Chapter 9
Local vs. Global:
Intelligent Local Face Recognition

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ABSTRACT

Face recognition in real world applications is a very difficult task because of image misalignments, pose and illumination variations, or occlusions. Many researchers in this field have investigated both face representation and classification techniques able to deal with these drawbacks. However, none of them is free from limitations. Early proposed algorithms were generally holistic, in the sense they consider the face object as a whole. Recently, challenging benchmarks demonstrated that they are not adequate to be applied in unconstrained environments, despite of their good performances in more controlled conditions. Therefore, the researchers’ attention is now turning on local features that have been demonstrated to be more robust to a large set of non-monotonic distortions. Nevertheless, though local operators partially overcome some drawbacks, they are still opening new questions (e.g., Which criteria should be used to select the most representative features?). This is the reason why, among all the others, hybrid approaches are showing a high potential in terms of recognition accuracy when applied in uncontrolled settings, as they integrate complementary information from both local and global features. This chapter explores local, global, and hybrid approaches.
INTRODUCTION

Face recognition represents a very hot research topic and is gaining an increasing attention from both academics and commercial companies due to its potential applications in surveillance, law enforcement, and human-computer interaction. Face authentication systems are very accurate and quite easy to implement under controlled conditions, and literature provides a very wide set of techniques, which are very effective especially with cooperative users. However, recognition performances dramatically drop down when those methods operate in more unrestricted conditions, because of disrupting factors like pose, illumination and expression (PIE) changes, low image resolution, or the presence of structural components like beards, mustaches and glasses. This is principally due to the fact that earlier approaches presented in literature were holistic or global methods, in that they considered the face image as a whole.

Since the presentation of the Principal Component Analysis (PCA) by Turk and Pentland in 1991, holistic approaches have been extensively investigated over the last two decades. PCA finds the principal components of the original face image space and provides an optimal transformation for face representation. PCA based authentication systems project the original face image in a lower dimensional feature space by retaining only coefficients associated with the largest eigenvalues. On the other hand, local distortions such as illumination changes or occlusions on the face image heavily influence the resulting feature vector, causing a significant drop in accuracy that can be ascribed to the fact that the transformation found by the PCA is optimal for representing patterns, but not for recognizing them (Belhumeur et al., 1997; Duda et al., 2001). Pattern classification requires discriminative features, which is the main motivation for Linear Discriminant Analysis (LDA) (Etemad & Chellappa, 1997; Martinez & Kak, 2001) generally outperforming principal component analysis. LDA minimizes the within-class variance, while maximizing the between-class variance of a given set of images by means of a linear transformation. Both PCA and LDA produce global feature vectors with almost all non-zero coefficients and are very sensitive to local changes on a face image, since each pixel within the image influences almost all dimensions of the subspace projection. On the contrary, the independent component analysis (ICA) (Bartlett et al., 2002) generates spatially localized features, as the vectors it produces are statistically independent. Bartlett et al. (2002) also shown a different way of applying ICA to a set of face images in order to uniformly spread data samples in the new subspace. In this case, feature vectors exploit fine details to distribute samples in the subspace.

PCA, LDA and ICA are all techniques devoted to extract relevant information in a face image as efficiently as possible. Extracted features usually undergo a classification process whose goal is to assign a new face sample submitted to the system to its corresponding class, with different classes representing identities that have been previously enrolled. A different group of approaches involves techniques borrowed from artificial intelligence. Artificial Neural Networks (ANN) (Latha et al., 2009), are largely used for classifying face features because of their ability to learn from training data. Back-propagation neural networks (BPNN) (AL-Allaf et al., 2013) model the way a human being recognizes faces, with the aim of implementing a recognition system that incorporates artificial intelligence. Actually, the work by AL-Allaf et al. (2013) is a typical example of the way in which PCA based feature extraction can be combined with BPNN feature classification. Support Vector Machines (SVM) (Vapnik, 1998) have been also largely used in face classification when dealing with local distortions like the occlusions (Hongjun & Martinez, 2009). SVM are a non-probabilistic binary linear classifier and represent a powerful technique for two-class pattern recognition problems. Given a set of training samples, the basic