# Multicategory Nonparallel Support Vector Machine and Application to Financial Market Prediction

*A THESIS*

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*by*

**Deepak Kumar**

(E.No. D11041)


**SCHOOL OF BASIC SCIENCES**
**INDIAN INSTITUTE OF TECHNOLOGY MANDI**
**Mandi-175005, India**

*Dedicated to*

My Family

## Declaration by the Research Scholar

I hereby declare that the entire work embodied in this Thesis is the result of investigations carried out by me in the School of Basic Science, Indian Institute of Technology Mandi, under the supervision of Dr. Manoj Thakur, and that it has not been submitted elsewhere for any degree or diploma. In keeping with the general practice, due acknowledgments have been made wherever the work described is based on finding of other investigators.

Place: Signature:

Date: Name: **Deepak Kumar**

## Declaration by the Research Advisor

I hereby certify that the entire work in this Thesis has been carried out by Deepak Kumar, under my supervision in the School of Basic Science, Indian Institute of Technology Mandi, and that no part of it has been submitted elsewhere for any Degree of Diploma

Signature:

Name of the Guide: **Dr. Manoj Thakur**

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# Abstract

The purpose of the work presented herein is to introduce nonparallel hyperplanes support vector machine classifiers for the problems of multi-category classification and then to design a financial decision support systems for making investment decisions in financial markets. The support vector machine (SVM) classifiers are very effective and efficient to construct decision surface that can separate data points belonging to different classes. The idea of a single decision surface is generalized to two nonparallel planes that are generated in such a way that each plane is placed nearest to its corresponding class and as far as possible from the other class.

A least squares version of Nonparallel Hyperplane Support Vector Machine (LSNHSVM) classifier is proposed for binary classification problems. The solution of the proposed LSNHSVM reduces to a system of linear equations as opposed to a quadratic programming problem in the case of NHSVM. Thus, LSNHSVM classifier is computationally faster as compared to NHSVM. LSNHSVM is further generalized for solving multi-class classification problem "*directly*". The resulting classifier is named as Multi-category Least Squares Nonparallel Hyperplane Support Vector Machine (MLSNHSVM). MLSNHSVM constructs $K$ nonparallel hyperplanes simultaneously by solving a system of linear equations. MLSNHSVM has significantly higher classification accuracy as compared to Multiclass Support Vector Machine (MSVM) and Multi-class Least Squares Twin Support Vector Machine (MLSTSVM) classifiers and is also considerably efficient than multi-class SVM.

Most of the classification problems in real life have unbalanced data. To overcome this difficulty associated with unbalanced data classification, Weighted Multi-category Generalized Eigenvalue Proximal Support Vector Machine (WMGEPSVM) and Weighted Multi-category Improved Generalized Eigenvalue Proximal Support Vector Machine (WMIGEPSVM) are proposed where a weighted factor is introduced by define a modified balancing technique. These classifiers generate $K$ nonparallel decision surfaces for $K$ classes, such that each surface is closest to its corresponding class and the farthest from the rest of the classes. Both WMGEPSVM and WMIGEPSVM are found to significantly improve the classification accuracy of MGEPSVM and MIGEPSVM (without applying weighted fac-

tor). The WMGEPSVM and MGEPSVM are also found to be superior to Multiclass Support Vector Machine (MSVM) and Multiclass Least Squares Twin Support Vector Machine (MLSTSVM).

Another objective of the present work is to investigate the predictive capabilities of SVMs to forecast the direction of the financial time series and to utilize the strength of machine learning techniques to develop profitable financial trading systems. First, a hybrid approach is proposed to predict the one day forward direction of the financial time series. The proximal support vector machine (PSVM) classifier uses technical indicators and oscillators as input for predicting the direction of various financial markets. The PSVM classifier is found to be satisfactory in predicting the trends in financial markets. Owing to the fact that selection of relevant input variables can significantly improves the predictive capacities of prediction algorithms, various feature selection techniques are utilized with PSVM and the resultant hybrid PSVM models are found to significantly improve the performance of PSVM algorithms.

The hybrid multi-category classifies utilizing RF technique for feature pruning task are utilized to design decision support systems for trading in financial markets. The decision support systems propose trading strategies for carry forward and intraday trading that make use of technical indicators as inputs to the hybrid predictive algorithms. The hybrid classifiers are trained using popular *trend reversal* and *range breakout* strategies employed for making investments decisions in the financial markets. The performance of the trading systems based on multi-category classifiers proposed in this work are found to be superior to the trading systems based on other classifiers and the BUY-HOLD trading strategy on the basis of various performance measures. Significant improvements in the performances of hybrid classifiers using RF technique are found as compared to their non-hybrid versions. The hybrid decision support systems are found to perform well in bullish, bearish or sideways market scenarios.

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