DOCTORAL THESIS

Discriminant analysis algorithms for face recognition

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Discriminant Analysis Algorithms for Face Recognition

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Abstract

Face Recognition research started in the late 70s and a number of algorithms/systems have been developed in the last decade. Among various algorithms, appearance-based approach is one of the promising approaches in face recognition. Linear Discriminant Analysis (LDA) and Principal Component Analysis (PCA) are two most popular feature extraction and dimension reduction techniques used in the appearance-based approach. From classification point of view, generally, LDA-based algorithms perform better than that of PCA-based algorithms. However, there are two major problems when applying LDA in face recognition. The first one is the small sample size (S3) problem. It occurs when the image dimension is larger than the number of training samples. In turn, the within-class scatter matrix becomes singular. The second is the complicated and nonlinear image distributions when the images are captured under different poses and illuminations. In this thesis, discriminant analysis algorithms are designed and proposed, from the subspace approach and the regularization approach, to overcome these two limitations.

In the subspace approach, a new Subspace-LDA (SLDA) method is proposed to solve the S3 problem. Compared with the existing LDA-based face recognition methods for solving S3 problem, the proposed SLDA method is more efficient and gives better performance. By applying the kernel trick in the SLDA method, a Kernel Subspace-LDA (KSLDA) method is proposed to solve the nonlinear face image distribution problem. One of the crucial factors in the Kernel approach is the determination of the kernel parameters which highly affect the generalization performance of the kernel-based learning methods. To further improve the performance of our proposed KSLDA method, an automatic parameter estimation algorithm based on eigenvalue stability, namely the Eigenvalue Stability Bounded Margin Maximization (ESBMM), is developed. The proposed ESBMM algorithm is able to estimate multiple kernel parameters in RBF kernel function. Moreover, the ESBMM algorithm is generic and can be applied to other kernel-based LDA methods. To demonstrate its effectiveness, the proposed ESBMM algorithm is also applied to another kernel-based LDA method, namely the Kernel Direct-LDA (KDDA) method. Experimental results show

that after applying the ESBMM algorithm, the performance of the KSLDA method and the KDDA method are both improved by around three percents.

This thesis also explores the regularization approach to solve the above-mentioned two problems. by applying the kernel trick into one-parameter regularized discriminant analysis (RDA) method, a kernel-based one-parameter regularized Fisher discriminant (K1PRFD) method is proposed. A gradient decent-based algorithm is also developed to find the optimal regularization parameter.

In the final part, to utilize different advantages of different classifiers, a weighted combination scheme is proposed to integrate different kinds of face recognition algorithms. By integrating the concept of component-based approach and the weighted combination scheme, we proposed a component-based SLDA method to solve the one training sample problem for LDA-based algorithms in face recognition. A face image is divided into five sub-blocks. The SLDA method is then applied to each block. The final conclusion is drew based on the fusion results of the five SLDA classifiers. Two other practical applications also demonstrate the effectiveness of the proposed weighted combination scheme.

Each algorithm developed in this thesis has been extensive evaluated using public available databases such as FERET, YaleB and CMU PIE databases. Comparison between the proposed algorithms and the existing related algorithms are also performed and reported in this thesis.

In short, The major contributions of this thesis are summarized as follows:

- An efficient and effective SLDA method and its kernel version KSLDA method are proposed to solve the S3 problem and the nonlinear distribution problem;

- To improve the generalization performance of the kernel-based LDA methods, the Eigenvalue Stability Bounded Margin Maximization (ESBMM) algorithm is proposed to select kernel parameters for the kernel-based LDA methods;

- Integrating kernel trick into one-parameter regularized discriminant analysis algorithm, the kernel-based one-parameter regularized Fisher discriminant (K1PRFD) method is proposed to solve the S3 problem and the nonlinear distribution problem.

- A weighted combination scheme is proposed to integrate different kinds of face recognition algorithms. By integrating the concept of component-based approach and the weighted combination scheme, a component-based SLDA method is proposed to solve the one training sample problem.

Moreover, this thesis concludes that

- Both the subspace approach and the regularization approach are good and feasible approaches to solve the S3 problem and the nonlinear distribution problem in face recognition;
- In general, kernel-based methods gives better performance than that of linear methods, provided that the appropriate parameters are selected;
- Kernel parameter(s) selection is a crucial factor for kernel-based methods. The proposed ESBMM algorithm has demonstrated this issue.

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