Chapter 7
Transform Based Feature Extraction and Dimensionality Reduction Techniques

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ABSTRACT

Various changes in illumination, expression, viewpoint, and plane rotation present challenges to face recognition. Low dimensional feature representation with enhanced discrimination power is of paramount importance to face recognition system. This chapter presents transform based techniques for extraction of efficient and effective features to solve some of the challenges in face recognition. The techniques are based on the combination of Radon transform, Discrete Cosine Transform (DCT), and Discrete Wavelet Transform (DWT). The property of Radon transform to enhance the low frequency components, which are useful for face recognition, has been exploited to derive the effective facial features. The comparative study of various transform based techniques under different conditions like varying illumination, changing facial expressions, and in-plane rotation is presented in this chapter. The experimental results using FERET, ORL, and Yale databases are also presented in the chapter.

INTRODUCTION

The face recognition process in human is a high-level visual task. Although human can detect and identify faces in a scene with varying conditions without much effort, building an automated system that accomplishes such task is very challenging. The challenges are even more profound when one considers the wide variations in imaging conditions. There are inter, and intra subject variations associated with face images. Inter subject variations are limited due to the physical similarity among individuals. Intra subject variations are extensive because of head position (rotation), presence or absence of structural components (beards, glasses, etc.), facial expression, illumination conditions, age, and occlusion by other objects or peoples. These variations are challenges in face recognition.
Face recognition is one-to-many matching process. It compares a specific face image (the probe) against all of the images in a face database (the gallery). The probe image is identified by determining the image in the gallery that most closely resembles the probe image.

Machine recognition of human faces from still and video images is an active research area spanning several disciplines such as image processing, pattern recognition, computer vision, etc. Given a still or video image of a scene using a stored database of faces, available information such as race, age, and gender may be used in narrowing the search. The solution of the problem involves segmentation of faces from cluttered scenes, extraction of features from the face region, matching, and identification. Psychophysicists and neuroscientists have been concerned with issues such as, uniqueness of faces, whether face recognition is done holistically or by local feature analysis, and use of facial expression for face recognition. Low dimensional feature representation with enhanced discrimination power is an important requirement of face recognition system. Extracting the effective and efficient features is a great challenge in face recognition (Chellappa 1995).

This chapter presents the different transform based techniques for feature extraction. The various analyses performed on these features to further reduce the dimensionality are discussed in this chapter. This chapter also presents two different techniques for feature extraction, which are computationally efficient and robust to zero mean white noise. These techniques attempt to exploit the capabilities of Radon transform (to enhance low frequency components), discrete cosine transform (DCT), and discrete wavelet transform (DWT) to derive effective and efficient face features. The effectiveness of these transform-based approaches is demonstrated in terms of both absolute performance and comparative performance.

BACKGROUND AND RELATED WORK

Feature selection for face representation is one of central issues to face recognition systems. Appearance based approaches, which generally operate directly on images or appearances of face objects, process the images as two-dimensional holistic patterns. Principle component analysis (PCA) and linear discriminant analysis (LDA) are widely used subspace analyses for data reduction and feature extraction in appearance-based approaches. Most of the appearance based feature extraction techniques can be classified into following types.

- Algorithms based on principal component analysis (PCA)
- Algorithms based on nonlinear PCA
- Algorithms based on linear discriminant analysis
- Algorithms based on nonlinear discriminant analysis

Algorithms Based on Principal Component Analysis

Projecting images into eigenspace is a standard procedure for many appearance based object recognition algorithms. Eigenspace is calculated by identifying the eigenvectors of the covariance matrix derived from a set of training images. The eigenvectors corresponding to non-zero eigenvalues of the covariance matrix form an orthonormal basis that reflects the image. Mathew Turk and Alex Pentland presented a well-known classical approach to the detection and identification of human faces using eigenspace called as principal component analysis (PCA).

PCA is a classical method that has been widely used for human face representation and recognition. The major idea of PCA is to decompose a data space into a linear combination of small collection of bases, which are pair wise orthogonal.