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Face Recognition using Eye Distance and PCA Approaches

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***Abstract*— Nowadays, Face Recognition is one of the most popular topics in Image Processing and Computer Vision. This heightened popularity is because of its non-intrusiveness, user-friendliness and immense application in fraud detection, law enforcement, surveillance and other security purposes. In this paper, we present four approaches for Facial Detection. The first approach we have exhibited is Normalized Cross Correlation which also has applications in pattern recognition, cryptanalysis, single particle analysis, and neurophysiology. For reliability, the output of correlation should be sharply peaked. The second approach, Peak to Side lobe Ratio (PSR) is used to measure the peak sharpness. The third approach uses one of the most important features of face i.e. eyes. The distance between the eyes being variable helps in classifying a person. The fourth approach Principal Component Analysis (PCA) is one of the traditional methods implemented for Face Recognition. Experimental results on GTAV database and Yale database shows that these approaches show sufficiently good results and is robust to illumination variation.**

***Keywords*— Face recognition, PCA, Normalize cross correlation, Eye distance approach, and Feature extraction.**

I. INTRODUCTION

Face Recognition is basically a system which recognizes any image given as an input to the system. In this paper, a comparative analysis is to be carried out for the different methods used for facial recognition. The execution of these techniques on a large set of database will provide the overview of the system performance. Face recognition systems fall into two categories: verification and identification. Face verification is a 1:1 match that compares a face image against a template face image, whose identity is being claimed. On the contrary, face identification is a 1: N problem that compares a query face image against all image templates in a face database to determine the identity of the query face.

Facial recognition is an important field within biometrics and computer vision. With biometrics, we can more reliably identify or authenticate a person. A notable advantage of facial recognition method is that it is less cumbersome for end users as compared to fingerprint recognition, palm prints, iris recognition and retina scans. Computer vision (branch of artificial intelligence) aims to provide the means for machines to visually perceive the environment the way humans do. By means of facial and expression recognition, computer vision can help machines to recognize as well as interact with humans more effectively.

Section 2 considers some of the related work with our proposed techniques. Face databases are considered in section 3 and feature extraction methods are considered in section 4. Finally, section 5 defines face recognition or feature matching technique and the followed section after that considers conclusion and discussion.

II. PREVIOUS WORK

Various works on face recognition has been published in early decade. PCA and LDA acquired much success than other approaches. We have already surveyed all the methods in [1]. Transform based approaches like haar transform and wavelet transform is proposed in [2]. Face recognition based on Hausdorff distance and distance metric is done by [3]. In [4], the author has used configural information, which is relation between parts and is important in the way faces are visually represented. [5] has proposed technique for face recognition based on PCA followed by LDA. In this method, face image is projected to Eigen space using PCA and LDA is used as classifier. Alan [7] proposed an approach based on deformable template for recognising face. It is parametric geometric model which is formed using extraction of facial features and determination of spatial organization between these features.

III. FACE DATABASE

When benchmarking an algorithm, it is recommendable to use a standard test data set for researchers to be able to directly compare the results. While there are many databases in use currently, the choice of an appropriate database to be used should be made based on the task given (aging, expressions, lighting etc.). Another way is to choose the data set specific to the property to be tested (e.g. how algorithm behaves when given images with lighting changes or images with different facial expressions).

A. GTAV Face Database [8]

Recently, a face database has been created with the main purpose of testing the robustness of face recognition algorithms against strong pose and illumination variations. This database includes a total of 44 persons with 27 pictures per person which correspond to different pose views (0^{o}, $\pm 30^{o}$,$\pm 45^{o}$,$\pm 60^{o}$ and $\pm 90^{o}$) under three different illuminations (environment or natural light, strong light source from an angle of 45^{o}, and finally an almost frontal mid-strong light source). Furthermore, at least 10 more additional frontal view pictures are included with different occlusions and facial expression variations. The resolution of the images is 240 × 320 and they are in Bitmap (BMP) format.

Fig. 1 Example of a person on the GTAV database (Different pose views).

Fig. 2 Example of a person ID on the GTAV database (Different illuminations).

Fig. 3 Example of a person ID on the GTAV database (Different pose views).

Fig. 4 Example of a person on the GTAV database with occlusions.

B. *YALE Database [9]*

The YALE database contains 5760 single light source images (figures) of 10 subjects each seen under 576 viewing conditions (9 poses × 64 illumination conditions). For every subject in a particular pose, an image with ambient (background) illumination was also captured. Hence, the total number of images is in fact 5760 + 90 = 5850.

Now, a word about the naming of each image: The first part of the filename of an image follows the same convention as the filename of one of the "tarred" (and "gzipped") files. It begins with the base name 'yaleB' and is followed by the two digit number signifying the subject number and then by the two digit number signifying the pose. The rest of the filename deals with the azimuth and elevation of the single light source direction.

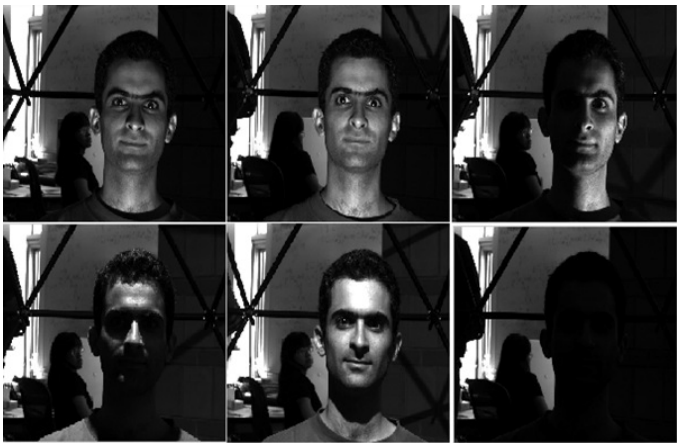

Fig. 5 Example of YALE database.

The images in the database were captured using a purpose-built illumination rig. This rig is fitted with 64 computer controlled strobes. The 64 images of a subject in a particular pose were acquired at camera frame rate (30 frames/second) in about 2 seconds, so there is only small change in head pose and facial expression for those 64 (+1 ambient) images. The image with ambient illumination was captured without a strobe going off. The positions of the strobes in spherical coordinates are shown in this postscript file.

IV. Feature Extraction

Feature extraction technique is used to reduce the dimension of information in terms of features from an image so further recognition of an image becomes computationally easy and fast. Various types of feature extraction methods are used in proposed approach.

A. *Normalized Cross Correlation*

In signal processing, cross-correlation (C) is a measure of similarity of two waveforms as a function of a time-lag applied to one of them. This is also known as a sliding dot product or sliding inner-product. It is commonly used for searching a long-signal for a shorter, known feature. It also has applications in pattern recognition, single particle analysis, electron tomographic averaging, cryptanalysis, and

$$C = \frac{\sum_{i=1}^{n}(x-\bar{x})(y-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x-\bar{x})^2(y-\bar{y})^2}}$$

neurophysiology.

(1)

For image-processing applications in which the brightness of the image and template can vary due to lighting and exposure conditions, the images can be first normalized. This is typically done at every step by subtracting the mean and dividing by the standard deviation.

B. PSR Approach

For authenticity, the correlation output should be sharply peaked and it should not exhibit such strong peaks for impostors. Peak to side-lobes ratio (PSR) defined below is used to measure the peak sharpness [11].

$$PSR = \frac{peak - mean}{\alpha} \quad (2)$$

Figure 6 illustrates how the PSR is estimated. First, the peak is located (shown as the bright pixel in the center of the figure). The mean and the standard deviation of the 20 × 20 side-lobe region (excluding a 5 × 5 central mask) centered at the peak are computed.

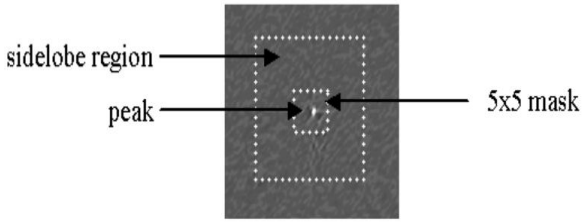

Fig. 6 Estimation of the peak to side lobe ratio (PSR).

For authentic image, PSR should be high compare to non-authentic images. PSR is also invariant to constant illumination changes [12].

C. Eye Distance Approach

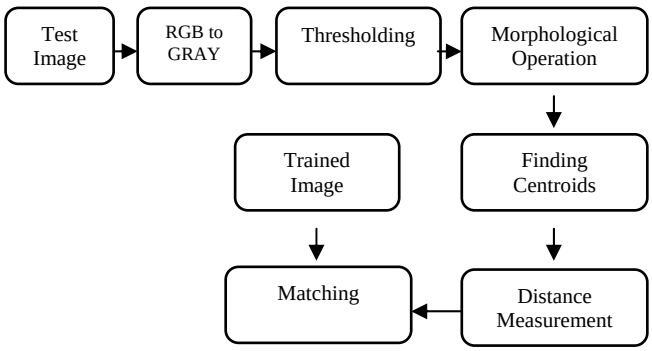

Fig. 7 Block diagram of Eye Distance Approach.

Eyes can be considered one of the main features of face and hence it helps in face recognition. For different persons, the distance between two eyes varies as the features of each and every person are different. So by evaluating the distance between two eyes of different persons, we can classify a person and determine its class. The flowchart of this method is shown in figure 7.

Consider the test image from the dataset and convert the image into gray image. Then after, apply the threshold level as shown in figure 7. Now convert the image into binary image and dilate the eye portions as shown in figure 7. Find the centroids of each eye and find the distance between these two centroids. Repeat this procedure further more times for training the images for different classes and then match the images according to the distance obtained.

D. PCA Approach

L. Sirovich [13] and M. Kirby in 1986 [14] showed that Principal Component Analysis (PCA) is a dimensional reduction system that minimizes the mean squared error between the original images and the image can be reconstructed for any given level of compression. The goal of this technique was to reduce the dimensionality of the data while retaining as much as possible of the variation present in the dataset. Kirby and Sirovich used PCA to represent faces which was then extended by Turk and Pentland to recognize faces [15].

Using this method, we find a subset of principal directions (principal components) in a set of the training faces. Then we project faces into the space of these principal components and get the feature vectors. Face recognition is performed by comparing these feature vectors using different distance measures. Using the PCA-based face recognition method, we calculate the eigenvectors and eigen values of the covariance matrix of the training data. If this matrix is large, calculation of eigenvectors becomes complicated. In order to solve this problem, we can use the decomposition of the covariance matrix incremental eigenspace learning, operations with eigenspaces [16].

V. RESULTS

Results are acquired using MATLAB 2012b release Intel(R) Core(TM) i5-2430M CPU @ 2.4GHz with 6 GB RAM on 64 bit operating system. All proposed approaches and both face database are considered for results. Ten classes are considered and 50 images of each class so total 500 from Yale database and same for the GTAV face database. Training images are 500 and training images are same. Face recognition is done using Euclidean space distance between features of test image and train image. Performance evaluation of each technique is done using Recognition rate (R). It is the ratio of number of images correctly identified to the total number of input images taken for testing.

A. Normalized Cross Correlation

Algorithm defined stepwise. Consider the images of different classes and convert them to grayscale images. Find their normalized cross-correlation and obtain the recognition rate.

B. PSR Approach

Consider the images of different classes and find their normalized cross-correlation. Find its PSR by using equation 2 as shown in figure 6. Authentication is done based on PSR value and its value should be high compare to other training images PSR i.e. fully matched image is having highest PSR compare to other. Recognition rate is obtained after this procedure.

C. Eye Distance Approach

Distance between eyes is found using approach defined in figure 7 and results are shown in figure 8. Figure 8(a) is original image and thresholding version of respective image is followed in figure 8(b). eye extraction is done using manually then morphological operation is performed (figure 8(c)) and resulted blobs detected from eyes in image are

shown in figure 8(d). Perceived distance is matched with distance stored in the database of train images of each class. Whichever distance matches correctly that image is considered as positive match.

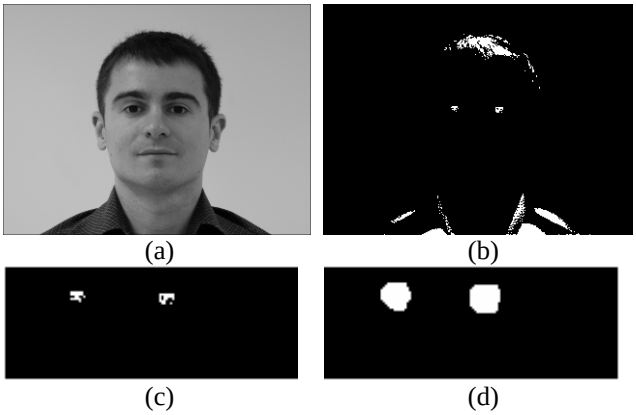

Fig.8. Results of eye distance approach

D. PCA Approach

By projecting all training images into eigenspace, weights are found for each and every train image. Matching is performed by comparing weights of test image after projecting it to eigenspace with that train image weights.

VI. Comparative Analysis

The comparative analyses of the different approaches which are used for face recognition have been shown in figure 8. From figure 9, it is clear that we get maximum accuracy using PCA algorithm. Also, Eye Distance technique gives acceptable accuracy but is not sufficient for applications which need high accuracy. The PSR and Cross Correlation approaches give adequate performance rate but not as good as PCA approach.

TABLE I
Recognition Rates of various Approaches

Approach	Recognition rate (%)
Cross Correlation	64.7
PSR	68.3
Eye Distance	72.72
PCA	75

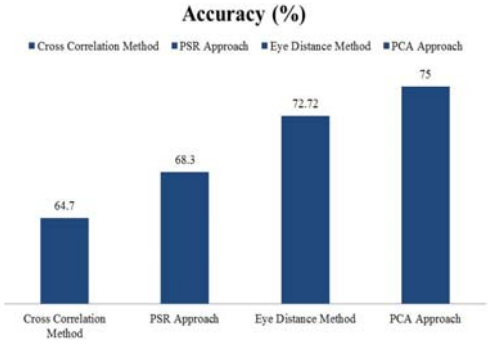

Fig. 8 Comparison of accuracy of proposed approaches.

VII. Conclusions

Face recognition is performed using various methods in this proposed approach. Two different types of database are considered for improving efficiency and checking accuracy with various face images as inputs to face recognition system. PCA approach and eye distance approach give efficient results compared to other methods. Due to change in background condition (like illumination) and variation in foreground object appearance (like pose and occlusion), PCA and eye distance approach lack in accuracy. Future enhancement in this face recognition system can propose new feature extraction techniques which are illumination as well as pose invariant.

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