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Ant Colony Optimization Based Support Vector Machine Towards Predicting Coronary Artery Disease

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Abstract: ***Data mining is the progression of finding the hidden information from the dataset available. Data mining started stepping and playing a major role in the medical field and it helps the medical practitioner to take a decision. Classification is considered as the major research issues in data mining. Classification is done based on the characteristics or features available. Currently, coronary artery disease (CAD) is getting evolve in South Asia countries, which is becoming a major cause for death. Data mining algorithms are being used to diagnosis of diseases, mostly in CAD. Currently available algorithms gets lack in classification towards accuracy. In this paper, a novel classification algorithm is proposed to effectively classify towards the prediction of CAD, namely ant colony optimization based support vector machine. It is designed to classify and predict CAD more accurately. The proposed algorithm classify the records in a dataset in a random manner instead of sequence manner. A threshold value is used for classification for more accurate results. The proposed algorithm is tested on Z-AlizadehSani dataset for the classification of heart disease among the patients. This research work uses the benchmark performance metrics namely sensitivity, specificity, and classification accuracy. The result shows that ACO-SVM is giving better results than SMO, BSMO, Bagging and NN algorithms.***

Keywords: Ant Colony, Classification, Heart Disease, Prediction, SVM.

I. INTRODUCTION

To execute tedious and lengthy process automatically, computers have been introduced. Nowadays computers are almost used in every field. Memory sizes of the computers are increased unimaginable manner where the size of the computers decreased too. It helps the human in taking appropriate decision. Investigation methods are implemented by researchers to learn from data by the computers. Machine learning plays a major role in the discipline of scientific operations which deals with procedures, algorithms, and mathematical models. These kinds of methods are used to fabricate a prediction model depending the input that the user feed to the computer system for taking a decision or making a prediction. Currently, Data Mining (DM) is identified as a benchmark area in computer science, where the techniques used in machine learning are used to discover the hidden information which is not discovered before in datasets, where the dataset size is small or large or very large. DM is the process of making an analysis on relationships between the data. The ideas of tasks in DM include mathematics, machine learning, and artificial intelligence. In the knowledge discovery in databases (KDD) process, DM is considered as the middle step. It aims to find the valuable patterns in the dataset available. The procedure in KDD includes (i) training the data, (ii) choosing the data, (iii) cleaning-up the data, (iv) incorporating previous knowledge, and (v) interpreting the consequences of mining. Classification has become main part of DM; it aims to classify the dataset into more than one classes. This can be achieved by implementing a setting from the values of a vector to categorized classes. Many fields such as finance, bio-informatics, classification of documents, multiple media of data, processing of text, and analysis of social network utilize the classification technique.

A. About CAD

Coronary artery disease (CAD) is emerging as a main cause for sudden-death in south asian countries. The main reason for CAD is atherosclerosis due to the presence of plaques in the artery wall, which results in the lumen stenosis. By default, plaques are reasons for the blood clot and block tending to the bloodstream to the myocardium. This will happen when the plaques in coronary rapidly rupture. By a chance, if a clot is not treated in a timely manner, it will result in ischemic changes in heart muscles. Hence, an early prediction/detection and analyzing the CAD is more important towards reducing the death and complications. CAD is considered as a circumstance which affect the heart severely.

B. Motivation

Considering future risk complication towards health, CAD results as a major problem among prediction of diseases. CAD is one of the major types of disease, where 25% of affected people die unexpectedly without having any symptoms previously. Heart attacks become severe in patients who are all affected by CAD. It is estimated that CAD may have an effect on the young generation people and it could have a negative effect. World Health Organization (WHO) have estimated 11.1 deaths (in million) all over the world from CAD in 2020.

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C. Problem Statement

Data mining algorithms are used to classify the patients for the prediction of CAD, but the classification accuracy seems to be very to proceed with the real time treatment. Most classifiers available for the specific dataset only, and not for other dataset. Classifiers performances are getting decreased when the features count gets increased in dataset. The time required for classification gets increased when the dataset size gets increased. Ordinary classifier that is based on data mining alone is not enough to make prediction for CAD, hence there exist a need for optimization based classifier to predict CAD more accurately.

D. Objective

The main intention of this research work is to propose a optimization based classifier to effectively classify the patient records available in dataset for the prediction of CAD. The proposed classifier aims to make predict CAD with dataset that have multiple features and records.

E. Organization of the Paper

This section of paper have discussed about motivation, problem statement and objective of the research, along with the introduction about DM and CAD. Reviews of the literature gets discussed in Section II. Section III discusses the proposed classifier namely ant colony optimization based support vector machine. Section IV discuss performance metrics used for evaluation. Section V discusses the data mining tool MATLAB and the Z-AlizadehSani dataset. Section VI demonstrates the results with discussion. Conclusion and future enhancement of the research work is discussed in Section VII.

II. LITERATURE REVIEW

Optimization based SVM [1] was proposed for the detection of CAD, which utilized the feature reduction concept PCA. It was used to classify the records into 2 classes, where the false positive gets increased which tends to negative results. Analytical based method [2] was used for the detection of CAD by considering the features count as it is, but the classification accuracy got down. Hybrid of multivariate and logistic regressions [3] was used to diagnosis of CAD . Classification accuracy became very low due to considering the entire features and following sequence manner. A classification method [4] was proposed to classify and predict heart disease which was based on heartbeat, it holds the feature of 1-vs-1 where features based ranking stage binds as like SVM binary classifier. Combination of k-nearest neighbor and genetic algorithm were used to classify the heart disease, where it performs the universal search in complexity and multi-model landscape, which failed to provide an optimal solution.A prototype [6] was developed to establish with unidentified information connected with heart disease from the earlier heart disease information recorded earlier. An attempt [7] was made on heart disease classification which aimed to predict heart disease, Hidden Naïve Bayes (HNB) was applied. A system [8] was designed theoretically to determine the protocol to forecast the level of risk with the health, where the protocol can be given preference based on requirement. Heart disease prediction system [9] was proposed to provide assistance to professionals in medical towards CAD prediction based on the clinical information of patients, where it includes the steps (i) selecting the features, (ii) develop an ANN algorithm, and (iii) to develop a prediction disease for heart disease. An investigation [10] was made with the excess variability of heart rate for selective patients, a classifier was proposed with the CART method. The results shows that it consume more time for the prediction of disease. A study [11] was made to expand an classifier for the assessment of risk in CAD patients, where it differentiates risk patients from lower and higher, also it utilizes standard long-term HRV measures. A classifier [12] was developed to identify Hypertrophic Cardiomyopathy, which is becoming one of the root-cause for heart disease. To assess cardiovascular-patient classifier performance, a random forest (RF) and a support vector machine (SVM) classifier was combined and tested using 5-fold cross validation. An approach [13] was made to determine significant information in CAD dataset for effective diagnosis, where it focus only on identifying the top rank features using principal component analysis with regression methods, where the performance goes down due to large size of dataset. Increment based decision trees method [14] was proposed to mine the evolutional rule for CAD classification, results came inversely towards prediction. A ensembled classifying [15] method was proposed for classifying the CAD with a voting scheme to overcome the limitations of conventional performance of past classifiers. A classification model [16] combining the concepts of chi-square and random forest was proposed for prediction of heart disease. The results shows that it is useful for medical field but it has given the results with very lengthy consuming time.

III. ANT COLONY BASED SUPPORT VECTOR MACHINE

A. Support Vector Machine (SVM)

Supervised machine learning is considered as a type of method expecting the necessary input and desired output from the user. The data given by the user are labeled for classification purpose aiming to provide learning basis for potential data processing. Mainly, a supervised machine learning method offers learning algorithms with an identified measure to support future decisions. In short, all supervised machine learning algorithms have X input variables and Y input variables and the user use the algorithm to study the classifying function from the input to the output,

$$Y = f(X) \tag{1}$$

SVM is a type of supervised machine algorithm which can be utilized for classification and regression use. Many fields (i.e., education, medicine, business, and so on) started using SVM algorithms for the classification and prediction purpose. In real time the SVM algorithm is used for the classification of text, spam detection, analysis of sentiment, opinion, decision support system, disease classification, image recognition and so on.SVM algorithm works on the basis of finding or discovering the hyperplane which divides the input or dataset (i.e., the input given by the user) into two classes, as shown in Figure 1.

Data points near to the hyperplane are the support vectors. If data points that are near to the hyperplane removed then there exists a change in the position or angle of the hyperplane. In short, the hyperplane is a line which classifies the data set in a linear manner.

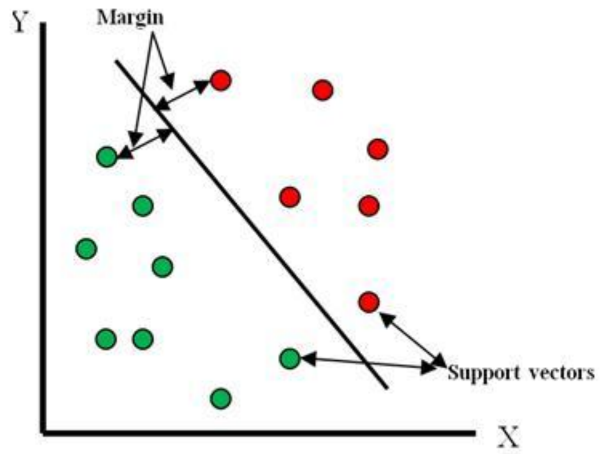

Figure 1. Support Vector Machine

Advantages of the SVM include (i) accuracy, and (ii) efficient working smaller datasets. Disadvantages include (i) not suitable for the larger dataset, and (ii) not suitable for the noisy dataset.

B. Ant Colony Optimization (ACO)

Ant based algorithms are optimization based and roused by natural foraging behavior of real ants. While looking for food, initially ants scrutinize the area surrounding its home in a random way. If a ant identifies a source for food, it assesses the capacity and nature of food and carry a tiny quantity of it to its home. Amid the arrival journey, the ant stores a trail of pheromone (which is a chemical substance) on the ground. The quantity of pheromone spread on the path relies on the measure level and food nature, which will control all the ants to food source. There arises a communication (indirect) among the ants by means of pheromone trails empowering it to locate the briefest ways between the home and food sources. This specific characteristic of real ants is utilized in the artificial ants to take care in solving optimization oriented problems. In ant colony optimization, artificial ants are built probabilistically incorporating dynamical forged pheromone trails. The focal part of the ACO algorithm is the pheromone methods including the state change control and refreshing guideline, which is utilized to probabilistically test the path.

Figure 2a to 2d demonstrates a situation with a route from the home to the food source, where all ants pursue the pheromone trail. Abruptly, when an obstacle gets in their direction towards the food source, them immediately first ant arbitrarily select the alternate path (i.e., upper and lower path). When comparing with the upper path and lower path, the upper path seems to be better and shorter than the lower path tending towards reaching the food source in a shorter time and distance. As already discussed, ants spread pheromone on their traveling path, pheromone gets diminished after a short course of time. The shorter path has the ants pheromone stronger than the longer path. According to the ACO algorithm, the paths which have stronger pheromone are considered as the best path in finding the solution to the problem [18]. This natural behavior of ants can be utilized in finding solutions to machine learning algorithm stream [18].

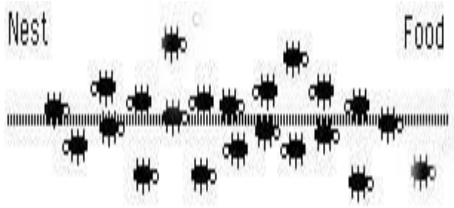

Figure 2a. Ants Trail From Nest To Food

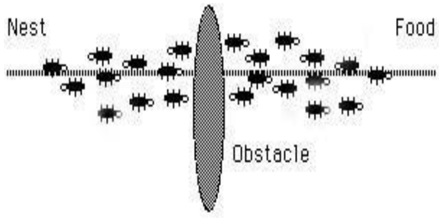

Figure 2b. Difficulty Facing By Ants

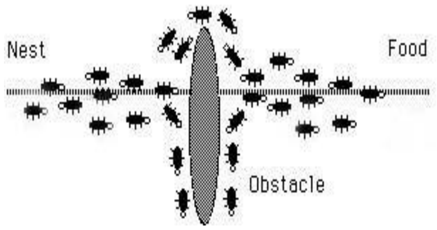

Figure 2c. Searching For An Alternate Solution

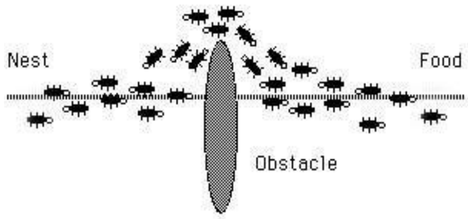

Figure 2d. Alternate Solution

Figure 2. Natural Behavior of Ant [18]

C. ACO-SVM

This section discusses SVM model based on ACO towards classification. The parameter estimations of SVM are progressively optimized by actualizing meta-heuristic procedure of artificial ants. Proceeding further, SVM model performs the task of classification. In ACO-SVM, the algorithm takes a set of input and output as $S = \{(xy_i, yz_i) | x_i \epsilon H, yz_i \epsilon \{\pm 1\}\}$ where $i = (1,2,\dots,l)$. It endeavors to build a decision function f by mapping input vectors $xy \text{ and } yz \ \epsilon\ \chi$ onto labels $yz\ \epsilon\ \{-1,1\}$ keeping in mind the end goal to classify the known or unknown data effectively. Then the user can start the ACO algorithm after inputs are given to the ACO-SVM model. To accurately set up an ACO-based optimization strategy for parameter optimization of SVM, the accompanying fundamental steps are necessarily to be taken. Essentially it's necessary to initialize parameters and factors of the algorithm. Grid intervals of each parameter are to be calculated

$$h_j = \left(Obs_{xy}^{upper} - Obs_{xy}^{lower}\right)/\ N \qquad (2)$$

where Obs_{xy}^{upper} and Obs_{xy}^{lower} indicate the upper and lower breaking point of a parameter of SVM, individually, xyholds the value between 1 and m. In the accompanying trial, gave $Obs_{xy}^{upper} = 2^{x>0}, Obs_{xy}^{lower} = 2^{x<0}$, where $xy = 1, 2, \ldots, m$.

At first, ant pheromone levels of the parameter that blends in all data are the equivalent; it gets maintaining a distribution of pheromone in a uniform manner. Therefore, the majority of the ants probably select beginning data (or record) in the dataset. Afterward, the ants choose the parameter that got blend in the data as per the above said state transition rule. Once after training the SVM with the parameters, the proposed algorithm assesses every parameter by ascertaining objective function. This step is rehashed until the most extreme iterative number (i.e., n time the total number of records in the dataset, where n denotes the number of expected classes).Discover the comparing subscript of the data with maximal pheromone quality and lessen the parameter scope:

$$Obs_{xy}^{lower} \leftarrow Obs_{xy}^{lower} + \left(m_j - \Delta\right) \times h_{j,} \qquad (3)$$

$$Obs_{xy}^{upper} \leftarrow Obs_{xy}^{upper} + \left(m_j + \Delta\right) \times h_{j,} \qquad (4)$$

where Δ is a coefficient of classes and the ants look in the area of the data with maximal pheromone until to the present cycle of the algorithm.The three steps are rehashed until the grid interval is not as much as predefined exactness ε, which is the terminal state of the optimization algorithm. As a rule, the more precise number of classes results in expanded time.

IV. PERFORMANCE MEASURES

In DM, algorithms performance are measured using specificity, sensitivity, and accuracy. It is considered as most important due to its applicability in the field of medicine. The confusion matrix is a type of table which provides visualization to the algorithms performance. Considering 2 class problem (Class1 and Class2), the matrixes will have rows and columns in the number 2, it identify the count of true positives (TP), true negatives (TN). false positives (FP), and false negatives (FN). These measures [17] are defined as follows:

- TP – It's the statistic count of Class1 samples which has been accurately classified.
- TN – It's the statistic count of Class2 samples which has been accurately classified.
- FN – It's the statistic count of Class1 samples which has been unjustifiably classified as Class2.
- FP – It's the statistic count of Class2 samples which has been unjustifiably classified as Class1.

$$Sensitivity = \frac{TP}{TP + FN} \qquad (5)$$

$$Specificity = \frac{TN}{TN + FP} \qquad (6)$$

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \qquad (7)$$

$$False\ Positive\ Rate = \frac{FP}{FP + TN} \qquad (8)$$

$$True\ Positive\ Rate = \frac{TP}{TP + FN} \qquad (9)$$

V. DATA MINING TOOL AND DATASET

A. About Matlab

To apply the proposed work, Matlab R2013a was used. Matlab is a tool for mining of machine learning, DM, text, and business analytics. It is mainly utilized for applications in research, edification, guidance, and engineering due to user-friendly and ease of use. Matlab comprises of inbuilt mathematical functions aim to solve scientific problems. It is well suited for designing, exploring and solving the iterative problems. The functions and applications available in Matlab are easy-to-use and help the researchers to design the predictive models in an accurate and rapid manner.

B. Z-AlizadehSani dataset

The dataset [17] consists of 303 patients records. Each record holds 54 features. Every feature in the dataset are assumed as the forecaster of CAD, which is according to medical literature, but some of the specific features are not yet all used in the approaches of DM for diagnosing the CAD. There exist 4 features snd grouped as: (i) demographic, (ii) symptom and examination, (iii) ECG, and (iv) laboratory and echo features. Every patient can be in any of two probable category, namely Normal or CAD. Patients are bought under the category of CAD, if their diameter narrows more than or equivalent to 50%, and else as Normal. Few features identifies the record of hypertension, Diabetes, Smoker, Ex-Smoker, and history of heart disease.

VI. RESULT AND DISCUSSION

A. Algorithms used to compare with ACO-SVM

- ✓ Sequential Minimal Optimization (SMO): It's a algorithm for resolving the optimization issues which gets arise during SVM training.
- ✓ Naive Bayes (NB) classifier: It's a straightforward classifier probabilistically which was based on applicably NB with the assumption of strong independence.
- ✓ Bagging algorithm: It's a hybrid method that trains few base classifiers by utilizing dataset as input.
- ✓ Neural Network (NN): It's a group based on interconnection of neurons (which is artificial). It utilizes a mathematics based model for processing of information based on a connection approach towards computation.

B. Analysis of TP, TN, FP and FN

Table 1: TP, TN, FP, FN Analysis

Algorithms	TP	TN	FP	FN
ACO-SVM	164	129	4	6
NB	119	110	19	55
NN	125	142	18	18
BSMO	158	126	8	11
SMO	159	126	8	10

C. Sensitivity Analysis

In Figure 1, Algorithms are plotted in the x-axis, and the percentages are plotted in y-axis which denotes the sensitivity. From the figure, it is clear and evident that the proposed ACO-SVM is outperforming than the other algorithms namely Naive Bayes (NB) [19], Neural Network (NN) [20], Bagging Sequential Minimal Optimization (BSMO) [21], and Sequential Minimal Optimization (SMO) [22].

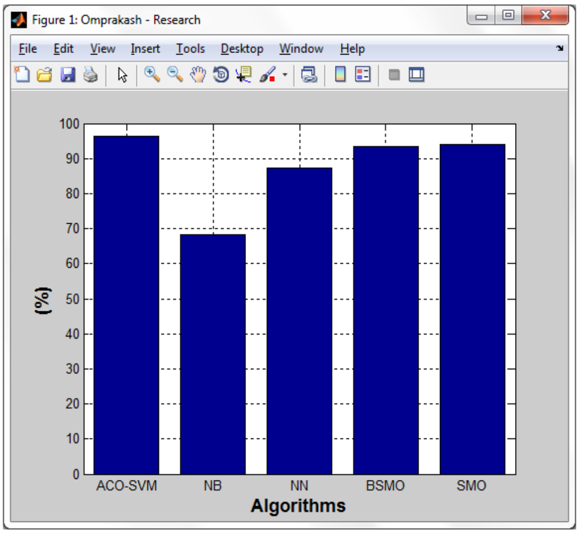

Figure 1: Sensitivity Analysis

D. Specificity Analysis

In Figure 2, Algorithms are plotted in the x-axis, and the percentages are plotted in y-axis which denotes the specificity. From the figure, it is clear and evident that the proposed ACO-SVM is outperforming than the other algorithms namely Naive Bayes (NB) [19], Neural Network (NN) [20], Bagging Sequential Minimal Optimization (BSMO) [21], and Sequential Minimal Optimization (SMO) [22].

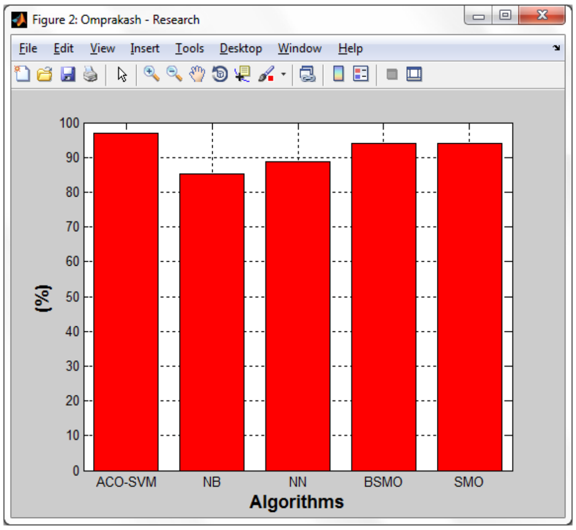

Figure 2: Specificity Analysis

E. Classification Accuracy Analysis

In Figure 3, Algorithms are plotted in the x-axis, and the percentages are plotted in y-axis which denotes the classification accuracy. From the figure, it is clear and evident that the proposed ACO-SVM is outperforming than the other algorithms namely Naive Bayes (NB) [19], Neural Network (NN) [20], Bagging Sequential Minimal Optimization (BSMO) [21], and Sequential Minimal Optimization (SMO) [22].

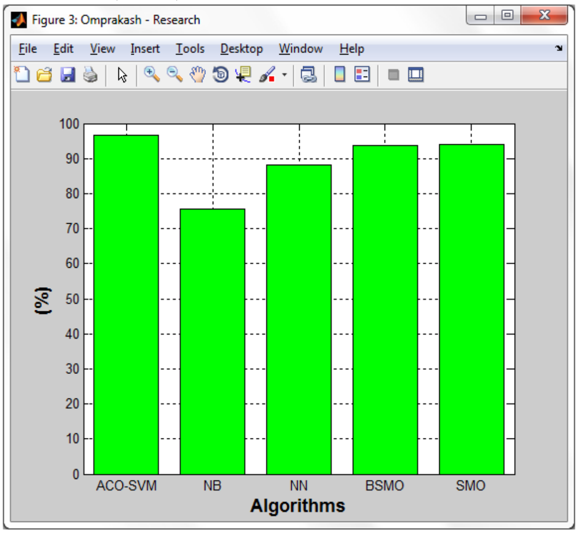

Figure 3: Classification Accuracy Analysis

F. True Positive Rate vs False Positive Rate

In Figure 4, Algorithms are plotted in the x-axis, and the percentages are plotted in y-axis which denotes the true positive rate and false positive rate. From the figure, it is clear and evident that the proposed ACO-SVM is outperforming than the other algorithms namely Naive Bayes (NB) [19], Neural Network (NN) [20], Bagging Sequential Minimal Optimization (BSMO) [21], and Sequential Minimal Optimization (SMO) [22].

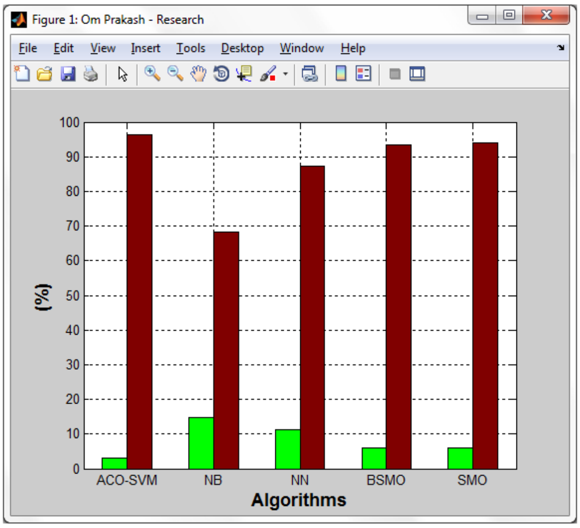

Figure 4: TPR vs FPR Analysis

VII. CONCLUSION

This paper has focused on analyzing and proposing an classifier to predict the coronary artery disease by using the optimization based classifier. An ordinary classifier will just check for the condition and segregate the class for prediction, but there exist a need for classifier which gives prediction with more accuracy. For this purpose this research work has enhanced the support vector machine by utilizing the ant colony optimization technique.

In this the weights of the records are classified by using the optimization technique, where the threshold value is set for increased accuracy. The proposed classifier is designed with reclassification when the objective function is not yet met, where the threshold value is fully utilized. The proposed classifier is evaluated with Z-AlizadehSani dataset for classification accuracy for the prediction of coronary artery disease. The results shows that the proposed classifier outperforms than the baseline schemes. Future enhancement of this research work can be focused with feature selection and advanced approach of data mining, which will result in achieving improved and increased classification accuracy.

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