible to comprehend how data mining functions. Artificial neural networks, decision trees, and genetic algorithms are just a few of the data mining approaches that are the end result of years of study and product development. The technology behind data mining benefits from this ability to retrieve data as and when necessary. Data mining can be seen as a natural progression in the development of information technology. Huge volumes of data are readily available thanks to this technology, and the need to transform that data into knowledge and information is urgent. Data mining is the process of removing valuable information or patterns from vast amounts of data. Knowledge discovery (mining) in databases is sometimes referred to as KDD, knowledge extraction, data/pattern analysis, data dredging, information harvesting, business intelligence, and other names. The term "data mining" simply refers to the examination of data in a database using tools that look for trends or anomalies without knowledge of the data's meaning

IV. ATHEROSCLEROSIS:

One of the serious diseases that affects human arteries is atherosclerosis. The blood vessels that supply oxygen and blood to the heart and other body organs must originate from these arteries. These diseases are caused by too much fat, cholesterol, and other dangerous substances that can clog arteries and prevent the passage of blood and oxygen. Additionally, plagues are extremely harmful because they cause the arteries to become small and stiff. The most serious condition that can result in severe cardiac arrest is atherosclerosis. Retinal fundus imaging is useful for making an early diagnosis of this etiology. A sophisticated technique called fundus imaging

uses a 2-D representation of a 3-D retinal image that is slightly translucent. The FOV of fundus cameras may typically be extended up to 40 to 45 degrees, with an average pupil dilation of roughly 4 mm. These cameras designate a specific item for capturing photos of the eye's front region. The fundus is physically situated behind the eyeball. Thus, it is acceptable and possible to record the identification of normal alterations in the abnormal or diseased area. The use of a fundus camera can aid in early diagnosis, treatment process observation, and patient education.

Fundus cameras are used to take pictures that are utilized to diagnose and treat atherosclerosis, macular degeneration, and hypertension.

4.1 DATA MINING ALGORITHMS

Several data mining algorithms have been developed as a result of data mining research. These algorithms can be applied directly to a dataset to build models or to derive important conclusions and inferences from it. Decision tree, Naive Bayes, k- means, artificial neural network, etc. are some common data mining algorithms. The section that follows talks about them.

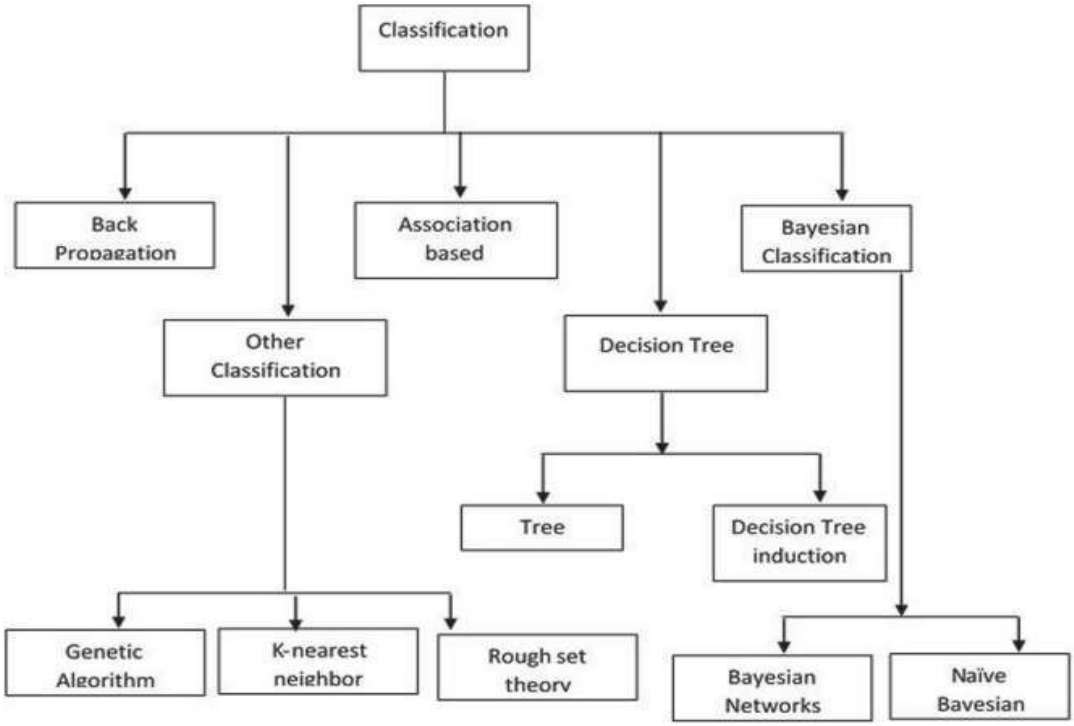


Fig 1: Data Mining Classification Method

4.1.1 DECISION TREE

A decision tree is a decision assistance tool that employs a graph or model resembling a tree of decisions and their potential outcomes, such as utility and chance event outcomes. It is one method of showing an algorithm. In operations research, decision trees are frequently used in decision analysis to assist in finding the approach most likely to succeed. It is also a well- liked machine learning tool. By sequentially mapping from the root node to the leaf nodes, a decision tree can be converted into a collection of rules with ease. Finally, by adhering to these guidelines, the proper conclusions can be drawn.

4.1.2 C4.5

A decision tree serves as the classifier in this instance. It is a supervised learning technique that employs pruning and knowledge acquisition to get better outcomes. It is widely used, relatively quick, and the output is simple to understand.

4.1.3 K-MEANS ALGORITHM

In order to make the members of a group more similar, K-means divides the provided set of objects into k groups. K- means does not only determine the number of clusters; it also "learns" the clusters on its own, without being told to which cluster a specific observation should belong. K-means can therefore be referred to as a semi-supervised learning technique. Over huge datasets, K-means is especially useful.

4.1.4 ID3 ALGORITHM

By comparing the values of the attributes, the ID3 algorithm (Quinlan 1986), a decision tree-building algorithm, determines the classification of objects. Starting with a collection of items and the specification of their properties, it creates the tree top down. A property is tested and the results used to partition the object at that node are set at each node of the tree. Until the set in a particular sub tree is homogeneous with regard to the classification criteria, this process is repeated recursively. It then turns into a leaf node. Information gain is maximized and entropy is reduced at each node. To put it another way, the quality that separates the candidate set into the subsets with the highest homogeneity is examined.

4.1.5 SUPPORT VECTOR MACHINE (SVM)

It is a method of supervised learning that divides data into two categories over a hyper plane. Except that it doesn't employ any Decision trees at all, Support vector machines carry out a similar duty to C4.5. To reduce the possibility of misclassification, the support vector machine tries to increase the margin (the distance between the hyper plane and the two nearest data points from each respective class). Scikit- learn, MATLAB, and LIBSVM are a few examples of well-known support vector machine implementations.

V. PROPOSED METHODOLOGY

5.1 PROPOSED ALGORITHM-1

The proposed ensemble classifier based on boosting methods. the support vector machine work as base classifier and KNN classifier work as variable classifier and collect the similar features of atherosclerosis data and process to support vector machine. The processing of features of atherosclerosis dataset by glow-worm optimization algorithm. The glow-worm optimization algorithm circulates the value of Lucifer in and collect relevant features to mapping of class. The process of ensemble classifier used K features and S classifier. The data search space of classifier is K ×S

Process of boosting ensemble classifier

The process of boosting

Consider K={ k1,k2,k3,… ,kn} be the atherosclerosis dataset

S={} ensemble classifier set C={c1,c2,c3,… ,cn} classifier set

$X = trainingset, X \in K$

$Y = test\ set, Y \in k$

M=n(K)

Consider init =1

L(init)= random subset of X; L(init)ϵX P(0)={}

Fori =1 to P do

if i>1

f(i) = irrelevant features of dataP(i-1) + M(i) P(i) = training process of classifier C(i) and S(i) S= S C(i)

for i = 1 toM R(i) = Y

next i

estimate = max(R(i): i=1,2, …, n)

Rule of ensemble classifier

1. the base class features = $\{k_1, k_2, \ldots \ldots kn\}$, where each $k_j = \{z_{j1}, z_{j2}, \ldots \ldots z_{js}\}$is collection of features of Em class $\{C_1, C_2, \ldots \ldots \ldots C_k\}$, the class of features are non-overlapping the process of ensemble describe as .

$Em(C_k) = \{\{z_j, z_k, \ldots \ldots . z_m\} \subseteq \{zf_1, zf_2, \ldots \ldots z_s\}\}$ (4.3)

2. let the kernel mapping of support vector machine classifier class is

$M_{i+1}[EM(C_g) = Em(C_g) \cup z_r] > S_i[Em(C_K)]$ (4.4)

3. prediction of ensemble classifier is $Em(C_k)$.

$Pre_{Em(C_K)} = pre(Em(C_K)) \leq S$ (4.5)

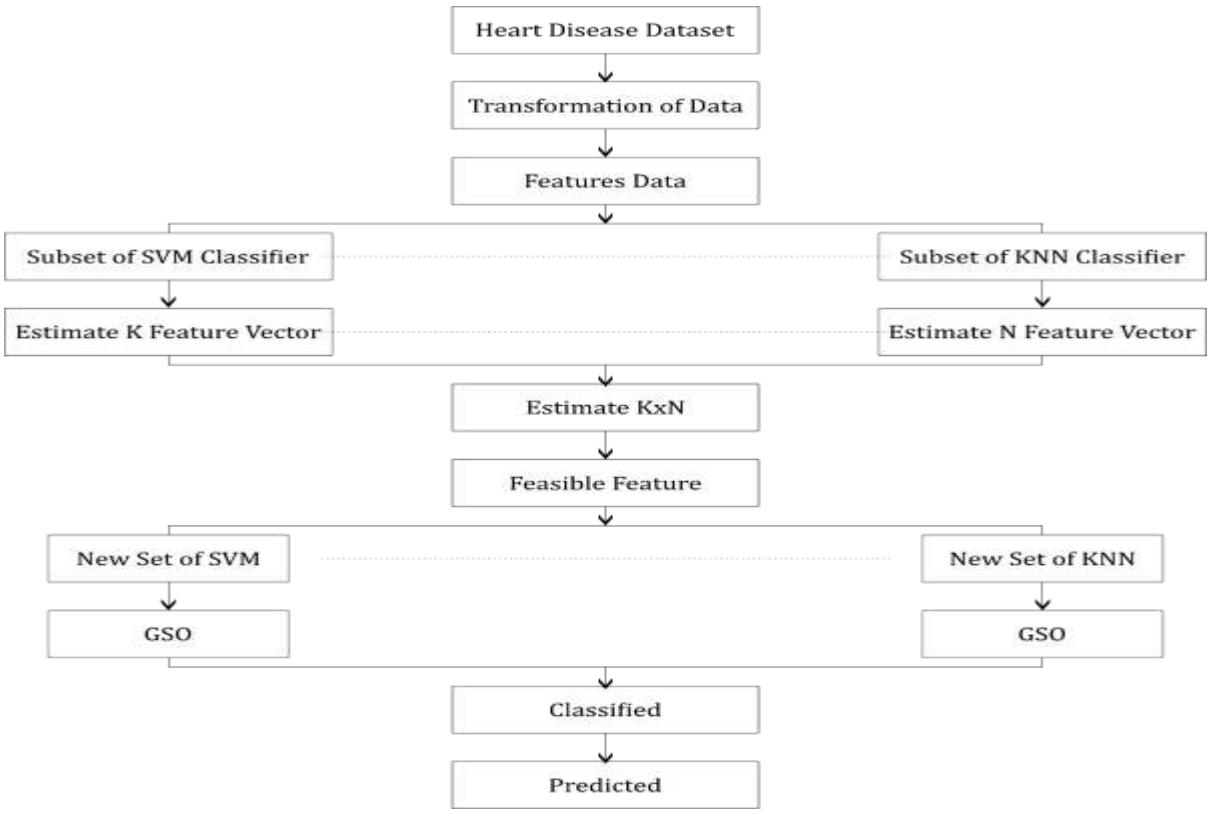


Figure .2: Process model of proposed work.

5.2 MACHINE LEARNING ALGORITHM

Machine learning also includes the examination of statistical models and methods. And computers employ these sorts of algorithms to fulfil a given purpose without the usage of obvious interruptions. It is a subfield in artificial intelligence. Machine learning algorithms use a mathematical model based on a training dataset to predict or make judgments without being explicitly programmed to do so. To complete the task effectively, machine learning employs several algorithms such as Random Forest, decision tree, and Navie Bayes. Machine learning is identical with statistical statistics, which uses computers to generate predictions. Data mining is the study of data in which machine learning focuses on examining and analyzing the data through unsupervised learning. Machine learning techniques, theory, and application fields are among the benefits that mathematical optimization provides. ML algorithms and approaches will process and predict data from massive amounts of data. First and foremost, the dataset, referred to as patient data collection, is pre-processed in this image. This step is required since the data has been cleansed in order for the machine learning algorithm to use it in this procedure. The model may use a single algorithm or a combination of algorithms in a hybrid approach.This model's output is a classifier; it is the most significant portion since it is the intelligence, and classifiers are the part that permits prediction. If the classifier is given the input data, it can predict without the need for human intervention. If the input data is information about a new patient and the data-set fed into the model is a medical dataset of healthy and unwell patients.

5.3 SUPPORT VECTOR MACHINE (SVM)

SVM (Support vector machine) is machine learning algorithm derived by Vipin in 1990[10]. The support vector machine applied in various filed of image classification and pattern recognition. The nature of support vector machine is linear, non- linear and sigmoid. The non- linear support vector machine mapping the feature data with respect to one plane to another plan [2, 3, 16]. The separation of data plan is non- linear and decision factor correlate with margin function of support vector. The hyperplane of equation is derived as

$WD.xi + b \geq 1\ if\ yi = 1$ (4.6)

$WD.xi + b \leq -1\ if\ yi = -1$

Here W is weight vector, x is input vector yi label o class and b is bias.

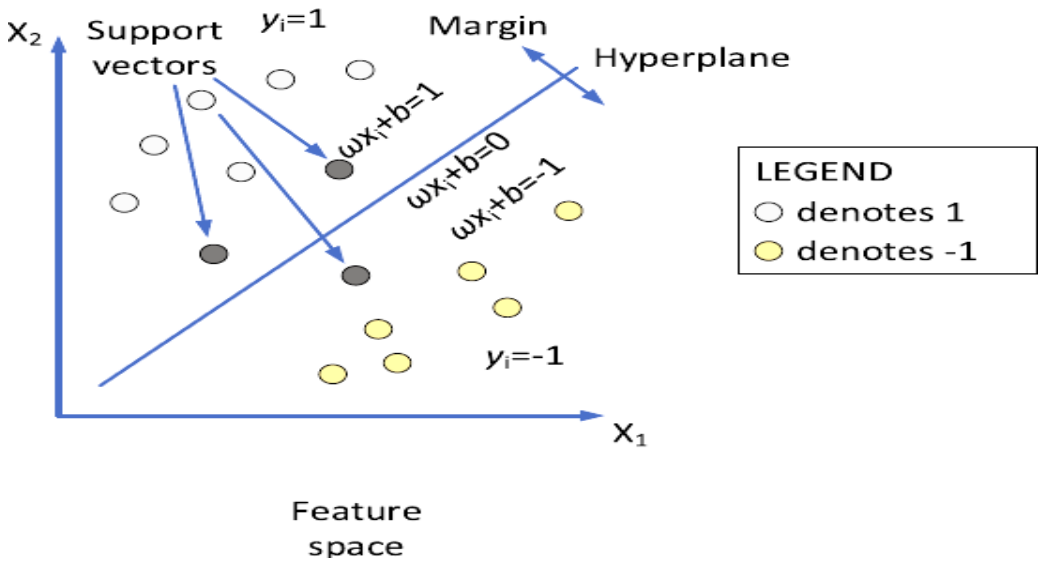


Figure 3: Process block diagram of support vector machine.

5.4 KNN

The KNN classifier is simple algorithm of machine learning, it also knows as lazy classifier. The classification accuracy of KNN classifier varies in range of 70-80%. The major utility of KNN classifier in case of pattern recognition. The KNN classification algorithm applied on the case of continuous nature of attribute. The processing of KNN algorithm describe here

1. Estimate K training attribute which belong to unknown attribute
2. Chose the common occurring classification of K

For the estimation of similarity in class of K instance applied different distance equation. The very famous distance equation is Euclidean distance equation.

Input: A data set according to sample selection Output : a mixed transform table data
class: E={},the set of the equivalence classes QIC={},set of equivalence classes with similar QI sets
CIP{}, set of attributes with similar class
DIP=number of different class values in the remaining dataset Begin
While CIP>= attribute
Cluster T to m tables according QI For i=1 to m
Bucketize attributes according SA values While |DIPi|>=ℓ Create_equivalence_classes ()
E=E U Create_equivalence_classes() return E
Incorporate the remaining attributes to E End
Generate equivalence class with prototype is Input: CIP
Output :E Begin
Randomly selection of a attributes tm from the smallest group
E={tm}
For p=1 until attribute-1
Select a attributes tp that minimizes the gcp E=EU tp
Remove tp from T Remove tm from T Return E
End
Process of cluster generation in prototype classification Input: data set used defined
Output: QIC={}, set of tables with attributes with similar QI sets Begin
Insert T to the decision tree classification QIC={ QIC1, QIC2,… QICm }
return QIC End

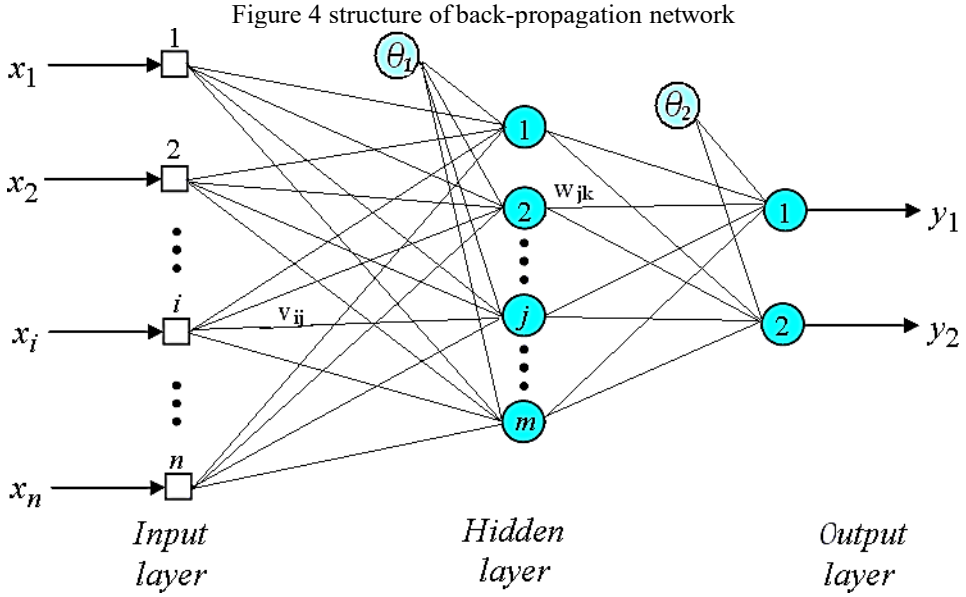
5.5 DECISION TREE (DT) ALGORITHM

A decision tree is predictive model of data classification. The p rocessing of decision tree algorithm follows the tree structure of feature set. The partition of branch applied the concept of maximum entropy. The feature attribute has maximum entropy treat as leaf node class. The learning process of decision tree algorithm is very simple and suitable for the prediction of medical data analysis. The decision tee rule formation according to the behaviors of feature attribute narrated in terms of maximum occurrence of probability. The core algorithm of decision tree is C4.5. the processing of these algorithm on design of tree in manner of top to down as class label. The entropy and gain are two functions manage the processing of decision tree algorithm.

5.6 PROPOSED ALGORITHM-2

The back propagation neural network model basically controls the rate of error in terms of desired output difference proceed in source of network and enhance the rate of detection of given sample data of breast cancer. The processing part of back propagation algorithms divided into two part one is training part and other is application part.

Figure 4 structure of back-propagation network



5.7 PROPOSED ALGORITHM-3

Proposed models are creating for data training for minority and majority class data sample for processing of associative classification level of rules. The associative classification process a data input for training phase for SMOTE and CMTNN sampling technique for classifier. While single- layer SOM networks can potentially learn virtually any input output relationship, SOM networks with single layers might learn complex relationships more quickly [12]. The function SOM creates wiener and successor matrix. For example, a ensemble layer network has connections from layer 1 to layer 2, layer 2 to layer 3, and layer 1 to layer 3. The ensemble - layer network also has connections from the input to all cascaded layers. The additional connections
might improve the speed at which the network learns the desired relationship. SOM artificial intelligence model is similar to feed- forward back-propagation neural network in using the back-propagation algorithm for weights updating, but the main symptom of this network is that each layer of neurons related to all previous layer of neurons. Tan-sigmoid transfer function, log - sigmoid transfer function and pure linear threshold functions were used to reach the optimized status.

5.5.1.1 Data are passes through ACR

5.5.1.2 ACR makes a multi-level rule set using rule mining algorithm

5.5.1.3 level of rules going to SOM ensemble process

5.5.1.4 The training phase data are passes through SMOTE AND CMTNN sampler

5.5.1.5 The sampling of data passes through SOM AND balanced the data for minority and majority ratio of class

5.5.1.6 The sampled data assigned to k-type binary class

5.5.1.7 Binary class data are coded in bit form

5.5.1.8 if code bit value is single assigned the class value

5.5.1.9 Else data goes to training phase

5.5.1.10 . Balanced part of training is updated

5.5.1.11 Find accuracy and relative mean Error

5.5.1.12 Exit

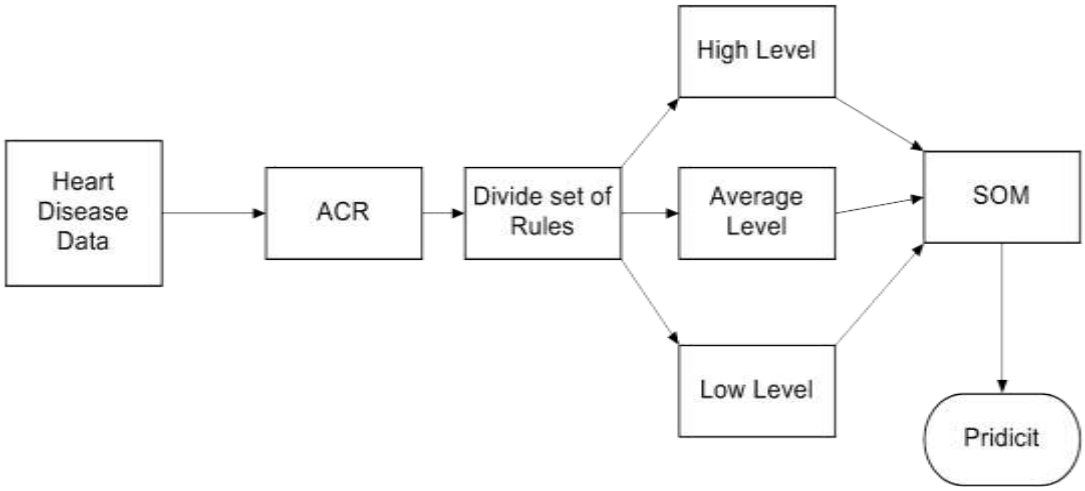


Figure 5 proposed model for ensemble based associative classification with SOM network

VI. IMPLEMENTATATION PROCCESS

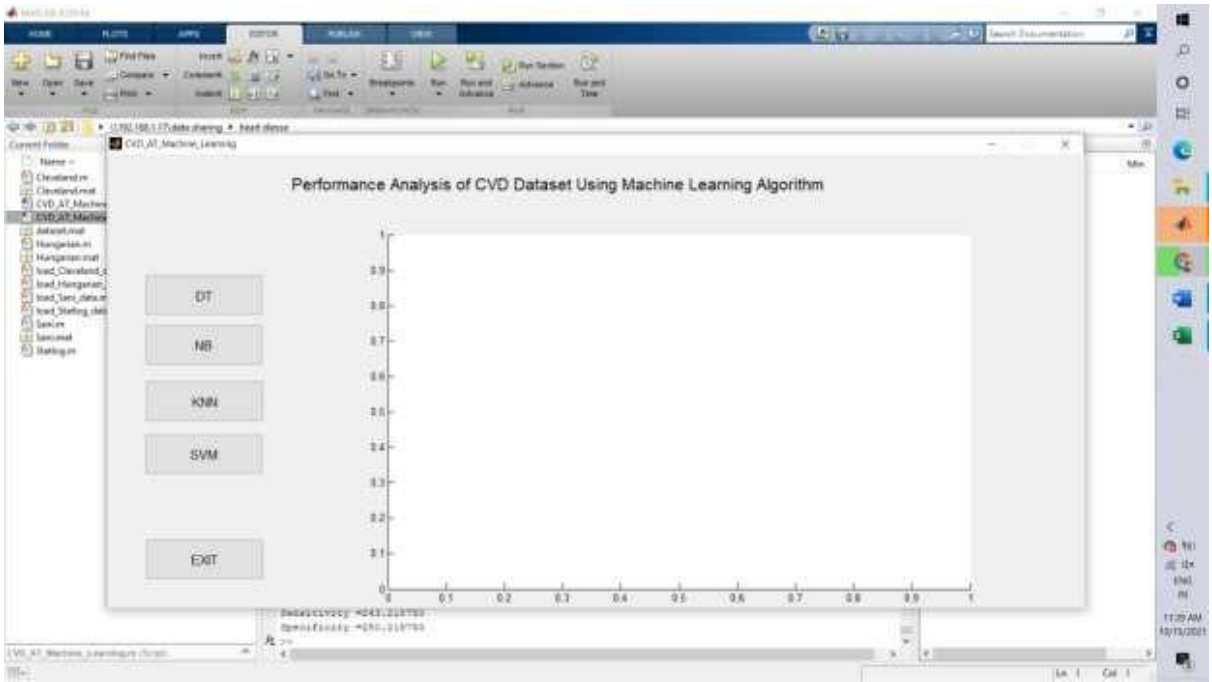


Figure 6 : initial window of the simulation in MATLAB software and here we can seen the GUI of our model .

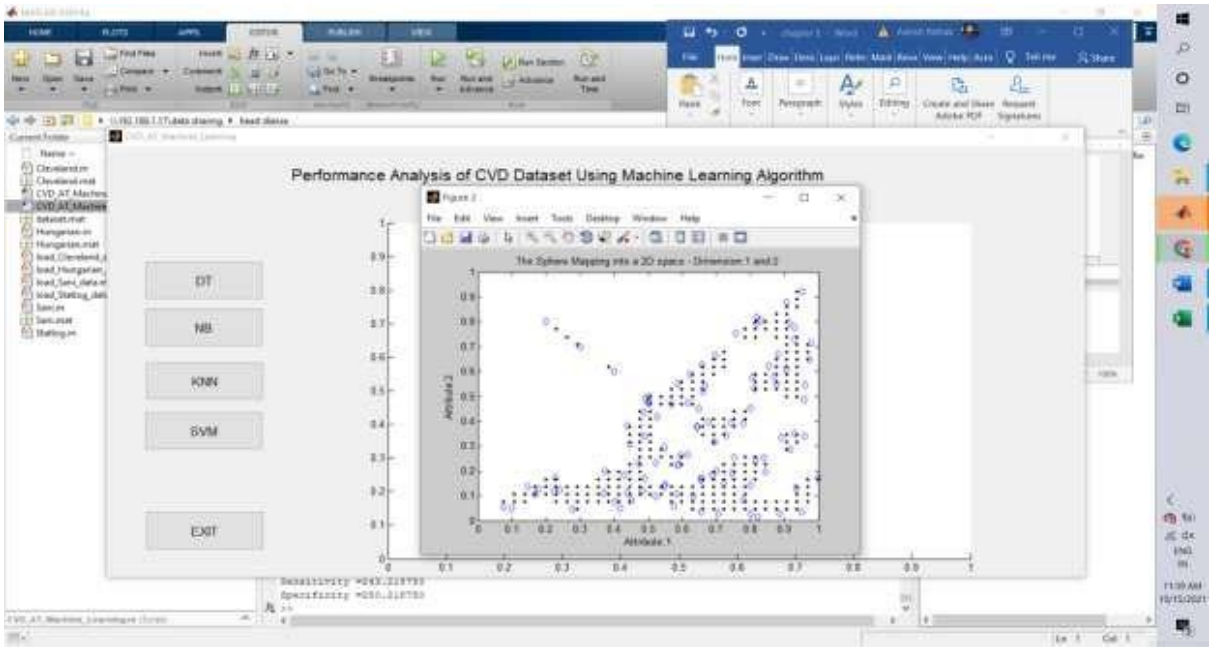


Figure 7: window show that using the DT method simulation in MATLAB software.

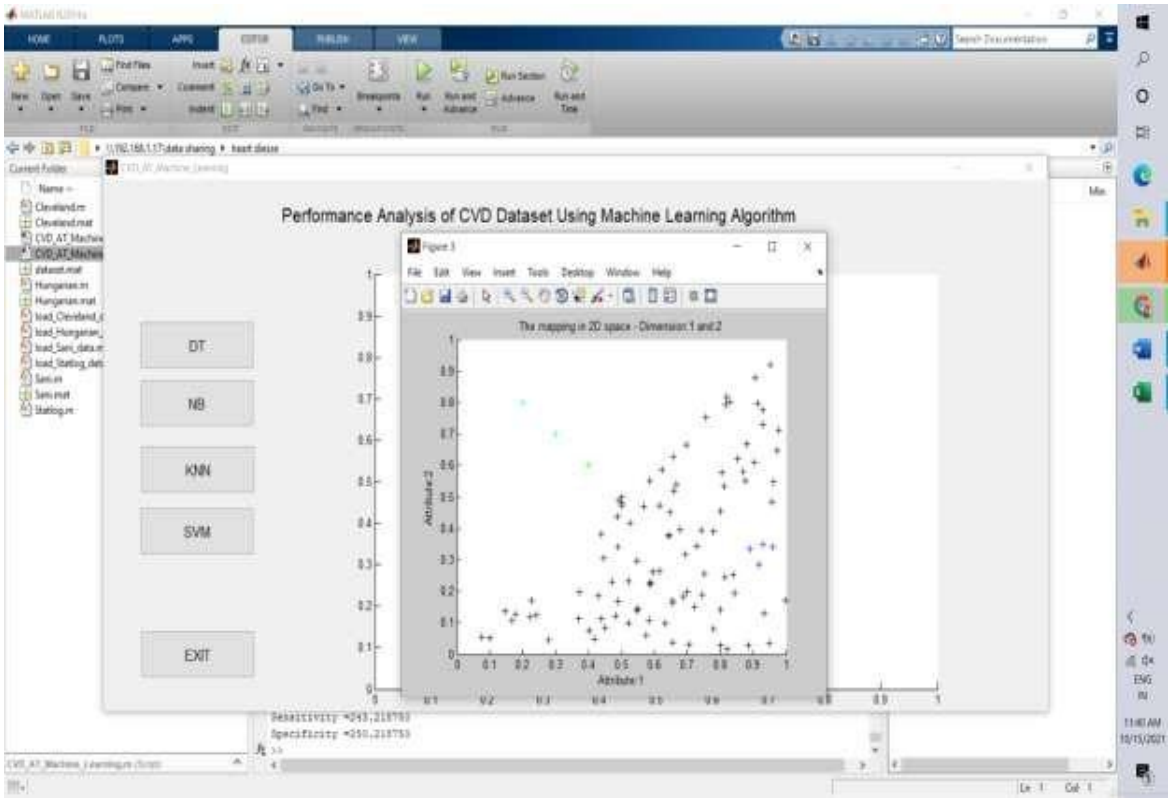


Figure 8.: window show that the of the out figure 3 using the DT method simulation in MATLAB software.

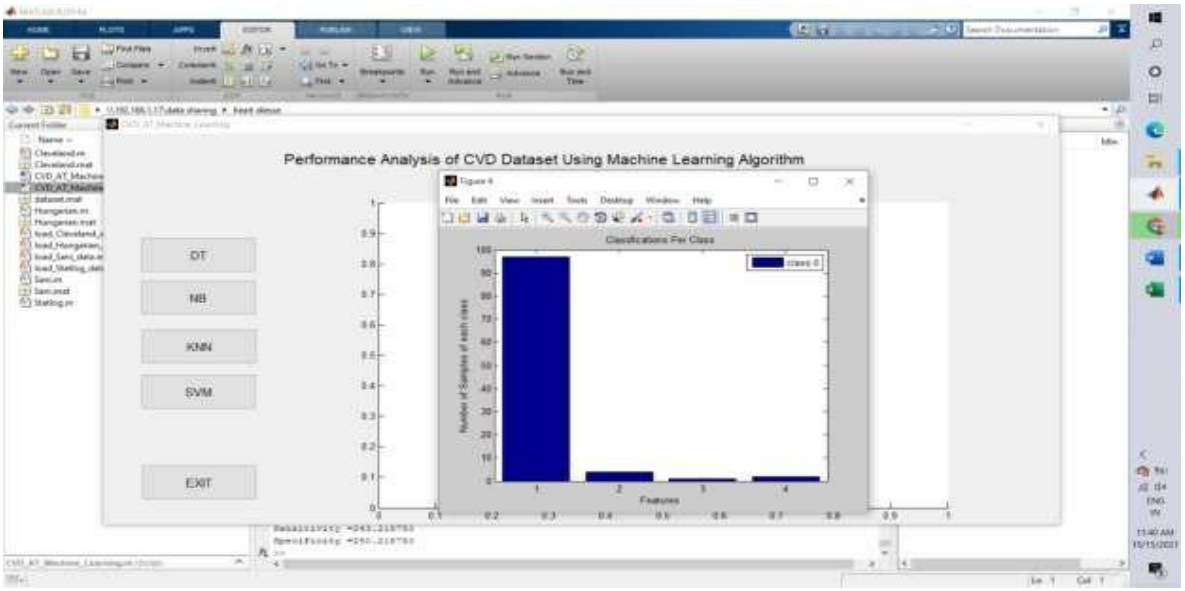


Figure 9 : window show that the of the out figure 4 using the DT method simulation in MATLAB software.

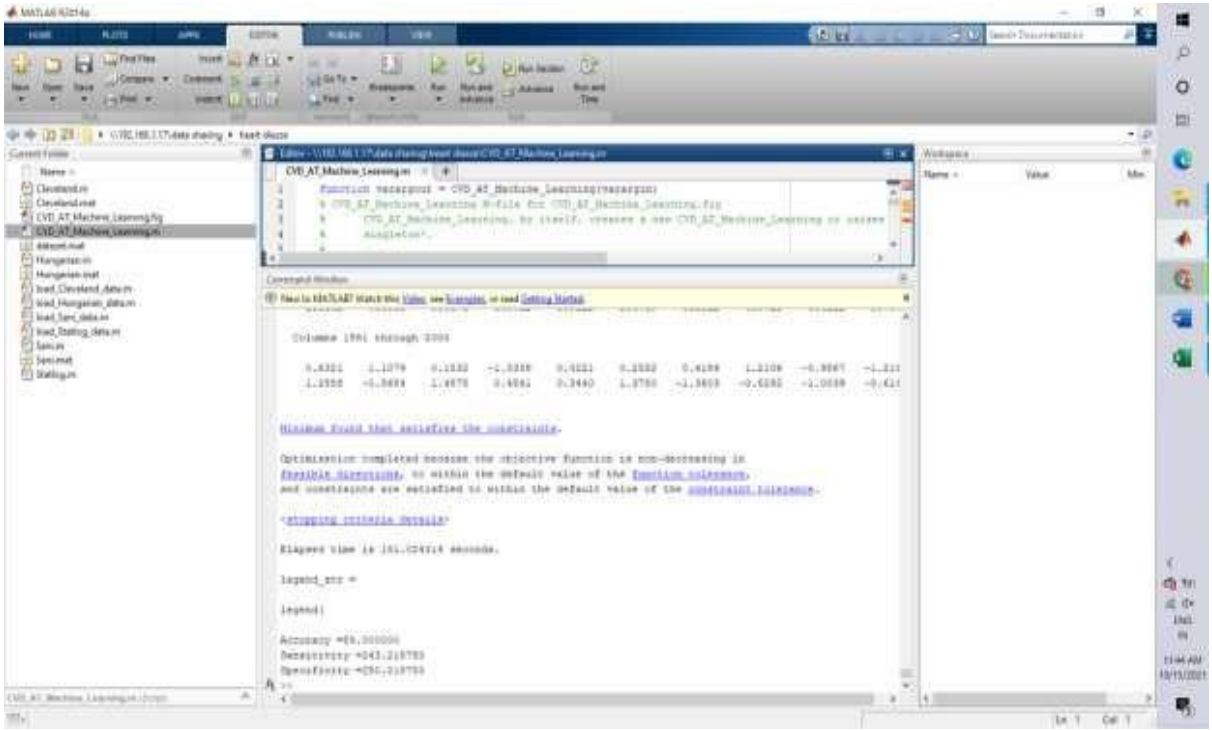


Figure 10 : window show that the of the output result of accuracy, sensitivity, specificity using DT method simulation in MATLAB software.

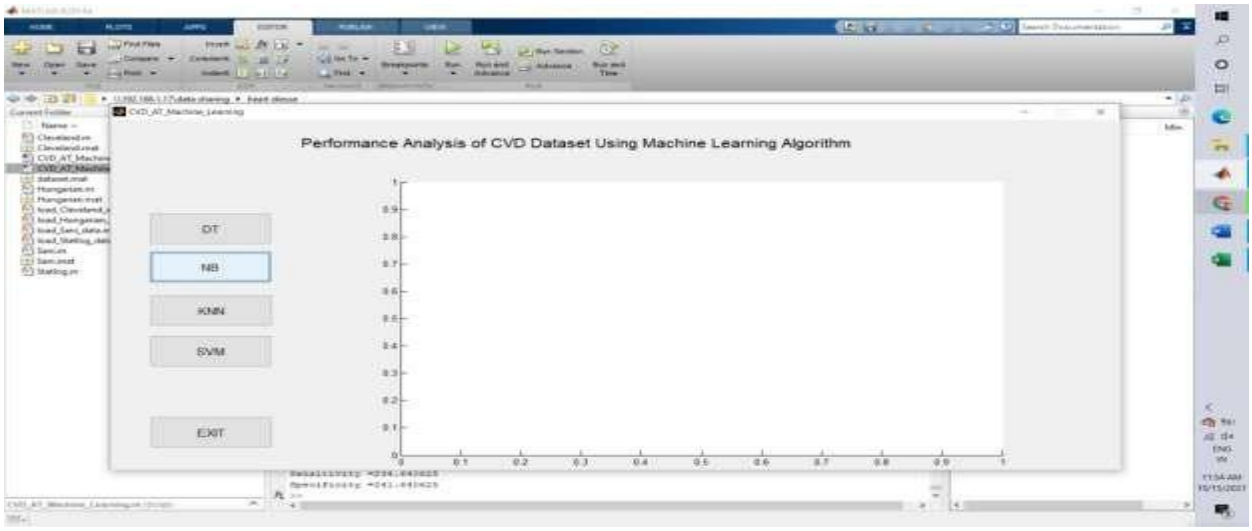


Figure 1 1 : window show that the GUI of our simulation model hit the NB method n MATLAB software.

VII. CONCLUSION

The early detection of cardiovascular disease (CVD) saves millions of lives worldwide. Cardiovascular disease has various causes high blood pressure, diabetes, high cholesterol and many other factors. Atherosclerosis disease is the leading cause of artery arrest and heart stroke. The performance of automatic CVD detection is a very challenging task. The accurate detection of disease symptoms suggests medicine and curing heart disease. Early data mining algorithms are applied to detect and classify atherosclerosis disease. The sampling and selection of attributes face a bottleneck problem in classifying heart disease. The advancement of machine learning algorithms improves the classification and detection ratio of heart disease. The prediction and analysis of atherosclerosis disease machine learning applied four classification algorithms: vector machine, decision tree, naïve Bayes and KNN. The results of the support vector machine influence the process of atherosclerosis disease detection. Four data sets validate the algorithm used: Cleveland, Hungarian, Starlog and Z-Alizadeh Sani. The training and testing process applied a 10 cross- fold ratio. The NB and DT algorithms give better performance than KNN algorithms.The accuracy of KNN algorithms depends on the variation of K attributes. The selection of features and attributes plays a significant role in prediction accuracy. The machine learning algorithm's outcomes reached an overall accuracy of 88% and 85% of sensitivity. Decision tree, NB, and KNN were the accuracies compared with the support vector machine, respectively 87.00%, 89.01%, and 81.10%. Thus, this comparison has shown that the support vector machine is better. Still accuracy of machine learning algorithms is a challenging task. A large number of features and the dataset's size decline the classification algorithms' performance. The glowworm optimization feature selection cum optimization algorithm reduces the number of features and increases the atherosclerosis disease detection classification ratio. The glowworm optimization reduces the unwanted features of datasets. The proposed ensemble classifier overcomes the limitation of the binary classification algorithm. The ensemble classifier used two classifier support vector machines and KNN. The process of boosting increases the mapping of features and reduces the noise and outlier data of atherosclerosis patients. The proposed algorithm was assessed on different datasets and tried with a combination of datasets.

VIII. SUGGESTION FOR FUTURE WORK

In the current decade, the cardiovascular disease classification application is not commercial. However, prosed algorithms have applied any classification for different heart disease. Therefore, the specific limitation of the proposed algorithms handles in the future is mentioned here.

1. Development of a sensory algorithm for quality data sampling.
2. Minimization of null value and normalization of data of user.
3. lightweight feature extraction methods
4. Generalization of results in all tasks of CVD classification.

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