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Face Recognition using PCA and Eigen Face Approach

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Abstract: Face is a complex multidimensional structure and needs a good computing techniques for recognition. Our approach treats face recognition as a two-dimensional recognition problem. In this scheme face recognition is done by Principal Component Analysis (PCA). Face images are projected onto a face space that encodes best variation among known face images. The face space is defined by Eigen face which is eigenvectors of the set of faces, which may not correspond to general facial features such as eyes, nose, and lips. The Eigen face approach uses the PCA for recognition of the images. The system performs by projecting pre extracted face image onto a set of face space that represents significant variations among known face images. Face will be categorized as known or unknown face after matching with the present database. If the user is new to the face recognition system then his/her template will be stored in the database else matched against the templates stored in the database. The variable reducing theory of PCA accounts for the smaller face space than the training set of face.

Keywords: Face Recognition, PCA, Eigen face, Eigen Vector.

I. INTRODUCTION

The Face is a complex multidimensional structure and needs good computing techniques for recognition. The face is our primary and first focus of attention in social life playing an important role in identity of individual. We can recognize a number of faces learned throughout our lifespan and identify that faces at a glance even after years. There may be variations in faces due to aging and distractions like beard, glasses or change of hairstyles. Face recognition is an integral part of biometrics. In biometrics basic traits of human is matched to the existing data and depending on result of matching identification of a human being is traced. Facial features are extracted and implemented through algorithms which are efficient and some modifications are done to improve the existing algorithm models. Computers that detect and recognize faces could be applied to a wide variety of practical applications including criminal identification, security systems, identity verification etc. Face detection and recognition is used in many places nowadays, in websites hosting images and social networking sites. Face recognition and detection can be achieved using technologies related to computer science. Features extracted from a face are processed and compared with similarly processed faces present in the database. If a face is recognized it is known or the system may show a similar face existing in database else it is unknown. In surveillance system if a unknown face appears more than one time then it is stored in database for further recognition. These steps are very useful in criminal identification. In general, face recognition techniques can be divided into two groups based on the face representation they use appearance-based, which uses holistic texture features and is applied to either whole-face or specific regions in a face image and feature-based, which uses geometric facial features (mouth, eyes, brows, cheeks etc), and geometric relationships between them.

II. PRINCIPAL COMPONENT ANALYSIS

Following Diagram shows the Face Recognition System with Principal Component Analysis.

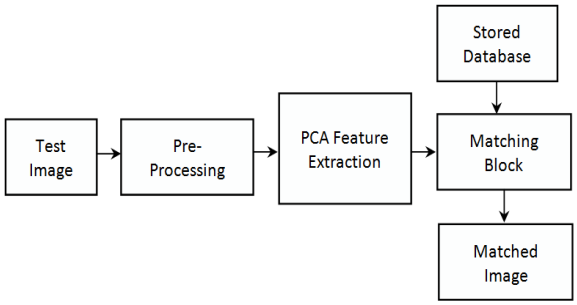

Fig.1. Block Diagram of Face Recognition with PCA

A. *Face Image Representation*

Training set of m images of size $N \times N$ are represented by vectors of sizeN_2.

Each face is represented by $\Gamma_1, \Gamma_2, \Gamma_3, \ldots\ldots, \Gamma_M$

Feature vector of a face is stored in a N × N matrix. Now, this two dimensional vector is changed to one dimensional vector.

For Example - $\begin{bmatrix}1 & 2\\ 2 & 1\end{bmatrix} = \begin{bmatrix}1\\2\\2\\1\end{bmatrix}$

Each face image is represented by the vector Γ_i

$$\Gamma_1 = \begin{bmatrix}1\\-2\\2\\-3\end{bmatrix} \Gamma_2 = \begin{bmatrix}1\\3\\-1\\2\end{bmatrix} \Gamma_3 = \begin{bmatrix}2\\1\\-2\\3\end{bmatrix} \Gamma_4 = \begin{bmatrix}1\\3\\1\\1\end{bmatrix} \ldots . \Gamma_M = \begin{bmatrix}1\\2\\2\\1\end{bmatrix}$$

B. *Mean and Mean Cantered Images*

Average Face Image is calculated by

$$\Psi = \frac{1}{M}\sum_{i=1}^{M} \Gamma_i \qquad (1)$$

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$$\begin{bmatrix}1\\-2\\2\\-3\end{bmatrix}+\begin{bmatrix}1\\3\\-1\\2\end{bmatrix}+\begin{bmatrix}2\\1\\-2\\3\end{bmatrix}+\begin{bmatrix}1\\3\\1\\1\end{bmatrix}+\cdots+\begin{bmatrix}1\\2\\2\\1\end{bmatrix}\longrightarrow\begin{bmatrix}-1\\-1\\2\\-3\end{bmatrix}$$

$$\Psi=\frac{(\Gamma_1+\Gamma_2+\Gamma_3+\cdots+\Gamma_M)}{M} \quad (2)$$

Each face differs from the average by

$$\Phi_i=\Gamma_i-\Psi \quad (3)$$

This Image is called mean cantered image.

$$\Phi_1=\begin{bmatrix}2\\-1\\-1\\0\end{bmatrix}\ \Phi_2=\begin{bmatrix}2\\4\\-3\\5\end{bmatrix}\ \Phi_3=\begin{bmatrix}3\\2\\-4\\6\end{bmatrix}\ldots.\Phi_M=\begin{bmatrix}2\\3\\0\\4\end{bmatrix}$$

C. Covariance Matrix

A covariance matrix is constructed as:

$$C=AA^T\ whr\ A=[\Phi_1,\Phi_2,,\Phi_M\ of\ size\ N^2\times N^2] \quad (4)$$

$$A=\begin{bmatrix}2&3\\-1&-2\\-1&1\\0&2\end{bmatrix}\quad A^T=\begin{bmatrix}2&-1&-1&0\\3&-2&1&2\end{bmatrix}$$

Size of covariance matrix will be N × N (4x 4 in this case). Eigen vectors corresponding to this covariance matrix is needed to be calculated, but that will be a tedious task therefore, for simplicity we calculate A^TA which would be a 2 x 2 matrix in this case.

$$A^TA=\begin{bmatrix}1&2\\2&1\end{bmatrix}$$

size of this matrix is M x M.

Consider the eigenvectors v_i of A^TA such that,

$$A^TA\,X_i=\lambda_iX_i \quad (5)$$

The eigenvectors v_i of A^TA are X1 and X2 which are 2 x1. Now multiplying the above equation with A both sides we get,

$$AA^TA\,X_i=A\lambda_iX_i \quad (6)$$

$$AA^T(A\,X_i)=\lambda_i(AX_i) \quad (7)$$

Eigen vectors corresponding to AA^T can now be easily calculated now with reduced dimensionality where $A\,X_i$ is the Eigen vector and λ_i is the Eigen value.

D. Recognition Steps

The test image, Γ is projected into the face space to obtain a vector, Ω as

$$\Omega=U^T(\Gamma-\Psi) \quad (8)$$

The distance of Ω to each face is called Euclidean distance and defined by

$$\varepsilon_k^2=\|(\Omega-\Omega_k)\|^2\quad whr\ k=1,2,\ldots..M \quad (9)$$

Where Ω_k is a vector describing the kth face class. A face is classified as belonging to class k when the minimum ε_k is below some chosen thresholdΘ_c. Otherwise the face is classified as unknown.

Θ_c is half the largest distance between any two face images:

$$\Theta_c=\frac{1}{2}\max j,k\ \|\Omega_j-\Omega_k\|; \quad (10)$$

$$whr\ j,k=1,2,\ldots..M$$

We have to find the distance ε between the original test image Γ and its reconstructed image from the Eigen faceΓ_f.

$$\varepsilon^2=\left\|(\Gamma-\Gamma^f)\right\|^2\quad whr\ \Gamma^f=U*\Omega+\Psi \quad (11)$$

If $\varepsilon\geq\Theta_c$ then input image is not even a face image and not recognized.

If $\varepsilon<\Theta_c$ and $\varepsilon_k\geq\Theta$ for all k then input image is a face image but it is recognized as unknown face.

If $\varepsilon<\Theta_c$ and $\varepsilon_k<\Theta$ for all k then input images are the individual face image associated with the class vector Ω_k.

III. RESULTS AND DISCUSSION

Now for Matching Test Image with Train Database we need to do following Steps.

1. Input Test Image for matching.

2. Train Database in Colour form is as follows.

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3. Now Next step is to convert Colour image form Colour to Grayscale.

4. Next step is to find Mean centred Image.

5. Now Next Step is to find Eigen Faces of the Train Database.

6. Chart of Euclidian Distance of each and every image of train database for Matching.

IMAGE FROM TRAIN DATABASE	EUCLIDEAN DISTANCE
IMAGE NO 1	4.5220
IMAGE NO 2	4.6526
IMAGE NO 3	5.9814
IMAGE NO 4	0.7730
IMAGE NO 5	0.7842
IMAGE NO 6	0.3650
IMAGE NO 7	1.4676
IMAGE NO 8	1.3598
IMAGE NO 9	1.1543
IMAGE NO 10	5.4000
IMAGE NO 11	5.7219
IMAGE NO 12	5.7016
IMAGE NO 13	0.5888
IMAGE NO 14	0.1047

7. On the basis of Euclidean Distance we just find which image from training data base is closest to the test image. In above table IMAGE NO 14 having low Euclidean Distance so that IMAGE NO 14 is closest to the Test Image. Following image is a match for Input Test Image.

IV. MATLAB IMPLEMENTATION

Matlab Implementation of Face Recognition with PCA is shown below.

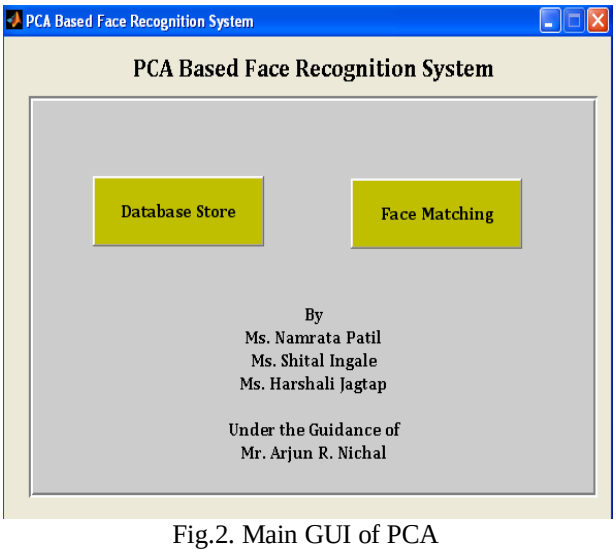

Fig.2. Main GUI of PCA

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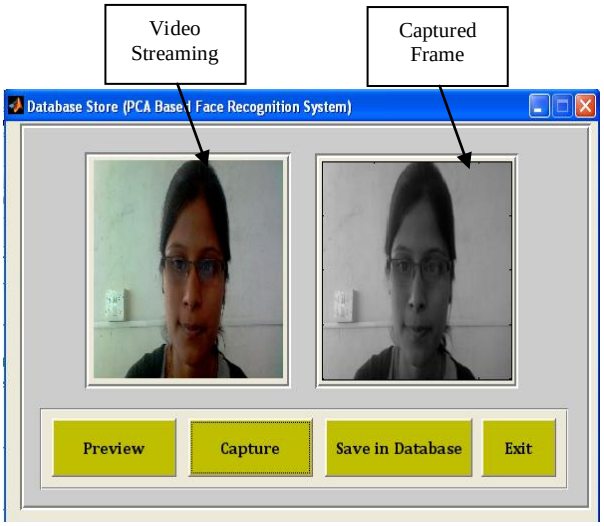

Fig.3. Database Store

This GUI is used for Storing Image of new user to the database. Webcam is used for real time streaming of Video. After clicking on Capture button Frame is captured and displayed in respective axis, then this frame is saved in folder database with the help of Save in database button.

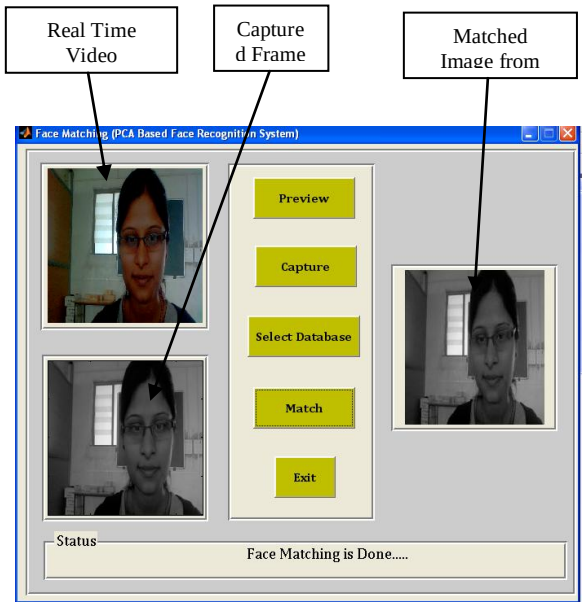

Fig.4. Face Matching GUI

V. CONCLUSION

The Face recognition is an upcoming area. There are lots of potentials scenarios where it can be used. Considering this is not completely reliable to be used as an independent technique for an authentication. Face recognition may be thrown out of the gear with plastic surgery, so it might need to be combined with other technologies such as iris scan to improve reliability. With improvement in tools and technologies, it only a matter of time before the incidence of false identification of subjects is reduced to an acceptable level to make face recognition more useful.

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BIOGRAPHIES

Prof.A.R.Nichal received his B.E. degree in Electronics and telecommunication from Shivaji University at Ashta in 2010 and received M.Tech in Electronics from Walchand College of engineering, Sangli in 2012. His area of interest is Digital Image Processing and embedded system. He published 8 International journal papers, 1 Conference paper, 1 Ebook and He has one blog on Fundamentals of Image Processing, Matlab Basics and Embedded System.

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