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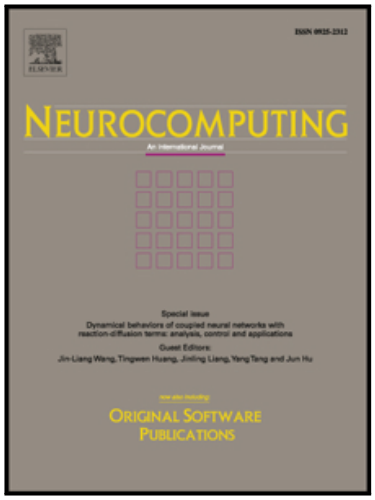

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Range space super spherical cap discriminant analysis

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Abstract

To overcome the separability problem caused by sample fusion in the process of sample vectors normalization, this paper presents a unit super spherical cap discriminant analysis in the range space of the total scatter matrix. It is proved that the unit super spherical cap model can maintain the topological invariability of the structural characteristics of sample vectors. Furthermore, a sufficient condition is derived for improving the separability of sample data under the proposed model. The proposed algorithm projects sample data to the range space of the total scatter matrix, and then adds one dimension to each sample of the range space and nonlinearly maps it on the surface of the unit super spherical cap. We put forth a new classifier called the "spherical inner product nearest neighbor classifier" for the transformed data. It is designed for the deviation problem of the discriminant vector and the separability problem caused by sample vectors normalization when different sub-classes are located in different low-dimensional subspaces or manifolds. Experimental results on different databases show that our method outperforms other methods in terms of recognition accuracy and numerical stability.

Keywords: Fisher linear discriminant analysis; separability problem; super spherical cap discriminant analysis; range space.

1. Introduction

Fisher linear discriminant analysis (FLDA) [1] is one of the most popular feature extraction methods. It has been successfully applied to various pattern classification problems. However, FLDA adopts the between-class scatter matrix as the maximum metric. This may limit the maximal dimensions of the extracted feature space to C-1, where C is the number of classes of training samples. If the dimensions of the feature space are below C-1, the close classes in the original space will be merged. This is the so-called separability problem [2]. In addition, a basic assumption of FLDA is that the class distribution of samples is homoscedastic. This assumption is impossible in some practical applications [3]. This is known as the heteroscedasticity problem in pattern classification.

In the past, many feature extraction methods have been proposed for pattern recognition [4]-[11]. An enhanced fisher discriminant criterion (EFDC) was proposed in [9]. EFDC combined the intra-class variation with the Fisher discriminant criterion to construct an efficient dimensionality reduction function. The main advantage of this method was stable intra-class representation and it provided very useful discriminant information for classification. Considering local geometrical structure information also includes the local inter-class pattern variation, Di Zhang et al.[10] proposed a complete global-local LDA method (CGLDA) to incorporate local similarity information, local intra-class pattern variation, and local inter- class pattern variation. To effectively utilize global and local geometrical structures, a joint global and local-structure discriminant analysis (JGLDA) [11] was presented to reduce dimension. These methods showed good performance in some databases. To overcome the singular problem of matrix when calculated projection vectors, PCA [12] was first used to make the matrix become nonsingular. However, some potential discriminatory

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