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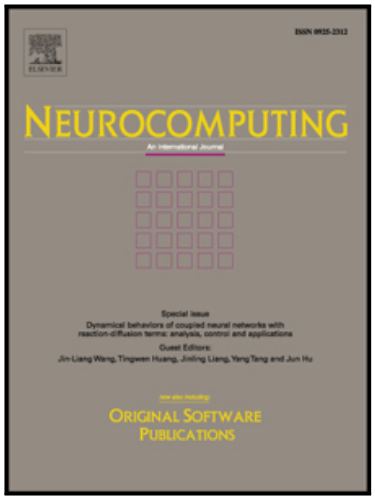

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Improvements on least squares twin multi-class classification support vector machine

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Abstract

Recently, least squares twin multi-class support vector machine (LSTKSVC) was proposed as a least squares version of twin multi-class classification support vector machine (Twin-KSVC), both based on twin support vector machine (TWSVM). In this paper, we propose a novel multi-class classifier termed as Improvements on least squares twin multi-class classification support vector machine that is motivated by LSTKSVC and Twin-KSVC. Similarly to LSTKSVC that evaluates all the training data into a "$1-$ *versus* $-\ 1-$ *versus* $-$ *rest*" structure, the algorithm here proposed generates ternary output $\{-1, 0, +1\}$. Whereas Twin-KSVC needs to solve two quadratic programming problems (QPPs), the solution of the two modified primal problems for our algorithm is reduced to two systems of linear equations. Besides that, in our algorithm the structural risk minimization (SRM) principle is implemented by introducing a regularization term, along with minimizing the empirical risk. To test the efficacy and validity of the proposed method, numerical experiments on ten UCI benchmark data sets are performed. The results obtained further corroborate the effectiveness of the proposed algorithm.

Key words: Twin support vector machine, Twin-KSVC, Structural risk minimization, Multi-class classification, Least squares

1. Introduction

The support vector machine (SVM) approach, originally proposed by Vapnik and his colleagues [1, 2, 3, 4] for binary classification, is a promising machine learning technique when compared with other machine learning approaches, such as artificial neural networks [5]. SVM solves a quadratic programming problem (QPP) assuring that once an optimal solutions is obtained, it is the unique (global) solution; It also implements the structural risk minimization principle, which minimizes the upper bound of the generalization error [6]. The basic idea of SVM is to find an optimal separating hyperplane with a maximum margin between two parallel support hyperplanes [7].

Different from the standard SVM, which uses a single hyperplane, Mangasarian and Wild [8] proposed a generalized eigenvalue proximal support vector machine (GEPSVM), for binary classification problems, which aims to generate two nonparallel hyperplanes such that each hyperplane is closer to its class and is as far as possible from the other class. This idea leads to solving two generalized eigenvalue problems, which in turn reduces computational cost compared with SVM, that is needed to solves one quadratic QPP [9].

Thereafter, a non-parallel hyperplane classifier termed as twin support vector machine (TWSVM) was proposed by Jayadeva et al. [10] for binary classification in light of the generalized eigenvalue proximal support vector machine (GEPSVM). TWSVM aims at generating two non-parallel hyperplanes by solving a pair of QPPs such that each hyperplane is closer to the pattern in one of the two classes and is as far as possible from the other. Each QPP is smaller than the ones traditionally found in SVMs, which makes TWSVM work almost four times faster than the standard SVM classifier .

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