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A New Methodology to Arrive at Membership Weights for Fuzzy SVM

Maruthamuthu A., National Institute of Technology, Tiruchirappalli, India
Punniyamoorthy Murugesan, National Institute of Technology, Tiruchirappalli, India*
Muthulakshmi A. N., National Institute of Technology, Tiruchirappalli, India

ABSTRACT

Support vector machine (SVM) is a supervised classification technique that uses the regularization parameter and Kernel function in deciding the best hyperplane to classify the data. SVM is sensitive to outliers, and it makes the model weak. To overcome the issue, the fuzzy support vector machine (FSVM) introduces fuzzy membership weight into its objective function, which focuses on grouping the fuzzy data points accurately. Knowing the importance of the membership weights in FSVM, the authors have introduced four new expressions to compute the FSVM membership weights in this study. They are determined from the fuzzy C-means algorithm's membership values (FCM). The performances of FSVM with three different kernels are assessed in terms of accuracy. The experiments are conducted for various combinations of FSVM parameters, and the best combinations for each kernel are highlighted. Six benchmark datasets are used to demonstrate the performance of FSVM, and the proposed models' performances are compared with the existing models in recent literature.

KEYWORDS

Classification, Fuzzy C-Means Clustering, Fuzzy Membership, Fuzzy Support Vector Machine

1. INTRODUCTION

The idea of Support Vector Machine (SVM) took a noteworthy part in regions of classification of data because of expanded accentuation in computerized upheaval and Machine learning developments. Machine learning is a scientific branch, emerged from artificial intelligence and tries to learn from the data to explore models or algorithms using supervised or unsupervised, or reinforced learning algorithms. SVM has shown good generalization performance than other traditional classifiers like decision tree, k-Nearest Neighbor, Bayesian classifier, Neural Network, and different statistical classifiers (Han et al., 2012). SVM builds an ideal hyperplane in a higher dimensional space for better classification of data. The algorithm is to increase the distance between the hyperplane margins and decrease the misclassification error. SVM serves as one of the best-supervised classifications for both distinctly separable and non-distinctly separable data (C Cortes & Vapnik, 1995). SVM adopts characteristics like avoiding overfitting problems and obtaining global optimal, unlike artificial intelligence-based techniques. For datasets that are not distinctly separable, the penalty function is introduced in the model with oblige for the progressions that occur because of the changes that happen due to the violation of linear separability. To reduce the computational complexity, it is replaced with kernel function $k\left(x_i, x_j\right)$, which helps in visualizing the information in higher dimensional space (C Cortes & Vapnik, 1995).

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Since SVM is sensitive to outliers or noises and leads to misclassification of data, an alternative method called the Fuzzy Support Vector Machine (FSVM) is proposed (Lin & Wang, 2002). The FSVM has been found to show better performance in numerous real-time applications like Categorization of text pattern (T. Y. Wang & Chiang, 2007), leukemia disease diagnosis, Electro Cardiogram arrhythmia detection (Özcan & Gürgen, 2010), Evaluation of credit risk (Shi & Xu, 2016; G. Wang & Ma, 2012; Yu, 2014).

As the model requires membership weights assigned to data points, this study has incorporated the Fuzzy C-means (FCM) clustering algorithm for the generation of membership value to show the attitude of data points towards one particular class. The current study's contributions are the new expressions to create the membership weight of each data point from the membership values obtained through FCM. The proposed model is compared with the recent literature (Sridevi et al., 2017), and the performance comparison is made in terms of accuracy.

The paper has been organized as follows. A brief introduction to different types of SVM has been discussed in Section II. The new methodology has been proposed in Section III. The results and discussion have been written in Section IV. Concluding remarks have been talked about in Section V.

2. RELATED WORKS

A detailed explanation of SVM and FSVM models is given in the upcoming section. This section presents the literature related to the current study. The recent literature on fuzzy-based clustering algorithms and subsequently FSVM related works have been discussed here.

Clustering is an imperative unsupervised machine learning approach employed to identify some inherent structure in a set of patterns or objects. Cluster analysis aims to split a set of objects, commonly vectors in a multi-dimensional space, are grouped into subsets so that the objects in the same subset are similar in some perception and objects in different clusters are dissimilar in the same perception. The different selection of measured data or features, proximity measures, clustering criteria, and clustering algorithms may lead to totally different clustering results (Karlekar et al., 2019). The types of clustering based on different ways can be classified as Hierarchical, Partitional, Fuzzy-based, density-based, structure-based clustering algorithms. The current study revolves around the concept of fuzzy, and thus fuzzy-based approaches are studied.

The studies that have been around in measuring the fuzziness of fuzzy sets in different domains by using different means are listed as follows: (a) the novel generalized exponential intuitionistic fuzzy entropy (GIFE) and generalized exponential interval valued intuitionistic fuzzy entropy (GIVIFE) with interval area (Wei et al., 2019) and the application of this study can be seen in (Wei et al, 2020), (b) similar to the previous research, the decision making in the neutrosophic environment was made using (α, β, γ) based cut set based approach (Bhaumik et al., 2020) and neutrosophic hesitant fuzzy generalized hybrid weighted average method (Li et al., 2020), (c) triangular fuzzy number based approaches used in cooperative games application (Ye & Li, 2020). These studies give insight into the fuzziness measurements in different fuzzy environments.

Coming to fuzzy based approaches to clustering, some recent studies found to be informative are listed below.

The data in real-life cases are sometimes uncertain, and they are not reliable. Handling those datasets is very difficult as like fuzzy data. Some recent studies address this issue with different perceptions. For instance, (Sharma & Seal, 2021a) proposed a multi-view spectral clustering algorithm to make conclusions on uncertain objects. Similar to (Sharma & Seal, 2019), another multi-view clustering addresses uncertain data with an additional advantage over outliers. In this study, S-divergence and a new similarity function have been used to tackle the uncertain data. In another study from (Sharma & Seal, 2021b), S-distance is coupled with Euclidean distance and produced a new k-means algorithm to cluster the uncertain data. In a recent study, the S-distance is combined with spectral clustering and proposed a new clustering algorithm. It is then used to treat