Face Detection using Principal Component Analysis in Real Time Database

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Abstract- Face Recognition is the process of identification of a person by their facial image. In this system, a holistic Principal Component Analysis (PCA) based method, namely Eigenface method is studied and implemented on the Faces 94 database. This approach treats face recognition as a two-dimensional recognition problem. Face images are projected onto a face space that encodes best variation among known face images. The face space is defined by eigenface which are eigenvectors of the set of faces, which may not correspond to general facial features such as eyes, nose, and lips. Face will be categorized as known or unknown face after matching with the present database. Experimental results in this thesis showed that an accuracy of 98.8158% was achieved. The variable reducing theory of PCA accounts for the smaller face space than the training set of face.

Keywords – Image processing, Database, Eigenface & Eigenvector,PCA

I. Introduction

Human faces contain a lot of important biometric information. The information can be used in a variety of civilian and law enforcement applications. For example, identity verification for physical access control in buildings or security areas is one of the most common face recognition applications. [1] At the access point, an image of a claimed person's face is captured by a camera and is compared with stored images of the claimed persons. Then it will be accepted only if it is matched. For high security areas, a combination with card terminals is possible, so that a double check is performed.

- Objectives of this system are:

1. To use Principal Component Analysis to efficiently and effectively reduce the dimensions of the extracted data from the face data set.
2. Using results obtained to recognize person.
3. Retrieves images from a camera in real-time

4. Detects the presence of a face in the image
5. Identifies the face against some enrolled images
6. Through integration with the PCs authentication system, logs on the user corresponding to the identified face

II. PROPOSED ALGORITHM

This System works on this principle. The hardware part of the system covers the whole electrical system.

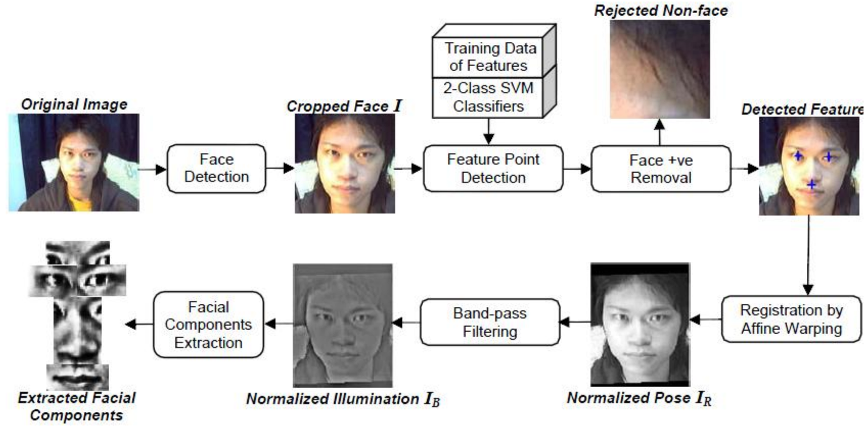


Figure 1.1 Face Detection Principles

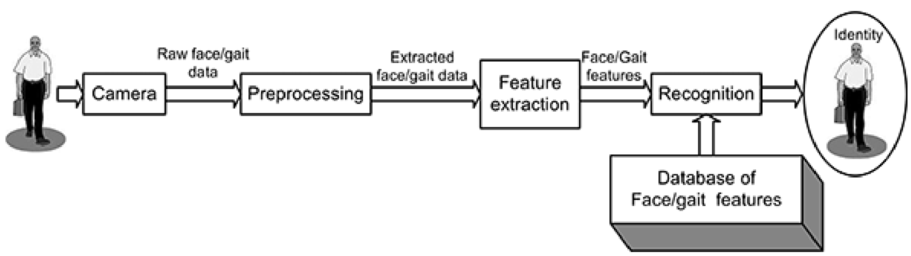


Figure 1.2:- Hardware Component working on this principle

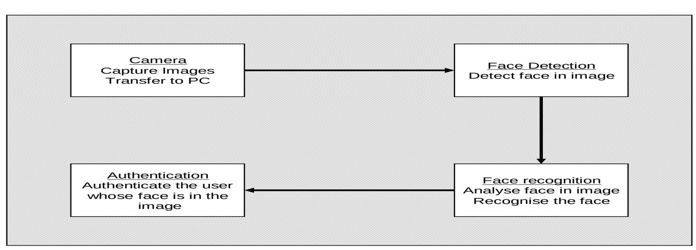
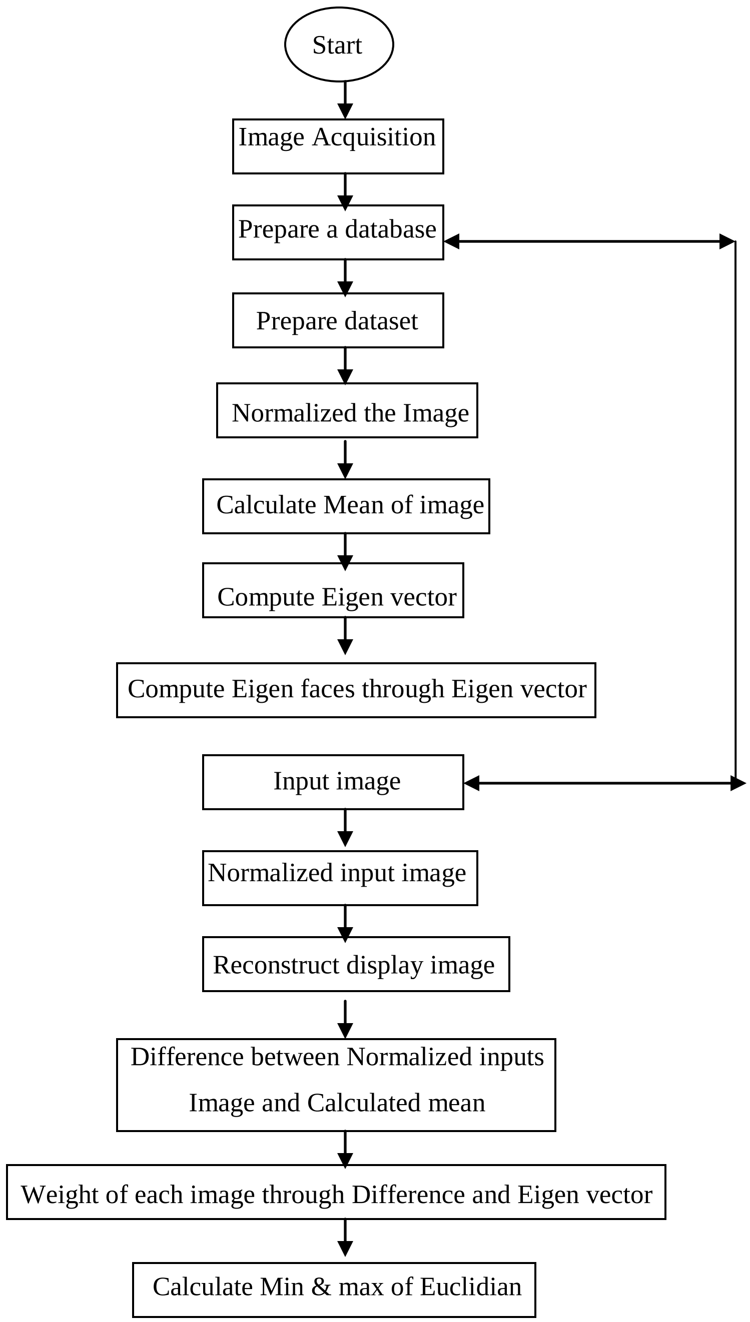


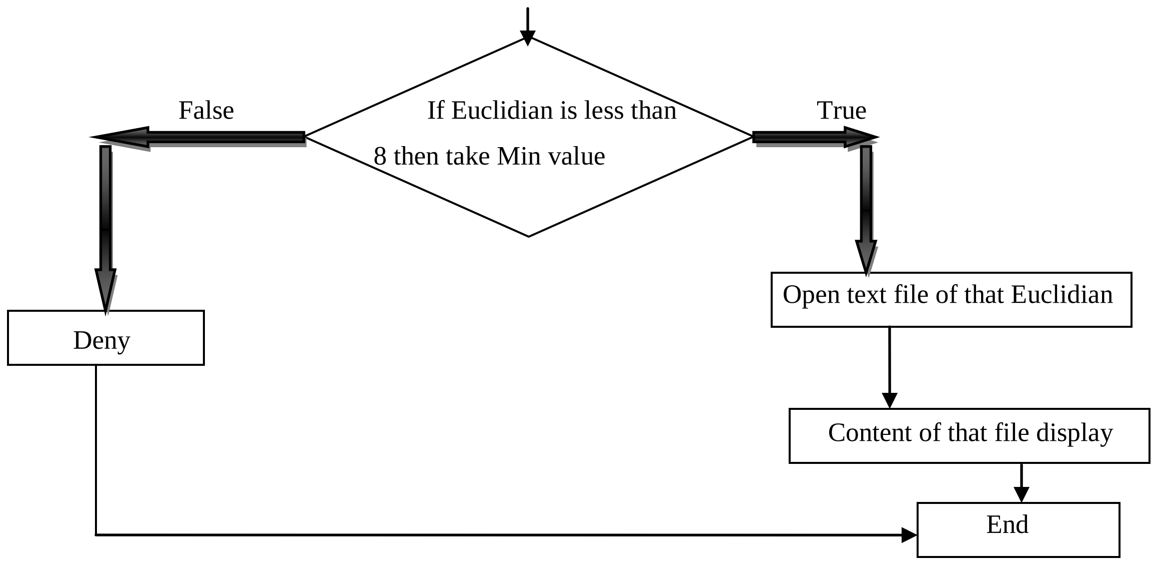
Figure: - 1.3 Overall project structure

III. PROCEDURE AND TECHNIQUES DEVELOPMENT

Procedures Adopted:-

- Flow of Work





- **Prepare a Training face database**

Database for different set of conditions is maintained. Ten different expressions for ten different people thus creating a 10x10 that is equal to 100 different set of face images. Rotated images in left and right direction and different illumination conditions are also considered while making the training set Size variations in a input face image can also change the output therefore input images by varying their size are also taken for recognition.

- **Prepare a Data set**

A test image for recognition is tested by comparing to the stored data set. A data set (or dataset) is a collection of data. Most commonly a data set corresponds to the contents of a single database table, or a single statistical data matrix, where every column of the table represents a particular variable, and each row corresponds to a given member of the data set in question. The data set lists values for each of the variables, such as height and weight of an object, for each member of the data set.

➢ Normalization of Image

Normalization is a process that changes the range of pixel intensity values. Normalization is sometimes called contrast stretching or histogram stretching.

➢ Calculate Mean of image

Compute the average face image (mean face) of the database. This is done with the code line:

m= mean (T, 2)

Where m is the average face image and T is the training set in the database. This line in the code executes the formula:

$$\mathbf{m} = \frac{1}{M_t}\sum_{i-1}^{M_t} \mathbf{temp}_i$$

Where Mt is the number of training images in the dataset and tempi is an image vector in the dataset

➢ Eigenvalue and Eigenvector

For a square matrix A, λ is an eigenvalue of A if there exists a non-zero vector x such that Ax=λx. In this case, x is called an eigenvector corresponding to λ, and the pair (λ, x) is called An eigenpair for A. Eigenvalues and eigenvectors are also known as, respectively, characteristic roots and characteristic vectors, or latent roots and latent vectors

➢ Compute Eigen faces through Eigen vector

Calculate the Eigen face by multiplying the eigenvectors whose eigenvalues have been retained by the centered images. It is done by the code line:

Eigen faces = A * L_eig;

- **Input image**

To test our system and proceed this process we take a image of person and our system use that image as input image and after doing some process system tells information about that person that this person is authenticated person or not.

- **Normalized input image**

Gray scale is parts of digital image .This type of image carry only intensity offer advice. Grayscale is a range of shades of gray without apparent color

- **Reconstruct display image**

These reconstruction techniques form the basis for common imaging modalities such as CT, MRI, and PET, and they are useful in medicine, biology, earth science, archaeology, materials science, and nondestructive testing.

- **Difference between Normalized inputs image and Calculated mean**

$$\boldsymbol{\Phi = \Gamma - \Psi}$$

is the difference of the Normalized input image from the mean image. Thus, each face differs from the average by

$\Phi = \Gamma - \Psi$ which is also called mean centered image.

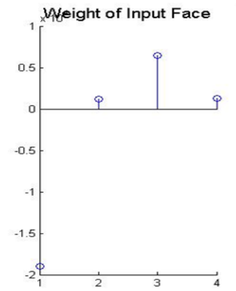
Difference matrix **A** = $[\boldsymbol{\Phi_1} \quad \boldsymbol{\Phi_2} \quad \boldsymbol{\Phi_3} \cdots\cdots\cdots \quad \boldsymbol{\Phi_{Mt}}]$

is the matrix of all the mean subtracted training image vectors and its size is (P x Mt).

- **Weight of each image through Difference and Eigen vector**

$$\boldsymbol{\Omega = [\omega,\ \omega,\ \omega,\ \omega_{M'}]^T}$$

is the representation of the normalized input image in the eigenface space. At this point, the images are just composed of weights in the eigenface space, simply like they have pixel values in the image space. The important aspect of the eigenface transform lies in this property.



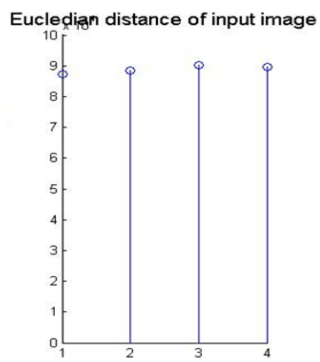
- Calculate Min & max of Euclidian

The Euclidean distance between this tested image and the projected image in the database is then calculated.

$$\varepsilon = \|\Omega - \Omega_K\|$$

Where Ω = projected test image and Ω_K = projected image.

The Euclidean distances between the tests projected image and the projected image of the training set as calculated by the system is given below:



At the last of the procedure we put a condition for the system

Condition: - Euclidian is less than 8 then take Min value

- If condition is true then Open text file of that Euclidian and display the Content of that file and send the information that this person is authenticated and open gate.

If condition is not true then send information, authentication deny and gate not open

To summarize the eigenfaces approach to face recognition involves the following steps:

•Collect a set of characteristic face images of the known individuals. This set should include a number of images of each person, with some variation in expression and in the lighting. (Say four images of ten people, so M = 40).

•Calculate the (40 x 40) matrix L, find its eigenvalues and eigenvectors, and choose the M' eigenvectors with the highest associated eigenvalues. (Let M' = 10 in example).

•Combine the normalized set of images to produce the (M' = 10) Eigen faces μk.

•For each known individual, calculate the class vector Ωk by averaging pattern vector Ω Calculated from the original (four) images of the individual. Choose a threshold θε that defines the maximum allowable distance from any face class, and a threshold θε that defines the maximum allowable distance from face space.

•For each new image to be identified, calculate its pattern vector Ω, the distance εI to each known class, and the distance ε to face space. If the minimum distance εk<θεand the distance ε <θε, classify the input face as the individual associated with class vector ωk. If the minimum distance εk = θε but distance ε <θε, then the image may be classify as "unknown", and optionally used to begin a new face class.

•If new image is classified as a known individual, this image may be added to the original set of familiar face images, and the eigenfaces may be recalculated. This gives the opportunity to modify the face space as the system encounters more instances of the known faces.

IV. RESULT

- Data Collection

Facial images were taken from Faces database. It is made up of 4 individuals who comprise 1 female and 3 male staff in separate directories. Separate directories were merged into one folder to achieve different lighting effect. The subjects were sitting at approximately the same distance from the camera and were asked to speak while a sequence of twenty images was taken. The speech was used to introduce moderate and natural facial expression variation.

Figure 6.1:- First 15 images of the First person that form the training set.

- Face Feature Extraction Algorithm

Step 1(a): Obtain the matrix representation of images.
The pixel intensity value on the grey scale runs from 0 to 255. Thus, the closer the value is to 0, the darker the image and the closer the value is to 1, the brighter the image

Step 2. Reshape image from 2D to 1D in order to create the face database with each row representing the image of a person
Step 3(a). Compute the average face image (mean face) of the database.
Step 3(b). The mean face, m, is a vector which is reshaped into 2D to be displayed as a matrix and an image

Step 3(c). Subtract the mean face vector as calculated from each image of the database created in step 2, to form the centered image

Step 4. Calculate the covariance of the resulting output in step 3

This executes the formula:

$$\mathbf{X} = \mathbf{A}.\mathbf{A}^{\mathbf{T}}$$

Step 5. All eigenvalues are sorted and those with values less than 0 are eliminated

Step 6. Calculate the eigenface by multiplying the eigenvectors whose eigenvalues have been retained by the centered images.

V. FACE RECOGNITION ALGORITHM

This algorithm shows the processes involved when a new image is to be recognized. At the recognition stage:

Step 1. The eigenfaces, the image index along with the projected image are loaded into the Computer system.

Step 2. This feature vector of the test image is then compared with the projected images of the training set in the database.

Step 3. The Euclidean distance between this tested image and the projected image in the database is then calculated. The Euclidean distances between the tests projected image and the projected image of the training set as calculated by the system is given below:

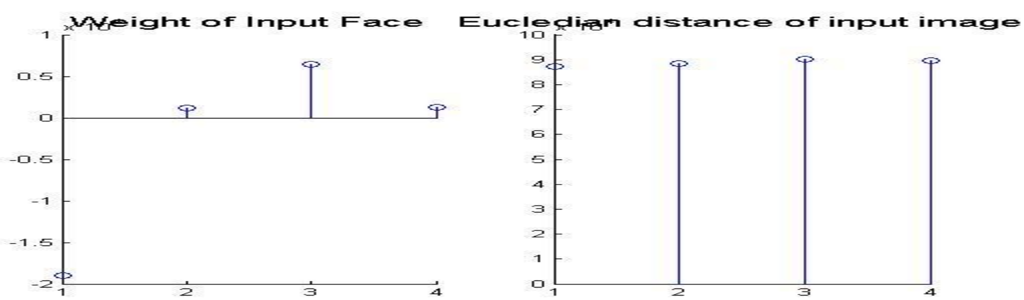


Figure 6.6 Weight if input Face And Euclidian Distance of the input image

Step: 5. the smallest Euclidean distance that corresponds to an image in the training set is assumed to be a match. It is selected along with its index. This index is then compared to the original index of the projected image in the database. In This thesis, the minimum of all the Euclidean distances was found to be 8.7299e+004.

Step 6. If the index of the test projected image and the projected image of the training set happens to be the same, then there is a valid match. Otherwise, it failed the test of success.

Fig. 6.7: A test image of Fig. 4.2 with corresponding equivalent in the training set.

This process is repeated for the rest of the images to be tested.

- **Algorithm Performance**

To calculate the accuracy rate during the testing stage, each image in the testing set is compared unto the eigenface of the training set and the index of the image with the smallest Euclidean distance is assumed to be a match, otherwise a mismatch. This process is repeated for the remaining 759 images of the test set. However, during matching with the test set, the algorithm is prone to errors which perhaps maybe due to the variation in the images. To check for this error of the algorithm, all the images found to match the training set are counted and their total match divided by the total number of images in the test set and their percentage is recorded.

$$Accuracy\ Rate = \frac{No.of\ matches\ found}{No.of\ Test\ image} * 100\%$$

In this thesis, an accuracy rate of 98.8158% was achieved with an error margin of 1.842%.

IV.CONCLUSION

Face Recognition using Principal Component Analysis was motivated by information theory. Facial images of 4 individuals were taken from Faces database which formed the data for this research. Principal component analysis, as a method was performed on the data, and a Matlab code of Matlab 2012a version was written as found in the appendix,

The code applied the method, which effectively reduced the dimension of the data (matrix) from an initial m x n as found in which is the training set in section 4.2.2, to a final (m1 x m2), which formed the feature vector for recognition. This final matrix of the projected image was used to form the feature vector for the recognition process. Based on the projected image, recognition was successful as the system achieved 98.8158% accuracy rate

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