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PCA Based Face Recognition and Facial Expression Identification System

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Abstract: The face is our primary focus of attention in social intercourse, playing a major role in conveying identity and emotion. We can recognize thousands of faces learned throughout our lifetime and identify familiar faces at a glance even after years of separation. This skill is quite robust, despite large changes in the visual stimulus due to viewing conditions, expression, aging, and distractions such as glasses, beards, changes in hairstyle. Though human faces are complex in shape, face recognition is not difficult for a human brain whereas for a computer this job is not easy. In this paper presents and analyzes the performance of Principle Component Analysis (PCA) based technique for face recognition. We consider recognition of human faces with two facial expressions: single and differential. The images that are captured previously constitute the training set. From these images Eigen faces are calculated. The image that is going to be recognized through our system is mapped to the same Eigen spaces. Next I used classification technique namely distance based used to classify the images as recognized or non-recognized. Presently I got result for the single facial expression now I am working for different facial expression.

Keywords: Eigen Faces, Principal Component Analysis, Face Recognition.

I. INTRODUCTION

Expression is the most important mode of non-verbal communication between people. Recently, the facial expression recognition technology attracts more and more attention with people's growing interesting in expression information. Facial expression carries crucial information about the mental, emotional and even physical states of the conversation. Facial expression recognition has practical significance; it has very broad application prospects, such as user-friendly interface between man and machine, humanistic design of goods, and emotional robot etc. With facial expression recognition systems, the computer will be able to assess the human expressions depending on their effective state in the same way that human's senses do. The intelligent computers will be able to understand, interpret and respond to human intentions, emotions and moods. The facial expression recognition system applied in different areas of life such as security and surveillance, they can predict the offender or criminal's behavior by analyzing the images of their faces that are captured by the control-camcorder.

Furthermore, the facial expression recognition system has been used in communication to make the answer machine more interactive with people. The answer machine has become more intelligent by analyzing the client's voice and dealing with the responses according to their emotions. Moreover, it is powerful in signed language recognition system that deals with the deaf and dumb people. The facial expression recognition system has a considerable impact on the game and entertainment field besides its use to increase the efficiency of robots for specific military tasks, medical robots, and manufacturing servicing. Generally, the intelligent computer with facial expression recognition system has been used to improve our daily lives. The face is our primary focus of attention in social intercourse, playing a major role in conveying identity and emotion. The human ability to recognize faces is remarkable. We can recognize thousands of faces learned throughout our lifetime and identify familiar faces at a glance even after years of separation. This skill is quite robust, despite large changes in the visual stimulus due to viewing conditions, expression, aging, and distractions such as glasses, beards or changes in hairstyle.

Though human faces are complex in shape, face recognition is not difficult for a human brain whereas for a computer this job is not easy. The complexity of recognition is prominent and several algorithms are reported in literature that could achieve the recognition with high degree of accuracy. Face recognition system is widely used in different areas that include a) criminal record and identification, b) Robot vision, c) security system, d) human computer interaction, e) image and field processing. Face recognition system is divided into two categories, i) appearance based and ii) component based. For appearance based, we consider the holistic feature or the whole face image as our feature for recognition. On the other hand, in component based face recognition, we consider geometrical relationship of different components of face such as eye, nose, lip etc as the features of a recognition system. Principal Component Analysis (PCA) is a fast and efficient technique that is widely used for appearance based face recognition. Principal Component Analysis (PCA) is a fast and efficient technique that is widely used for appearance based face recognition. This technique is also used for dimensionality reduction in different areas that include image processing, signal processing and data mining. This technique is sometimes also called eigenfaces.

The eigenfaces approach is chosen for this study considering its capability of recognizing real time images where orientation, illumination and distortion are continuously changing. This work focuses on how the images with real time attributes affect the recognition feature of eigenfaces technique. Our primary objective for this research is to minimize the complexity in calculation for bigger matrices. For example, if we have 120 pictures with the size of (180 × 200), we will have a very big number while calculating the one dimensional vector from 2D matrix (by calculating 180 × 200 × 120) which is a very big number. By using the eigenvectors, we could minimize the use of all the images and reduce them for example 40 pictures which will also bring down our total calculation to (180 ×200 × 40). Though, we are using lesser amount of data, we will still get the same level of accuracy. Besides, we could make the size even smaller by changing the order of matrix multiplication which in turn reduces the principal components, and the end we could work only on (40×120) matrix with the same level of accuracy.

II. RELATED WORK

A. Previous Approaches to Facial Expression Recognition

Bartlett explores and compares techniques for automatically recognizing facial actions in sequences of images. These techniques include analysis of facial motion through estimation of optical flow; holistic spatial analysis, such as independent component analysis, local feature analysis, and linear discriminant analysis; and methods based on the outputs of local filters, such as Gabor wavelet representations and local principal components. Lien describes a system that recognizes various action units based on dense flow, feature point tracking and edge extraction. The system includes three modules to extract feature information: dense-flow extraction using a wavelet motion model, facial feature tracking, and edge and line extraction. The system that used color information, Rajapaskse et al., (2004) proposes the use of non-negative matrix normalization (NMF) with color cannel encoding.

This process is performed by representing the (RGB) color channel as a three indexed data vector separately: red, green and blue channel for each image. Then the color using non-negative matrix (NMF), a decoding method, is applied. This technique makes better use of the color image because of the excessive iterative matrix and the decoding operation that involves inverting the matrix; the inherent processing cost was so big [4]. Author Yang, J. and Zhang; suggested a new technique two-dimensional Principal Component Analysis (2DPCA) for image representation. As opposed to Principal component analysis, two-dimensional principal component analysis is based on 2D image matrices rather than 1D vector. In two-dimensional Principal Component Analysis, Principal Component Analysis must be applied.

B. Approach Taken for Facial Expression Recognition

The work presented here provides a novel solution to the facial expression recognition problem, describing a facial recognition system that can be used in application of Human computer interface. There are three main components to this system: a Feature Extraction, Principal Component Analysis and Euclidean Distance Classifier. To classify the images final facial expression recognition system uses Euclidean Distance Classifier. The system developed is able to find and recognize the facial expressions of JAFFE database. It recognizes expression of the seven basic emotions, namely happy, disgust, neutral, anger, sad, surprise and fear.

III. PROPOSED FACIAL EXPRESSION RECOGNITION SYSTEM

A. System Architecture

This section describes facial expression recognition system architecture. Our system is composed by four modules: Preprocessing, Principal Component analysis and expression classification using Euclidian classifier. Fig.1 represents the basic blocks of facial expression recognition system

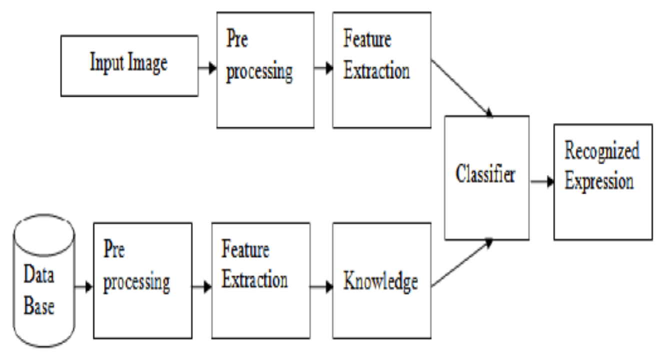


Fig.1. Facial Expression Recognition System Architecture.

B. Preprocessing

Pre-processing is the next stage after entering the data into the facial expression recognition system. The important data that is needed for most facial expression recognition methods is face position. In preprocessing module images are resized from 256 x 256 pixel value to 280 x 180 pixel values. The Sobel method has been used to identify the face edges. C. Principal Component Analysis (PCA) Principal component analysis or karhunen-loeve transformation is a standard technique used in the statistical pattern recognition and signal processing for data reduction. As the pattern often contains redundant information, mapping it to a feature vector can get rid of this redundancy and yet preserve most of the intrinsic information content of the pattern. These extracted features have great role in distinguishing input patterns. A face image in 2-dimension with size N × N can also be considered as one dimensional vector of dimension N2. Each of these vectors are of length N2, this describes N × N image and is a linear combination of the original face images. As these vectors are the eigenvectors of the covariance matrix corresponding to the original face images, and because they are face-like in appearance, they are referred as “Eigen faces”. After estimation of the covariance matrix, significant eigenvectors of the covariance matrix are computed.

The number of Eigen-vector depends on application and accuracy that the system needs and it is clear that if number of Eigen-vectors is large the accuracy of the method improved but computational complexity increased. We can retain the maximum information by retaining the coordinate axes that have largest eigenvalues and delete those that have less information. This technique involves

- Gather xi where i= 1 to p.
- Compute the mean m and subtract it to obtain xi-m.
- Compute the covariance matrix $C_{ij} = (x_i\text{-m}) (x_i\text{-m})$ T.
- Determine Eigen values and Eigenvectors of covariance matrix C such that CV=AV where A=dig (λ_1, λ_2 ...λ_p.), a diagonal matrix is defined by the eigen values of the matrix C and V = (V_1, V_2 ....V_p) be the associated eigenvectors.
- Sort the eigen values and corresponding eigenvectors such that $\lambda_1 \geq \lambda_2 \geq ,\ldots\ldots\ldots\geq \lambda_p$.
- Select the first l $\leq$ p eigenvectors and discard p-l eigenvectors to find the data in new directions.
- If the orthogonal matrix contains the eigenvectors of C, then C can be decomposed as C= VAVT where A is diagonal matrix of eigenvalues.

D. Facial Expression Classification

The proposed approach to the facial expression recognition involves following steps.

- The train images are utilized to create a low dimensional face space. This is done by performing Principal Component Analysis in the training image set and taking the principal components with greater Eigen. In this process, projected versions of all the train images are also created.
- The test images also projected on face space, all the test images are represented in terms of the selected principal components.
- In order to determine the intensity of the particular expression its Euclidean distance from the mean of the projected neutral images is calculated.
- The Euclidian distance of a projected test image from all the projected train images are calculated and the minimum value is chosen in order to find out the train image which is most similar to the test image.
- The test image is assumed to fall in the same class that the closest train image belongs to.

IV. EXPERIMENTAL RESULTS

A. Face Recognition

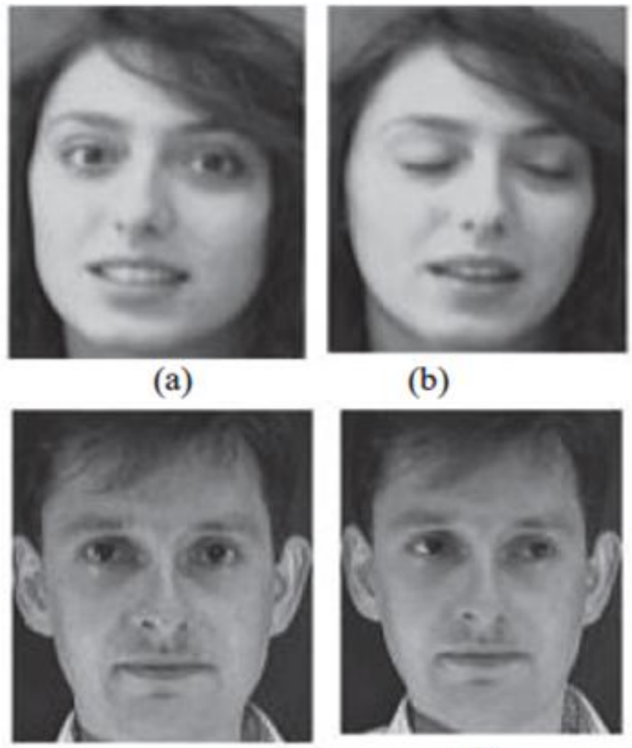
To evaluate the performance of the face recognition algorithm, as proposed in [8], we calculate a measure called recognition accuracy (RA) which can be defined as follows

$$RA = \frac{\text{No.of test images correctly recognized}}{\text{Total no.of test images}} \quad (1)$$

TableI shows the comparative results of PCA implementation on ATT and CSU databases. The system is trained by considering 3 randomly picked images for each individual and assigning them to one class. In our experiment, we have used 40 classes for ATT and 59 classes for CSU database.

TABLE I: Recognition Accuracy for ATT and CSU Databases

Database	Training samples per class	Total number of classes	PCA recognition accuracy
ATT	3	40	85.5%
CSU	3	59	81.3%



(a) (b) (c) (d)

Fig.2. Two sets of test images (b), (d) and corresponding recognition images (a), (c).

TABLE II: Facial Expression Confusion Matrix for Male Face

MALE FACE	Happy	Disgust	Sad	Surprise	Neutral
Happy	44	0	0	0	0
Disgust	0	44	0	0	0
Sad	0	0	43	1	0
Surprise	0	0	0	44	0
Neutral	0	0	3	2	39

B. Facial Expression Identification

Here, the expression such as happy, disgust, sad, surprise and neutral of a particular person are taken into consideration as shown in Fig.2. Initially these 5 prototypic expressions are trained using the train database. The system is then checked by giving the test images as input. A total of 30 images with each prototypic expression containing 6 images are used for training and 200 images are used for testing. The algorithm has been tested on various facial expressions of one male and one female subject. Table II and III show the corresponding confusion matrices.

TABLE III: Facial Expression Confusion Matrix for Female Face

FEMAL E FACE	Hap py	Disgu st	Sa d	Surp rise	Neut ral
Happy	33	0	0	0	1
Disgust	0	39	0	0	0
Sad	0	0	67	0	1
Surprise	2	0	0	18	3
Neutral	0	0	0	0	36

The Fig.3 below shows a sample of the results of facial expression identification, the test images and the corresponding recognized images for happy and surprise expressions.

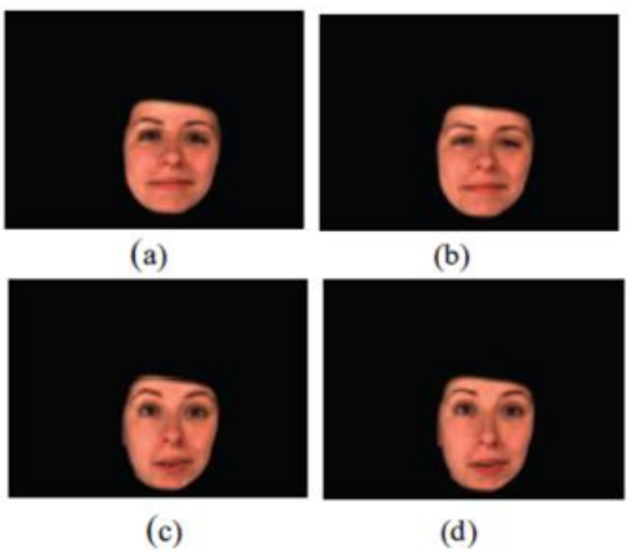


Fig.3. Test images (a) and (c) and corresponding recognized images (b) and (d).

V. CONCLUSION

We conclude with the following remarks. Training set and test images need to be taken in good, comfortable illumination settings and need to be frontal faces with minimal head tilt. Number of images in the training set is a significant factor. It impacts on defining the correct threshold value for accepting true matches and rejecting false matches. If we will take larger threshold then false recognition rate will increase. In this I showed all the result for different facial expressions.

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