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EDITORIAL

Enhancing Support Vector Machines with Fuzzy M-Estimator

Inspired Approaches for Robust Classification

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**Abstract**

Support Vector Machines (SVMs) are widely used for classification due to their strong generalization capabilities, but they remain sensitive to outliers and noise, particularly near decision boundaries. To enhance robustness and better manage boundary uncertainty, we propose a robust extension of the Support Vector Machine (SVM) framework by integrating M-estimator-based loss functions with fuzzy membership values to enhance classification performance in the presence of noise and outliers. We reformulate the SVM in a flexible primal optimization framework that allows for the integration of non-convex loss functions, including Fair, Cauchy, Welsch, and Geman-McClure, are utilized within the fuzzy M-estimators to assign adaptive weights and suppress the influence of noisy or misclassified data. Our method is evaluated on benchmark datasets such as Arrhythmia, Madelon, WBC, and Ionosphere, with artificial noise introduced to assess robustness. Experimental results show that the proposed fuzzy M-estimator SVMs, particularly those using Cauchy and Welsch functions, achieve higher classification accuracy and robustness under noisy conditions compared to traditional L1 and L2-SVMs. This approach offers both theoretical robustness and practical flexibility for real-world noisy data environments.

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**Keywords** Support Vector Machine · Fuzzy · Robustness · Classification · M-estimator

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# 1 Introduction

**2 Support Vector Machines and Robust M-Estimators**

**3 Binary Classification Using SVM: Implementation and Results**

**4 Multi-Class Classification Using SVM: Strategy and Evaluation**

**5 Fuzzy-Based Binary and Multi-Class Classification**

  5.1 **Fuzzy Estimator Framework**

  5.2 **Datasets and Implementation**

  5.3 **Experimental Results**

**6 Comparative Analysis and Robustness Assessment**

**7 Conclusion**

# [1] Xu et al. (2018): “A Survey and Taxonomy of Loss Functions in Machine Learning”

# [2] Zou & Hastie (2005): "Regularization and Variable Selection via the Elastic Net"

# [3] Platt (1998): "Sequential Minimal Optimization: A Fast Algorithm for Training Support Vector Machines"

# [4] Lin et al. (2019): "PSO Optimized 1-D CNN-SVM Architecture for Real-Time Detection and Classification of Diseases"

# [5] Das et al. (2020): "Particle Swarm Optimization-Support Vector Machine Model for Fault Diagnosis of Automotive Gearbox"

# [6] Chen et al. (2021): "Particle Swarm Optimization Algorithm and Its Applications: A Systematic Review"