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Abstract of the Thesis

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Enrollment No: **179999913029**
Faculty: **Engineering**
Discipline/Branch: **Computer/IT Engineering**
Title of the Thesis: **Design And Development Of Support Vector Machines Using Piecewise Linear Approximation Based Optimization Techniques**

Abstract

Machine learning has long championed the Support Vector Machine (SVM) for its classification prowess. Traditional research primarily focused on dual SVM optimization due to its compatibility with non-separable datasets via the kernel trick. However, the quadratic nature of dual optimization sometimes led to slower training speeds. This study explores an alternative perspective, emphasizing the primal SVM optimization problem. Instead of using the conventional approach, this research introduces a novel and fast technique that leverages the power of separable programming, termed the Piecewise Linear Approximation SVM (PLA-SVM). The crux of the method lies in transforming the inherently non-linear primal SVM problem into an approximating linear Programming (LP) problem through piecewise linear approximation using the lambda formulation of separable programming. Executing this transformational approach, the research harnesses the computational prowess of the GUROBI optimizer solver, unveiling a novel method for SVM optimization. The hard-margin PLA-SVM, designed for linearly separable datasets, was rigorously validated in the context of fault classification in a laboratory gas turbine engine. The study then introduced the soft-margin PLA-SVM, which introduces regularization parameters and slack variables for noisy or misclassified data. The proposed soft-margin PLA-SVM is validated on the IRIS flower dataset, PIMA Indian Diabetes dataset, Wisconsin Breast Cancer Original dataset, and Predictive Maintenance AI4I2020 dataset.In head-to-head comparisons with existing classifiers like SMO-based SVM, linear discriminant analysis, KNN (K-nearest neighbors), decision trees, ensemble boosted trees, tri-layered neural networks, and contemporary XGBoost, PLA-SVM consistently demonstrated significantly faster training speeds and minor improvements in accuracy, precision, F1 score, and AUC-ROC metrics. To showcase the strength of PLA-SVM, especially for large datasets, we performed practical experiments with around 30,266 observations from a machine learning tool – a DC motor kit for multi-fault classification. Recognizing the limitations of primal SVMs in handling non-separable datasets, we strategically transformed the non-separable dataset obtained from the machine learning tool using explicit kernel method.

The results revealed that PLA-SVM exhibited superior training speed with a slight improvement in accuracy and other key performance metrics. In summary, this research introduces a paradigm shift in SVM optimization and demonstrates its exceptional effectiveness across various datasets and practical applications.

This Ph.D. Thesis would be useful for academic researchers exploring advanced machine learning techniques, predictive analytics, and organizational policymakers seeking efficient data-driven decision-making tools.

List of Publication(s):

1) H124Shital Solanki and Ramesh Prajapati "Design of Primal Soft-margin SVM Leveraging Piecewise Linear Approximation based Linear Programming Technique," Journal of Propulsion Technology, Vol. 44, No. 4, pp. 1605-1614, 2023. https://doi.org/10.52783/tjjpt.v44.i4.1111 (Scopus indexed)
2) Shital Solanki and Ramesh Prajapati "Piecewise Linear Approximation-Driven Primal SVM Approach for Improved IRIS Classification Efficiency," International Journal of Scientific Research in Computer Science, Engineering, and Information Technology, Volume 9, Issue 5, September-October 2023. DOI: 10.32628/CSEIT12390542 (Peer-reviewed and Refereed journal)
3) Shital Solanki and Ramesh Prajapati, "Automated Wheat Seed Classification Using PLA Based SVM for Enhanced Varietal Identification," 5th International Conference on Sustainable and Innovative Solutions for Current Challenges in Engineering & Technology, 21–22 October, 2023. (Under Publication- Springer book series "Algorithms for Intelligent Systems")
4) Shital Solanki and Ramesh Prajapati "Performance Assessment Of PLASVM: A Novel Gurobi-Enhanced Piecewise Linear Approximation Based Approach For Diabetes Prediction," 1st International Conference on Recent Advancements in Computing Technologies & Engineering, 29-30 December, 2023. (Under Publication - AIP Conference Proceedings, Scopus Indexed)