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Automatic Face Recognition using Principal Component Analysis with DCT

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Abstract: *The Face recognition has found its extensive application in security.Face recognition has many applications ranging from security access to video indexing by content. An effective method in extracting features increases the efficiency and the recognition rate of the face recognition system and also makes its implementation easier. This paper proposes a methodology for improving the recognition rate of the face recognition system.The proposed method is tested using ORL database.Recognition rates for a database of 100 images shows promising results.*
Keywords: *Face recognition, Ffeature extraction, ORL database, PCA, Recognition rate.*

I. Introduction

In recent years, automatic face recognition has become a popular area of research. An excellent survey paper on the topic appeared recently in [l]. Recognition, verification and identification of faces from still images or video data have a wide range of commercial applications including video indexing of large databases, security access and other multimedia applications.As one of the most successful applications of image analysis and understanding, face recognition has recently received significant attention, especially during the past several years.

In this paper, a new single training sample method is proposed based on the study of PCA. This method can express the influence of eigenvector corresponding to different eigenvalue for face recognition, and image blocking method can extract more detail information of face image effectively, and finally maximum membership degree principle is used to recognize unknown face sample. Both of theoretical analysis and experimental results show that PCA can obtain better recognition rate.

The method used for face recognition is based on Principal Component Analysis with DCT.A whole face recognition system was proposed is based on PCA and DCT combination feature extraction. Normalization was used to eliminate the redundant information interference. Principal Component Analysis (PCA) was used for feature extraction and dimension reduction.In general for PCA based face recognition, the increase in the number of signatures will increase the recognition rate, however, the recognition rate saturates after a certain amount of increases.

At least two reasons are accounted for this trend: first it is widely used in real life applications and second, is the availability of feasible technologies after many years of research. The range of face recognition applications is very assorted, such as face-based video indexing and browsing engines, multimedia management, human-computer interaction, biometric identity authentication, surveillance, image and film processing, and criminal identification. Face recognition is a method of identity authentication on biometrics study. Comparing face recognition with another existing identification technology such as fingerprint and iris recognition, it has several characteristics that are advantageous for consumer applications, such as nonintrusive and user-friendly interfaces, low-cost sensors and easy setup, and active identification. This method can be divided in the following categorization: holistic matching methods, feature-based matching methods and hybrid methods. The holistic methods used the whole face as input. Principal Component Analysis (PCA), Linear Discriminate Analysis (LDA) and Independent Component Analysis (ICA) belong to this class of methods. This paper describes block PCA.

Face recognition has been an important issue in computer vision and pattern recognition over the last several decades. While a human can recognize faces easily, automated face recognition remains a great challenge in computer-based automated recognition research. One difficulty in face recognition is how to handle the variations in expression, pose, and illumination when only a limited number of training samples are available.

Currently, face-recognition methods are of two types, the geometric based approaches and the holistic-based approaches. Geometric-based approaches extract local features such as the locations and local statistics of the eyes, nose, and mouth and require correct feature detection and good measurement techniques. Holistic-based approaches extract a holistic representation of the whole face region and have a robust recognition performance under noise, blurring, and partial occlusion.

The two main holistic-based face-recognition approaches are the principal component analysis (PCA) and the linear discriminate analysis (LDA). PCA was first used in 1987 by Service and Kirby to represent facial images. Subsequently, Turk and Pent land applied PCA to face recognition and presented the well-known eigenfaces method [26]. Since then, PCA has been widely studied and has become one of most successful facial-feature-extraction approaches. Recently, other PCA-based approaches, such as the two-dimensional (2-D) PCA (2DPCA), have also been proposed for face recognition [1].

II. Face Recognition

Face recognition technique is a research hotspot in the fields of computer vision and pattern recognition, which is widely used in human-computer interaction, security validation and etc. Up to now, almost all the techniques are based on multi-sample. But in some special situations, such as passport verification and ID card verification, only one image can be obtained for one person, and these techniques may failed.

Principal Component Analysis (PCA), proposed by Turk[2], is one of the most important single sample face recognition methods, which can exactly express every face image via linear operation of eigenvector.

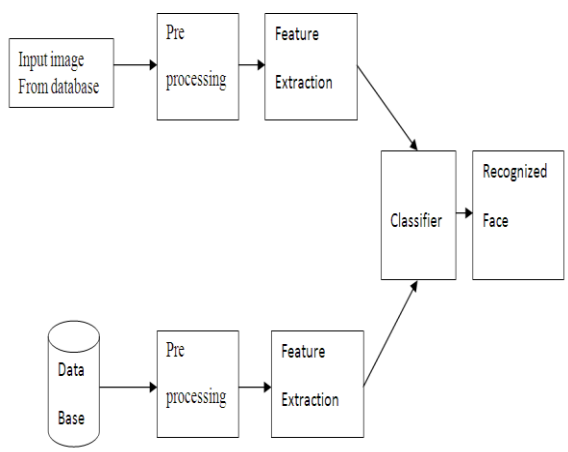

Fig. 1 Face recognition system

2.1. Face Recognition Problem

During the past decades, face recognition has receivedsubstantial attention from researchers. The challenges of facerecognition are the rapid and accurate identification orclassification of a query image [4]. Rapid can be associatedto speed and accuracy refers to recognition rate. Mosttechniques emphasize on the efficiency in getting positiveresults, but when it comes to implementation, speed is vital.The performance of a face recognition technique should beable to produce the results within a reasonable time [5]. Forexample, for video monitoring and artificial vision, real timeface recognition has a very important meaning. It is veryuseful that the system can detect, recognize and track subjectin real time [6]. In human-robot interaction, real-timeresponse time is critical [7]. Besides, it also enablescomputer systems to recognize facial expressions and inferemotions from them in real time [8].

2.2. Feature Extraction

Feature extraction is an important method in the fields ofpattern recognition and data mining technology. It extractsthe meaningful feature subset from original dates by somerules, to reduce the time of machine training and thecomplexity of space, in order to achieve the goal ofdimensionality reduction. Feature extraction transforms theinput data into the set of features while the new reducedrepresentation contains most of the relevant informationfrom the original data [9]. Feature extraction is a key step ofany face recognition system.Feature extraction is a process which transfers the data fromprimary spaces into feature space, representing them in a lowerdimensional space with less effective characters. Up to now,many methods of feature extraction have been proposed, suchas knowledge-based methods, feature invariant approaches,template matching methods, and appearance-based methods.Among them, the algorithm of

Eigenface, the most widelyusedmethod of linear map based on PCA (PrincipleComponent Analysis), has become the mainstream criterion totest the performance of various face recognition system.

III. Principal Component Analysis (PCA)

Principal Component Analysis (PCA) is a dimensionalityreduction technique that can be used to solve compressionand recognition problems. PCA is also known as Hotelling,or eigenspace Projection or Karhunen and Leove (KL)transformation [10] .

PCA transforms the original data space or image into asubspace set of Principal Components (PCs) such that thefirst orthogonal dimension of this subspace captures thegreatest amount of variance among the images. The lastdimension of this subspace captures the least amount ofvariance among the images, based on the statisticalcharacteristics of the targets [11].

The output components from this transformation areorthogonal or uncorrelated, and the mean square error can bethe smallest when describing the original vector with theseoutput components.PCA is a popular transform technique which result is notdirectly related to a sole feature component of the originalsample. PCA has the potential to perform feature extraction,that able to capture the most variable data components ofsamples, and select a number of important individuals fromall the feature components. PCA has been successfullyapplied on face recognition, image denoising, datacompression, data mining, and machine learning. Themajority of the applications of PCA are to use PCA totransform samples into a new space and to use lowerdimensionalrepresentation from the new space to denote thesample [12]. Implementation of the PCA method in facerecognition is called eigenfaces technique.

Turk and Pentland [13] presented the eigenfaces methodfor face recognition in 1991. Face images were projectingonto a face space defined by the eigenfaces, and theeigenvectors of the set of faces not necessary correspondedto isolated features such as eyes, ears, and noses. Theeigenfaces algorithm uses PCA for dimensionality reductionin order to find the best account of vectors for thedistribution of face images within the entire image space[14].

PCA has been widely investigated. It has become one ofthe most successful approaches in face recognition and themost fully characterized samples [15].

The procedures of Principal Component Analysis consistof two phases, training step and recognition step.

1) Training Step: This step is a process to geteigenspace from training image which previously has beenchanged into data matrix. Samples of data, on which thesystem needs to recognize, are used to create an EigenMatrix which transforms the samples in the image spaceinto the points in eigenspace.

2) Recognition Step: This step is a process to geteigenspace from test image which previously has beenchanged into data matrix. These results were then comparedwith results from training phase to get minimum difference

3.1.Image Blocking Method

Feature vectors reflect the characteristics of whole image, so details can not be always fully utilized. Image blocking is insensitive to face expression change and illumination variation, so more detail information can be obtained if apply image blocking in face image and regard feature vector of sub-image as recognition features. According to literature [3], there are several blocking modes to divided training image into multi rectangle sub-image, such as 2*2, 2*4, 4*4and etc. Sub-images in the same location from different training samples constitute the corresponding sub-image sets, and then subspace is constructed for each set and extract feature of each sub-image by using PCA, which is shown in Figure2.

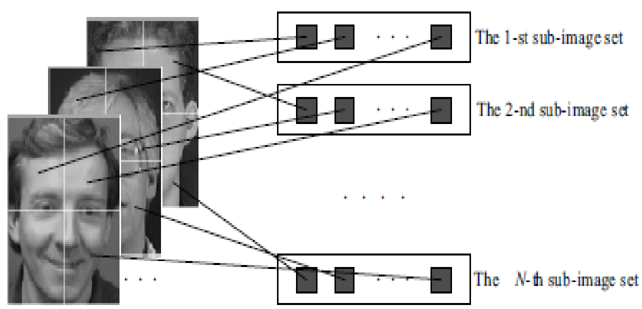

Fig. 2. Construction of sub-image sets

Sub-images in different location can form N subimagesets, in which PCA is used to obtain Noptimal projection matrixes X_1, X_2,…, $X_N$in row direction and N optimal projection matrixes Z_1, Z_2,…,$Z_N$in column direction respectively.
Recognition processing is shown in Figure 3.

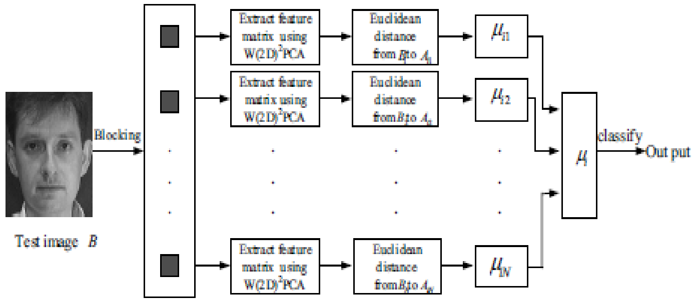

Fig.3. Processing of face image recognition

3.2.Influence of image blocking for recognition

Some image blocking modes is adopted, which are shown in Figure 4.
(a)original image (b) 2*2 (c) 2*4 (d) 4*1(e) 4*2 (f) 4*4 (g) 7*2 (h) 7*4.

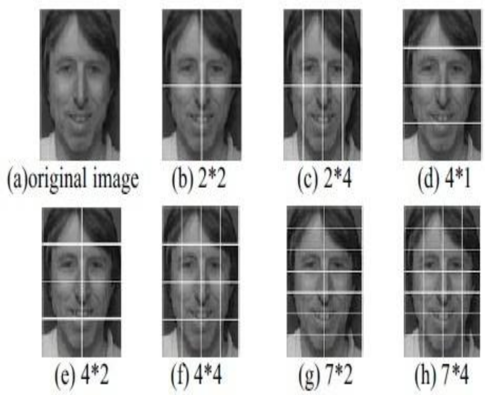

Fig. 4.Several different image blockingmethods

After image blocking, apply PCA in subimages. The experiment results are shown in Table2.
Recognition rate of blocking mode 4*4 can achieve the best, So it is effective to combine blocking method with PCA. Because the size of subimageis much smaller than original image, more detail information for recognition can be obtained. In addition, when the size of sub-image is too large or too small, the advantage of algorithm will be weakened.

IV.Facial Image Acquisition (the Database)

The data for this experiment is collected from thepublicly available database called the AT&T (the ORLDatabase) database of Faces. There are ten different imagesof each of 40 distinct subjects/individuals/persons. Forsome subjects, the images were taken at different times,varying the lighting, facial expressions (open / closed eyes,smiling / not smiling) and facial details (glasses / noglasses). All the images were taken against a darkhomogeneous background with the subjects in an upright,frontal position (with tolerance for some side movement).The size of each image is 92x112 pixels, with 256 greylevels per pixel. This data can be downloaded from [18]. Anexample is provided in Figure 5.

Fig.5. Sample images for a subject of the ORL Database

4.1 Experimental Setup

In order to evaluate the performance of PCA and DCT, a code for each algorithm has been generated usingMatlab. These algorithms have been tested using six set ofdatasets which are COPPEDYALE [18], FACE94, FACE95,and FACE96 [19], JAFFE [20], and AT&T "The Database ofFaces" (formerly "The ORL Database of Faces") [21]. Thesedatasets are grouped into separated datasets which representset of disturbed images, as described in figure 6 and table 1.

Fig. 6. Images sample in dataset (from top to down are sample of: ATT, CROPPEDYALE, FACE94, FACE95, FACE96, and JAFFE dataset)

Table 1. Dataset Description

Database Name	Sample Number	Total Images
ATT	40	400
CROPPEDYALE	38	2414
FACES94	152	3040
FACES95	72	1440
FACES96	151	3016
JAFFE	10	213

V. Result Discussion

The result of the overall experiments show that PCA isbetter in recognition rate (accuracy), especially torecognize face with expression disturbance. The PCAalgorithm only able to achieve levels of accuracy 92.60%. The recognition results are depictedin Table II. In term of time taken, PCA tends to be much better thanother algorithms, especially to recognize images with backgrounddisturbance. To get eigenvalue using LDA algorithm,calculation of within-class scatter matrix and between-class scatter matrix are needed. Meanwhile, there is only one stepto get eigenvalue in PCA algorithm, which is to calculate onescatter matrix. Therefore LDA algorithm needs more timethan PCA to extract feature.

Table 2. Recognition Rate

Dataset name	PCA
ATT	91.30%
CROPPEDYALE	90.30%
FACES94	99.90%
FACES95	87.00%
FACES96	94.00%
JAFFE	92.60%

Table3.Other ResultsRecently Reported On The ORL Database

Methods	Recognition Rate (%)	Year
CompletePCA+LDA	97.0	2003
DF-LDA	95.8	2003
NKFDA	95.1	2004
ELDA	95.85	2004
BDPCA+LDA	97.10	2006

VI. Conclusions

In general for PCA based face recognition, the increase in the number of signatures will increase the recognition rate, however, the recognition rate saturates after a certain amount of increases. Therefore, in our observation it is better to use robust image pre-processing systems, such as geometric alignment of important facial feature points (eyes, mouth, and nose) and intensity normalization which increases the recognition rate and simultaneously decreases the number of signatures representing images in the PCA space. Increase in the number and variety of samples in the covariance matrix increases the recognition rate. In general, the image size is not important for a PCA based face recognition system as long as the number of signatures before PCA-projection is more than the total number of sample images. These findings can provide useful performance evaluation criteria for optimal design andtesting of human face recognition systems.

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