International Journal of Emerging Science and Engineering (IJESE)
ISSN: 2319–6378 (Online), Volume-11 Issue-11, October 2023

A Survey on Various Approaches for Support Vector Machine Based Engineering Applications

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Abstract: ***Support vector machines describe a system that uses a feature space with a hypothesis space of linear functions that is trained using various learning algorithms from optimization theory. This paper presents a brief introduction to SVM, and a survey with different methods applied for obtaining results using classifiers. The aim is to classify and obtain results for different classes of points with different SVM classifiers and to justify the results using various methods like Gaussian Kernel, Custom Kernel, Cross Validate functioning of SVM classifiers through Posterior Probability Regions for SVM classification models with various types of data.***

Keywords: ***Support Vector Machine, Optimization Algorithms, Classifiers, Hyperplane, SVM Application, Pattern Recognition, Face Detection***

I. INTRODUCTION

Machine learning is quite an effective area which incorporates the concept for many different fields such as science, mathematics, cognitive science, computer science, statistics, and optimization. [2]. There are several classification techniques in the literature including k-nearest-neighbor classifier [2, 9, 15], feedforward and feedback networks, artificial neural network and SVM. SVM was first introduced in 1995 [1-12] and it was named as “Support Vector Network” in the early time, which is a binary classification algorithm and implements the ideology of mapping non-linearly vectors to a very high-dimension feature space to construct a linear decision surface (hyperplane) in this feature space [7]. This paper discusses the classification and results for different classes of points with different SVM classifier. In essence, an SVM categorizes data by identifying the optimal hyperplane that distinguishes all of the input data points from those of the other class. This paper reviews the different results to provide the best hyperplane with the largest margin between the two classes [8]. SVM is quite useful, when the data belongs to two different classes and classifies the data by finding suitable hyperplane which separates all data points of one class from that of the other class [8, 1, 3, 5, 17].

Manuscript received on 12 September 2023 | Revised Manuscript received on 21 September 2023 | Manuscript Accepted on 15 October 2023 | Manuscript published on 30 October 2023.
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The philosophy of SVM is to construct a hyperplane as a decision plane, which distinguishes the positive (+1) and negative (-1) classes with the largest margin as indicated in Fig. 1.

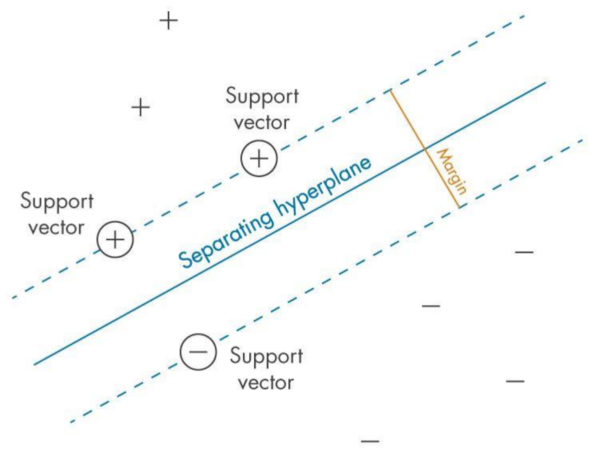

Fig. 1 Separation Hyperplanes

In the current time, SVM's high performance characteristic has made the state-of-the-art in various fields has made SVM demanding. Several methods of improving these models have been developed, in which how the input data can be handled using data normalization through optimization of kernel data [3, 26].

II. MATERIALS AND METHODS

The fundamental SVM-based advancements and an effective introduction to kernel approaches have been carried out in this study. Using support vectors which are closest to the separating hyperplane via support vectors.

(a) Train SVM Classifiers using a Gaussian Kernel- The outcome of this study nonlinear classifiers with Gaussian kernel functions by creating two classes of points, namely one for the annulus from radius 1 to radius 2 and another for the points inside the unit disk in two dimensions [8, 18]. This method produced 500 dots that were placed evenly throughout the unit disk.

(b) Train SVM Classifier using a Custom Kernel- With the various methods existing the one demonstrates how to use a kernel function, such as sigmoid kernel employed for training of SVM classifiers. With this technique, a unit circle's worth of points are generated in a random fashion [8, 14]. The procedure is to mark points in the first and third quadrants as being in the positive class [8, 14, 18].

(c) Train and Cross Validate SVM Classifiers- Using the process of classification the technique creates a Gaussian mixture model.

The order is to first create 10 base points for each of the two classes—green and red—and then generate 100 random points to categorize them. The SVM classification model's posterior probabilities are predicted across a grid for the data in Plot Posterior Probability Regions for SVM classification model, then plots the posterior probabilities over the grid. Basically there are three areas in two-class learning where in the classes can be distinguished, and other one where observations have positive class posterior probabilities of zero, the other one where they are one, and a third where they are positive class prior probabilities. [8, 18].

III. PROBLEM FORMULATION

This paper deals with the non-linear classifiers with Gaussian Kernel function. A method is used to show the use of Kernel Function, such as the sigmoid kernel to train SVM classifier and after that adjustment of function parameters of custom kernel. Now this classifiers form a Gaussian mixture model. Conversion of the model into a plot posterior is done for probability region for SVM classification model to estimate shows the prediction of posterior probabilities over grid observations.

IV. ALGORITHMIC STEPS FOR SVM ANALYSIS

An effective machine learning technique known as the support vector machine (SVM) is utilized for applications like regression, outlier detection, and linear or non-linear classification. After finding the greatest separation hyperplane between various classes present in the target feature is one of its algorithms main objectives. In the proposed work of general nature these are the steps followed for analysis of SVM algorithm as shown in flow diagram Fig. 2.

(i) Start the process for analyzing SVM. Read the input sample features from the available set of input training pair samples.

(ii) Selection of hyperplane depends on the points which justifies and highlights optimality.

(iii) Using of optimization algorithms to generate the weights, so that formulation of equations defining the decision surface separating the classes can be done.

(iv) Among all the formation of equations, it is easy to select criteria for separating hyperplane.

(v) Decision on the margin of separation and the particular hyperplane for which the margin of separation is maximized can be investigated. Determine the order of programming problem by multiplier method. Keeping the maximum margin for avoiding any error in the location of boundary this gives least chance of causing a misclassification.

(vi) Resolve the constraints for problem to estimate, to look for other solution points, re-describing these conditions.

(vii) Optimize the several constraints by problem optimization approach followed by formalization of the constraints in the SVM problem.

(viii) Inner product kernels should be checked in pattern recognition using SVM and to find the content of measure of similarity.

(ix) Identify into inner products either these are graphically or analytically. Make sure graphically is a better choice to predict different classes to judge maximize margin width. Checking is also verified to identify that the hyperplane is whether linear or orthogonal.

(x) For classification on hyperplane, obtain a line that points which side performs linearity or non-linearity using separable method.

(xi) A quadratic function can be used to separate sets that cannot be separated by a linear one. By transforming the data into a higher dimensional space, the objective is to achieve linear separation.

(xii) Analyze the variables classified for pattern recognition using the polar co-ordinates for non-linear SVM. Classifier the structure of SVM according to radial basis function, neural net activation function or linear function and find the best fit curve using SVM.

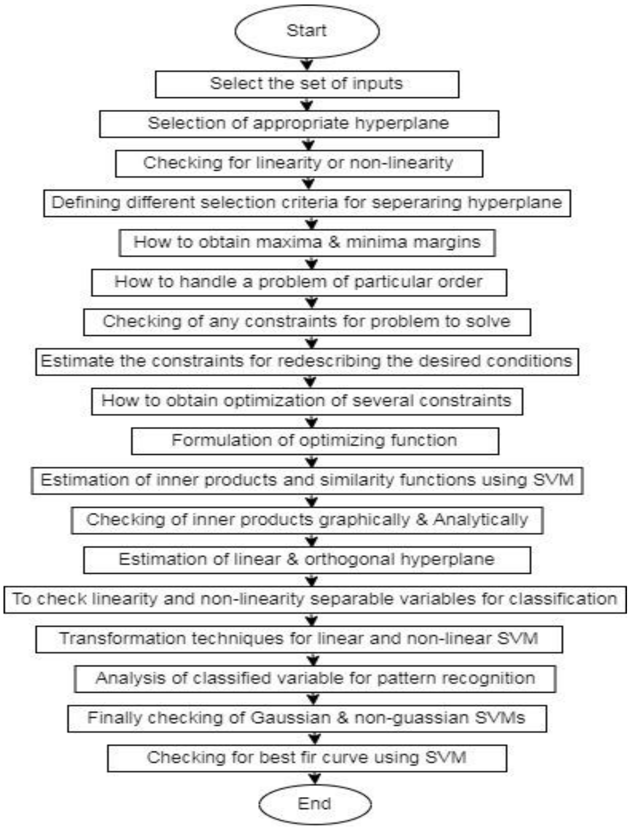

Fig. 2 Sequential Steps in Applying SVM for Classification & Pattern Recognition

V. EMERGING TRENDS FOR SVM APPLICATIONS

Various applications can be thought or different for SVM fields. SVM may be used to find images of faces from images without faces since the challenge of detecting faces can be done through binary classification effectively [5, 16, 19, 20, 4, 6]. The face recognition is a quite popular field of research and large numbers of algorithms have been already suggested [4, 5, 6, 16, 19, 22, 24]. Characteristic recognition is a challenging and problem of interest in the field of image processing via machine learning. In order for a machine to identify characters, symbols, and numbers, such as individuals is quite challenging. Numerous methods used in this field can also be utilised. [4-7, 16, 29, 30].

Retrieval Number: 100.1/ijese.K255510111123
DOI: 10.35940/ijese.K2555.10111123
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A significant area of research with applications to digital libraries and multimedia databases is data-based image retrieval [4, 5, 21, 27]. SVM classifiers are mostly useful for classifying images of useful and redundant informations [4, 5]. The weights assigned were based on the hyperplane's distance, which is estimated by SVMs using positive (+1) and negative (-1) samples [4, 5, 7]. SVM classifiers have quite effective in the medical field by providing accurate and quick disease diagnosis. This is the most important commitment in the field of health care for disease classification [16, 19, 20, 23, 25, 30, 35, 36, 37]. SVMs have been used for a wide range of other applications, such as pattern recognition, data compression, goal detection, and classification of images. SVMs are trained using a combination of flat and structured representation, for demonstration of effective performance in classifying the fingerprints [5, 4, 7, 16].

(i) Wind Energy System

Reference to requirements to the factors such as annual growth and economic impact, wind energy in recent times is one of the most significant renewable energy sources available [1, 6, 7]. Therefore, forecasting wind speed is a subject of interest for careful analysis. SVM plays a significant role in the forecasting of wind speed (or wind power) for which the SVR technique has been used to predict short-term wind speeds with good results as compared to those of competing algorithms like the Machine Learning Process [1, 13, 19].

(ii) Solar Energy System

SVM is a machine learning algorithm based on statistical learning theory and structural risk minimization. The primary idea in this method is to use non-linear mapping to estimate the nonlinear input region into an area with high-dimensional features. SVMs have also shown effective contribution in solar studies using methods [6, 7, 13, 19, 28, 31- 34, 38, 39]. SVM is used to calculate daily solar radiation based on exposure time with number of predictions issues [31-34].

VI. SIMULATION RESULTS

The results demonstrate the creation of a nonlinear classifier with a Gaussian kernel function. As the results are obtained in mathworks environment creating 100 points with a radius of 1 and 100 points with a radius of (r+1), each evenly dispersed throughout the unit disk. To do this, create an angle t uniformly between (0, 2), construct a radius r as the square root of a uniform random variable, and place the point at (r cos(t), r sin(t)), as illustrated in Fig. 3.

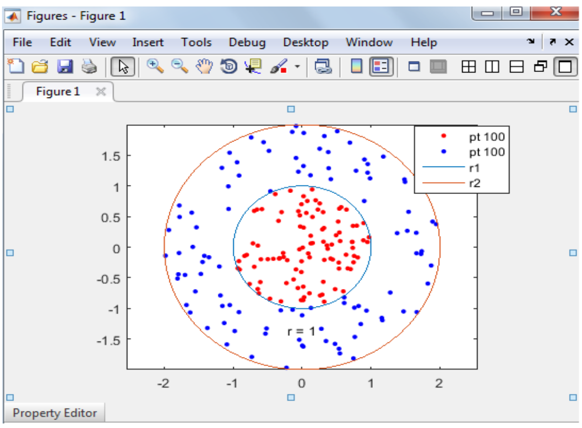

Fig. 3 A Non-linear linear Classifier with Gaussian Kernel Function

Now, train Support Vector Machine classifier with Kernel Function set to 'radial basis function' and Box Constraint set to Infinite. The results are shown in Fig. 4

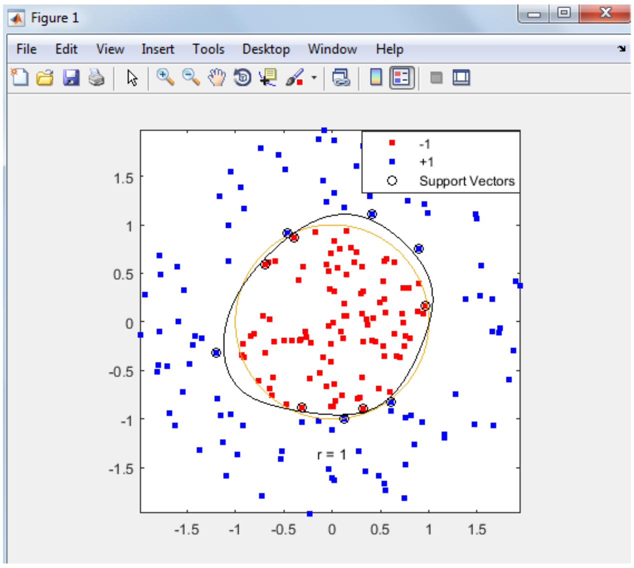

Fig. 4 A Non-linear Classifier with Gaussian Kernel function with decision boundary

The result demonstrates how to train SVM classifiers in mathworks environment and modify the parameters of a custom kernel function, such as the sigmoid kernel as per requirements. The outcome depicted in Fig. 5 generates a unit circle's worth of random points, with labelled points in the first and third quadrants belonging to the positive class and the second and fourth quadrant in the negative class.

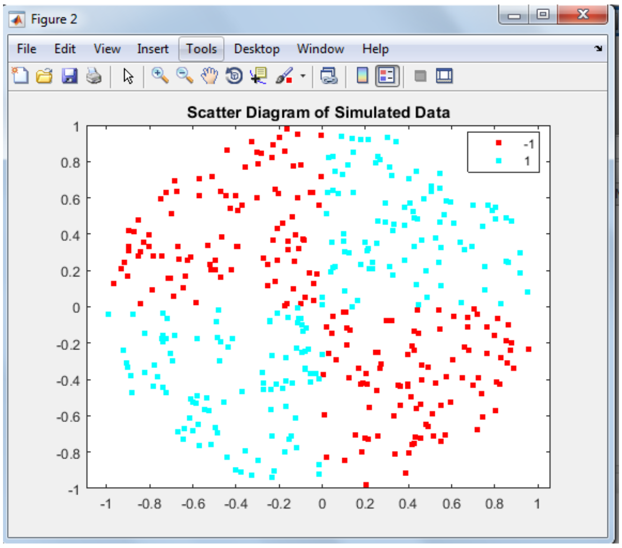

Fig. 5 Train SVM Classifier using Custom Kernel

Results obtained from a Gaussian mixture model are classified using a definite procedure. The process starts by creating 10 base points for the green class and 10 base points for the red class followed by creation of 100 random points. Create 100 green and 100 red points for classifying them using fitcsvm. In Fig. 6, use cross validation to fine-tune the classification.

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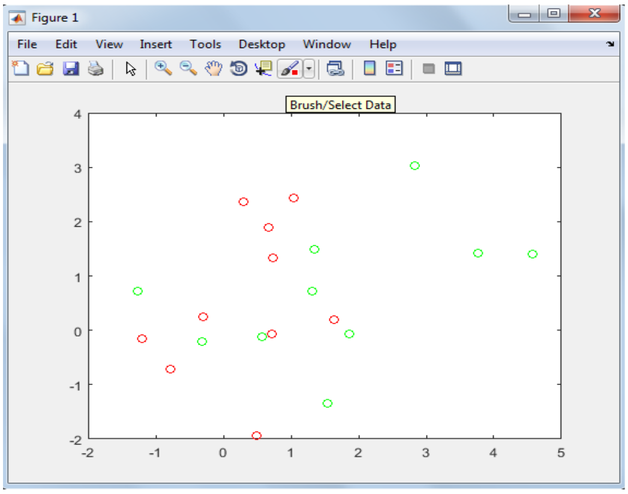

Fig. 6 Train and Cross Validate SVM Classifiers

It is challenging to classify the data points because numerous red base points are close to green base points. As depicted in Fig. 7, creatio of 100 data points for each class is done in Fig. 7 to train and Cross Validate SVM Classifiers. All the data have now been organized by making a matrix and a vector group to label each point's class as either +1, -1, or support vectors.

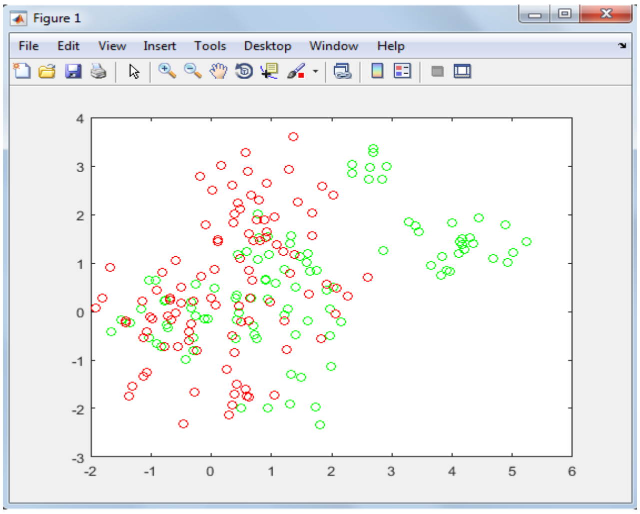

Fig. 7 Train and Cross Validate SVM Classifiers with 100 data points

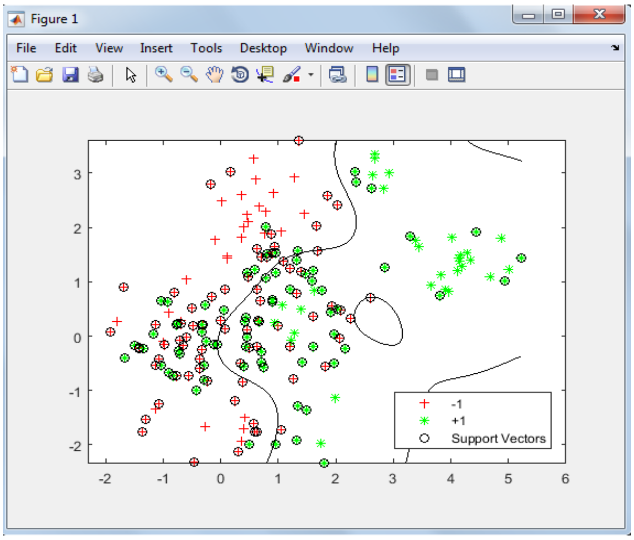

Fig. 8 Results with partition for Cross Validation

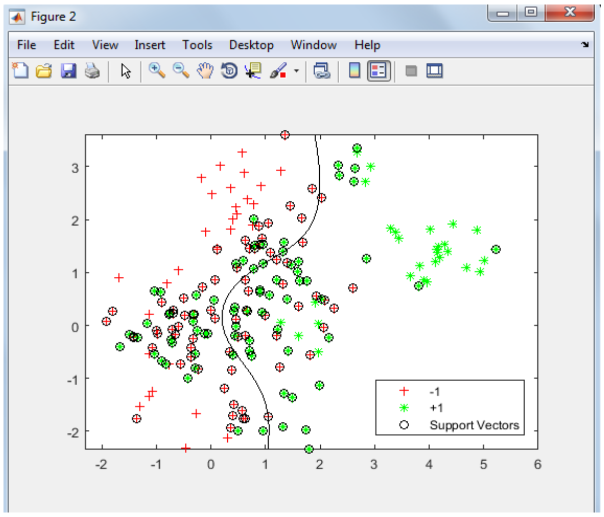

Fig. 9 Results with Partition for Random Cross Validation

As evident from the results in Fig. 9, it is required to set up a partition for cross validation. Without this phase, the cross validation is of random nature making it possible to identify an erroneous local minimum using a reduction process.

The results of Fig. 10 indicate how to forecast posterior probability of SVM models over a grid of data and then plot the posterior probabilities over the grid in order to analyze all the results. plotting the training data and the positive class posterior probability region. These three areas are identified using two-class learning.

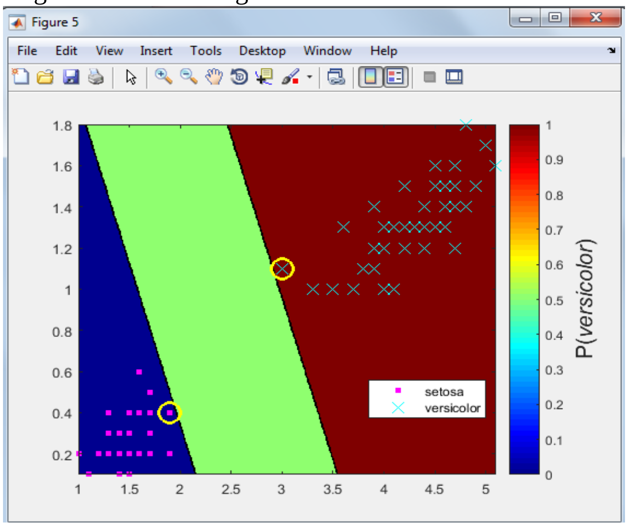

Fig. 10 Plotting of Posterior Probability Regions for SVM Classification Models

VII. CONCLUSION

After visualization of the results of different kernel classifiers, it is established that this can be applied in several areas as discused in this paper. One of the greatest methods for forecasting and data modeling is the support vector machine. Because SVM algorithms have good theoretical foundations and the ability to generalize, they may be applied to a variety of stream applications, which highlights their benefits.

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DOI: 10.35940/ijese.K2555.10111123
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SVM algorithms have been used in a wide range of research areas, including text and handwritten Character Recognition, Image Classification, Face Detection, Generalized Predictive Control, as well as Electrical Engineering applications in solar and wind energy system forecasting, among others. This article cites the works of researchers who have made significant contributions to a variety of engineering and non-engineering applications as it describes in depth the uses of SVM. As future work, the present analysis can be extended to further applications using combined SVM and ANN analysis.

DECLARATION STATEMENT

Funding/ Grants/ Financial Support	No, I did not receive.
Conflicts of Interest/ Competing Interests	No conflicts of interest to the best of our knowledge.
Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	All authors having equal contribution for this article.

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