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Chapter XII

Two-Directional PCA/LDA

ABSTRACT

This chapter introduces a two-directional PCA/LDA approach that is a useful statistical technique applied to biometric authentication. We first describe both bi-directional PCA (BDPCA) and BDPCA plus LDA. Then, some basic models and definitions related to two-directional PCA/LDA approach are given. Next, we discuss two-directional PCA plus LDA. And, finally, the experimental results and chapter summary are given.

INTRODUCTION

BDPCA Method

PCA has been very successful in image recognition. Recent researches on PCA-based methods are mainly concentrated on two issues, feature extraction and classification. In this chapter, we propose BDPCA with assembled matrix distance (AMD) metric to simultaneously deal with these two issues. For feature extraction, we propose a BDPCA approach. BDPCA can be used for image feature extraction by reducing the dimensionality in both column and row directions. For classification, we present an AMD metric to calculate the distance between two feature matrices and then use the nearest-neighbor and nearest feature line classifiers for image recognition. The results of our experiments show that BDPCA with AMD metric is very effective in image recognition.

PCA-based approaches have been very successful in image representation and recognition. In 1987, Sirovich and Kirby used PCA to represent human faces (Sirovich

& Kirby, 1987; Kirby & Sirovich, 1990). Subsequently, Turk and Pentland proposed a PCA-based face recognition method, eigenfaces (Turk & Pentland, 1991). PCA has now been widely investigated and successfully applied to other image recognition tasks (Lu, Zhang, & Wang, 2003; Wu, Zhang, & Wang, 2003; Huber, Ramoser, Mayer, & Penz, 2005).

Despite the great success of PCA, some issues remain that deserve further investigation. First, we have showed in this section that PCA is prone to be over-fitted to the training set because of the high dimensionality and SSS problem. Although no researchers directly pointed out the over-fitting problem, some PCA-based approaches, such as $(PC)^2A$ (Wu & Zhou, 2002; Chen, Zhang, & Zhou, 2004) 2DPCA (Yang & Yang, 2002; Yang, Zhang, Frangi, & Yang, 2004; Chen & Zhu, 2004) and modular PCA (Gottumukkal & Asari, 2004), had been proposed to address this problem. But $(PC)^2A$ just alleviates the over-fitting problem by blurring the original image with an intrinsic low-dimensional image, and both 2DPCA and modular PCA obtain a much higher feature dimensionality than classical PCA (Yang & Yang, 2002). Thus, further work is needed to solve the over-fitting problem and avoid the high-feature dimensionality problem of 2DPCA and modular PCA.

Second, there some work needs to be investigated in the design of classifiers based on the PCA feature. One general classifier is nearest-neighbor (NN) classifier using the Euclidean distance measure. Other distance measures, such as angle-based distance and Mahalanobis distance measures, had been studied to further improve recognition performance (Navarrete & Ruiz-del-Solar, 2001; Moon & Phillips, 1998; Yambor, Draper, & Beveridge, 2002; Perlikbakas, 2004). Recently, nearest feature line (NFL) classifier is introduced to eliminate the performance deterioration of NN caused by the reduction of prototypes (Li & Lu, 1999). Most recently, nearest feature space (NFS) and other variants or extensions of the NFL classifier had been investigated in Chien and Wu (2002), Ryu and Oh (2002), Wang and Zhang (2004) and Zheng, Zhao, and Zou (2004). Yet, even though previous studies of NN have shown that distance measures greatly affect the recognition performance, with reference to the NFL classifier, distance measures have been little investigated. Actually, other distance measures may produce better recognition performance for the NFL classifier.

In this chapter, we tried to simultaneously investigate these two issues. First, we propose a BDPCA method to circumvent the over-fitting problem. Besides, BDPCA can also avoid the high-feature dimensionality problem of 2DPCA and modular PCA. Second, we present an AMD metric to calculate the distance between two feature matrices and apply the proposed distance metric into the implementation of NN and NFL classifiers.

To test the efficiency of BDPCA with AMD metric, experiments were carried out using the ORL face database and PolyU palmprint database. Experimental results show that the proposed method is very effective and competitive compared with other image recognition approaches, and the AMD measure can be used to further improve the performance of the NN and NFL classifiers.

BDPCA Plus LDA Method

Appearance-based methods, especially LDA, have been very successful in facial feature extraction, but the recognition performance of LDA is often degraded by the so-called SSS problem. One popular solution to the SSS problem is PCA+LDA (fisherfaces), but LDA in other low-dimensional subspaces may be more effective. In this section, we