Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2017,4 (5): 326-331

Research Article ISSN: 2394 - 658X

# Face Recognition System Using PCA, LDA & Jacobi Method

**Neel Borkar and Sonia Kuwelkar**

*Department of Electronics and Telecommunication, Goa College of Engineering, Ponda, India*
*neelborkar2@gmail.com*

---

**ABSTRACT**

*This paper presents an efficient Face Recognition System using Principle Component Analysis and Linear Discriminant Analysis to recognize person and Jacobi Method is used to find Eigen values and Eigen vectors which is very important step for PCA and LDA algorithms. The Face Recognition is the ability to recognize people by their facial characteristics. Face recognition is an interesting computer vision problem with many commercial and law enforcement applications. Mug shot matching, user verification, user access control all become possible if an efficient face recognition system can be built. This Paper concerns face recognition system consisting of image preprocessing to smoothen the image, RGB to Gray conversion, and then recognition. PCA, LDA, ICA are different algorithms that have been used for face recognition system. This paper presents a combination on PCA and LDA to perform Face Recognition to increase the identification rate using the Jacobi method to find Eigen vectors of images. The images in dataset are authorized images and the images to be recognized are unauthorized images. By calculating Euclidian Distance between known images and unknown, images are classified as authorized or unauthorized images.*

**Keywords:** Principle Component Analysis (PCA), Linear Discriminant Analysis (LDA), Eigen Values, Eigenvectors, Jacobi Method

---

## INTRODUCTION

The Face Recognition Systems has evolved greatly during the last few decades. Because of this development there is increase in algorithmic complexity which takes long computation time and energy. Face recognition have wide applications. An efficient face recognition can be of great help in identification of persons, Forensics science, authentication systems and security systems. Various Face recognition algorithms are used for face recognition systems. PCA the principle component analysis, Linear Discriminant Analysis, Independent Component Analysis are mostly used Face Recognition Algorithms [1].

PCA is also called as Eigen face recognition algorithm developed by [2] Trunk and Pentland. The accuracy of this algorithm is dependent on the face that faces are centralized and are uniform. The PCA algorithm was eventually used to reduce the dimensionality of a large dataset to reduce the mathematical complexity. The LDA [3] algorithm eventually developed for data classification is now used for Face recognition system. The LDA separate's the within class faces and those of individual faces thus increasing the recognition rate. LDA is less sensitive to lighting pose variations etc but is more mathematically more complicated than PCA.

The ICA [4] algorithm uses the higher order relationship between the pixels whereas the PCA depends upon the pair wise relation between pixels. The neural Network based Face recognition systems are biologically inspired and behave like neurons of human beings. Just like neuron a perceptron calculates the weighted sum on numerical inputs and determines if person is recognized or not recognized. The neural networks require a lot of computation.

This paper presents a combination of PCA and LDA algorithm for face recognition system. The dataset of images is filtered using Gaussian filter using mask and RGB images are converted to gray scale. The principle component analysis is performed on the dataset to reduce the dimensionality. After PCA, LDA is performed to calculate scatter matrix within class and between class. The Euclidian Distance is used to classify image as recognized or not recognized.

**PRINCIPLE COMPONENT ANALYSIS AND LINEAR DESCRIMINANT ANALYSIS**

PCA also known as Karhunen Lower Transformation is used to reduce the dimensionality. Its main aim is to reduce the data onto lower dimensional space also called as Eigen space by computing the Eigen values and Eigen vectors of dataset. The output of PCA is the input to LDA algorithm. The LDA computes the scatter matrix within class and scatter matrix between class thus separating the images within class increasing the recognition rate. After calculating the weight matrix Euclidian distance is calculated. The Jacobi Eigen value algorithm is an iterative method for computation of Eigen value and Eigenvectors of a symmetric matrix. It is named after the person who invented it Carl Gustav Jacob Jacobi. Jacobi Eigen value computation requires a lot of mathematical computation and lot of rotation of the symmetric matrix. The Tranning module consists of face Gray scale conversion module, a Gaussian filter module to filter the image, Normalisation Module, and vector conversion module. The recognition module consists of all the pre-processing steps of training module. The image to be tested in converted to gray scale, filtered, normalized and then Papered onto the Eigen space by multiplying weights. Euclidian distance is calculated between the test image and train images and image is identified as recognized or unrecognized.

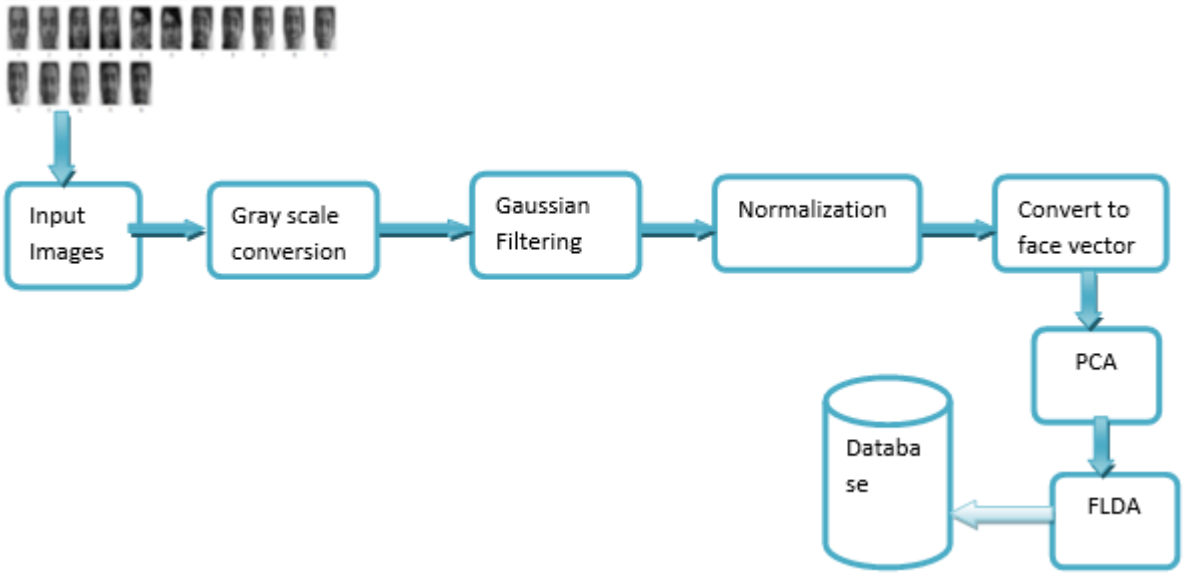


**Fig. 1 Block Diagram showing Training Phase of Face Recognition System**

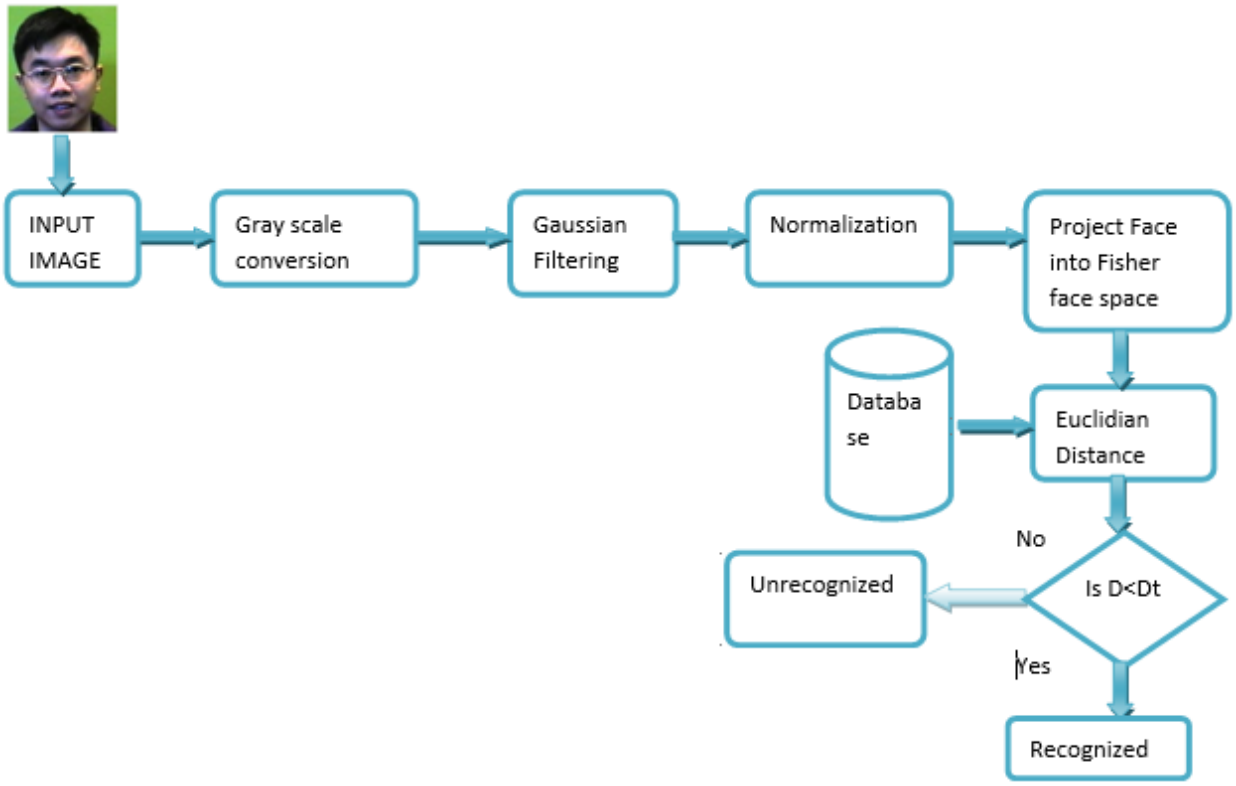


**Fig. 2 Testing phase of Face Recognition System**

## ALGORITHM

**Training Phase**

- Consider dataset of images of size n*m. The images in dataset are converted into grayscale. recognition rate of grayscale images is better than the]at of RGB images.

$$z = \begin{bmatrix} a_{11} & \dots & a_{1n} \\ : & : & : \\ a_{m1} & \dots & a_{mn} \end{bmatrix}$$

- Using the Gaussian filter, the noise on the images is reduced which increases the recognition rate. Next dataset images are converted into column matrix. All column matrix is appended into one matrix.
- The mean of calculated matrix is calculated and subtracted from each column matrix to normalize the dataset images. Thus we get Normalized images
- Formula to Calculate Mean of images is given by $\psi = \frac{1}{M}\sum_{i=1}^{M}\Gamma i$ (1)

$$A = \begin{bmatrix} a_{11} - m_1 & \dots & a_{1n} - m_1 \\ : & : & : \\ a_{m1} - m_m & \dots & a_{mn} - m_m \end{bmatrix}$$

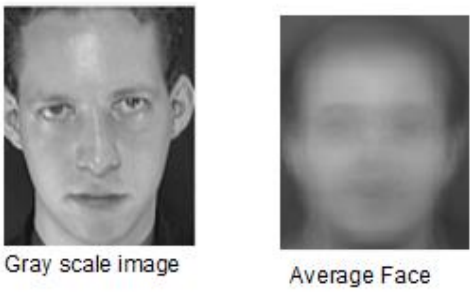


**Fig. 3 Gray scale image and mean subtracted average face**

- Next the covariance matrix is calculated of Matrix A by using the formula

$$C = A * A^T \quad (2)$$

- But this results in lot of computation as there will be many images in training set. To reduce computation, the dimensionality of matrix is reduced by using formula

$$L = A^T * A \quad (3)$$

- The next step of PCA calculates the eigenvalues and eigenvectors of Covariance Matrix L.
- To represent the images in Eigen space eigenvectors and eigenvalues of L are calculated using Jacobi Method to compute Eigen Values and Eigen Vectors of Covariance mat.
- Each image is represented as Eigen space by multiplying the eigenvectors and normalized matrix A given by formula

$$W = U^T * A \quad \text{(where U is the eigenvector of L matrix)} \quad (4)$$

- This Eigen space matrix W is the input to LDA algorithm.
- Let P be number i[of image samples {x1,x2,x3,....xp} and let each image belong to one of the classc{c1,c2,c3,....cc}. Ni be number of samples in each class.

$$\mu_i = \frac{1}{N}\sum_{i=1}^{N} x_i \quad \text{(where } \mu_i \text{ represents mean of all images in one class ci)} \quad (5)$$

- Next the Scatter matrix between class is calculated given by the formula

$$S_b = \frac{1}{N}\sum_{i=1}^{c} N_i(\mu_i - \mu)(\mu_i - \mu)^T \quad (6)$$

This scatter matrix Sb separates the images of one class to that of others.

- Next the within class scatter matrix is calculated using the formula

$$S_w = \frac{1}{N}\sum_{i=1}^{c}\sum_{x_k \varepsilon c_i} N_i(x_i - \mu_i)(x_i - \mu_i)^T \quad (7)$$

This matrix groups all the images belonging to one person together.

- Next the eigenvalues and eigenvectors of scatter matrix within class and between class is calculated by using Jacobi method which represents the face images onto the LDA Eigen space.
- After computing the eigenvector of scatter matrix the eigenvector is multiplied to the W matrix that represents the weight of PCA algorithm to compute Weight of LDA algorithm given by

$$\Omega=\text{eig\_lda}^{T}*w \quad \text{(where } \Omega \text{ is the calculated weight of LDA algorithm)} \tag{8}$$

- This completes the training phase of Face recognition system

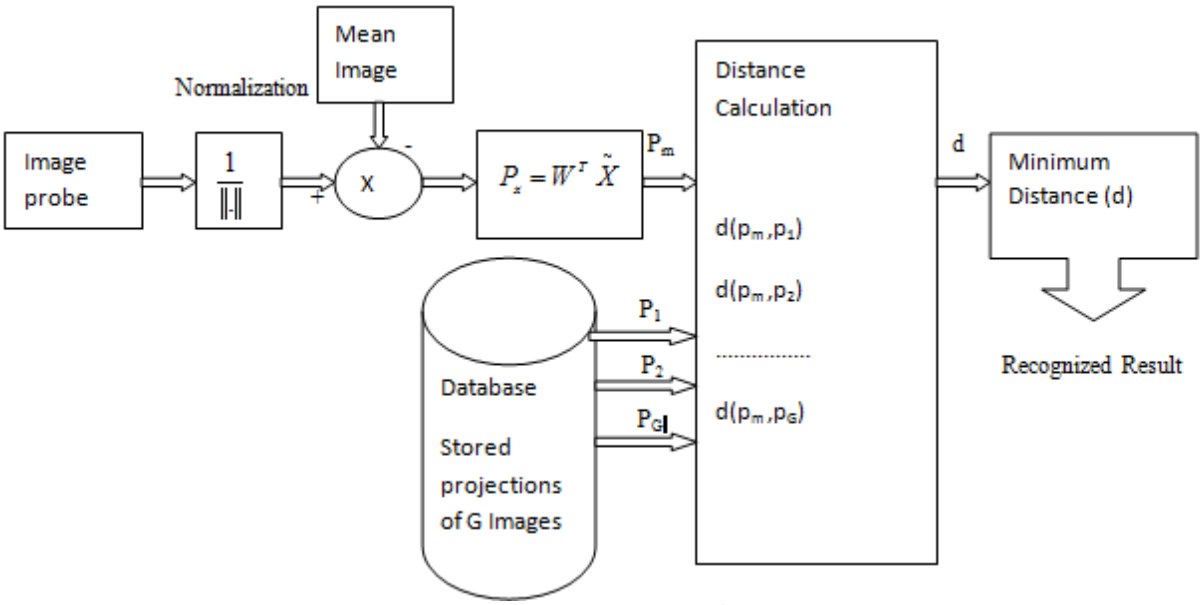


**Fig. 4 Figure showing Pictorial representation of Face recognition system**

**Recognition Phase**

In recognition phase the Image to be tested goes through all the steps of pre-processing starting from RGB to Gray conversion, Filtering, normalization to column vector conversion.

- The image matrix is converted into a column matrix

$$r = \begin{pmatrix} r_1 \\ . \\ . \\ . \\ r_m \end{pmatrix}$$

- Average face calculated in PCA algorithm is subtracted from the column matrix to normalize unknown image.

$$r = \begin{pmatrix} r_1 - m_1 \\ . \\ . \\ . \\ r_m - m_m \end{pmatrix}$$

- Next the unknown image is Papered onto fisheface space by multiplying weights of PCA and LDA.

$$\Omega=\text{eig\_lda}^{T*}*\text{eig\_pca}^{T}*r \tag{9}$$

- In the final stage of recognition, the Euclidian distance is calculated between fisher face Paperion of unknown image and that of dataset images given by formula

$$\varepsilon^2=\| \Omega-\Omega i\|^2 \text{ where i=1, 2.....n} \tag{10}$$

- The minimum Euclidian distance represents the authorized face from the dataset.

## MATLAB SIMULATION RESULTS

The Face recognition system using PCA and LDA algorithm is simulated in MATLAB. The dataset of images is AT&T dataset of images which consists of 400 face images of 40 individuals with 10 images per person each having dimensions of 112*92 pixels. Each pixel consists of an 8bit grey scale value ranging from 0 to 255. The images are taken at various different times varying in light, facial expressions etc. The images are in PNG format. Figure 5 shows some of AT & T database images.

**Fig. 5 AT&T dataset images**

### Implementation Results

As can be seen from figure 6 Query 1 is a test face image which we want to check if it is present in our database. During recognition Euclidean distance is computed between query 1 image and images present in our database. As can be seen from figure 6 Query 1 face image is not present in our database but one of its variant is present which is recognized in the above case as the Euclidean distance calculated is minimum. Figure 7 shows Query 3 image is test image. Euclidean distance is calculated between the test image and database. It can be seen that Euclidean distance is zero and the query 3 image and matched image are the same. This implies that the Query 3 image is present in our database.

Now consider Query 5 image as test image as shown in Figure 7 Euclidean distances is computed. But the computed Euclidean distance is greater than that of threshold value which implies that Query 5 image is not present in database as a result no match will be found. The table -1 shows the distance calculated between training set and test image. The above distance is for a person 1 having 10 different images. The face index represented in bold are in our dataset and rest are not in dataset but belong to same individual. The table shows that result of image is between 1 to 5 signifying all images of person one are correctly identified.

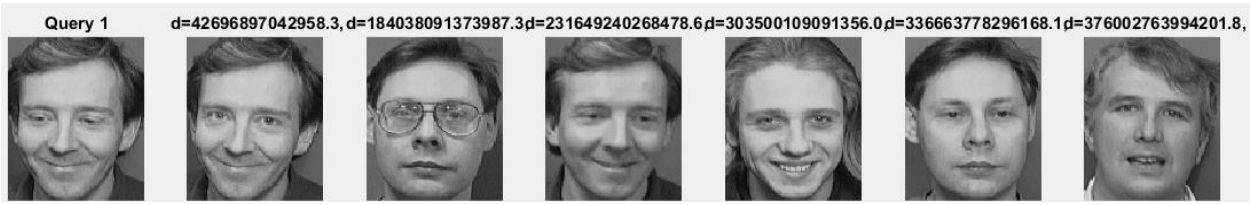


**Fig. 6 Query 1**

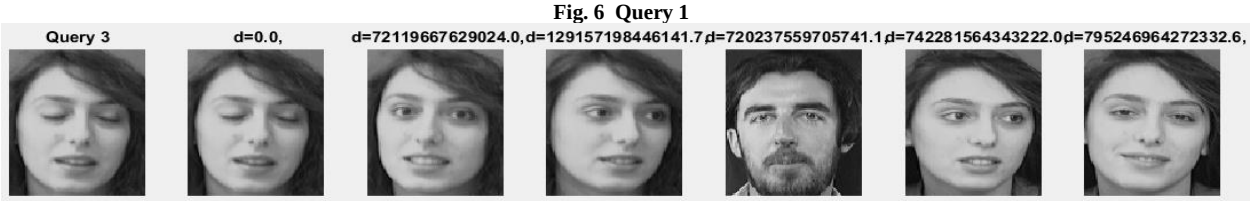


**Fig. 7 Query 3**

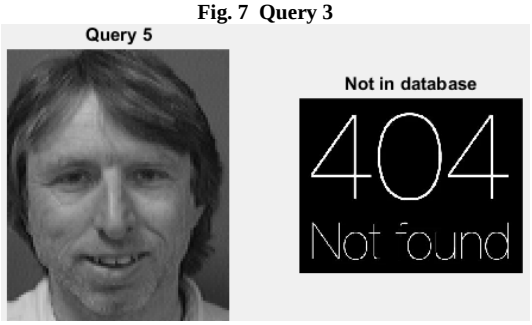


**Fig. 8 Query 5**

**Table -1 Various Euclidian Distance Calculated**

| Face Index | Person | Distance |
|---|---|---|
| **1** | 1 | 5.9708e-15 |
| 2 | 4 | 1.7475e+14 |
| **3** | 2 | 1.4456e-14 |
| 4 | 4 | 4.7453e+14 |
| 5 | 3 | 4.6641e+14 |
| **6** | 4 | 1.7584e-15 |
| 7 | 2 | 3.0021e+14 |
| **8** | 3 | 5.2133e-14 |
| 9 | 3 | 2.7327e+14 |
| **10** | 5 | 1.9362e-14 |

**Table -2 Accuracy of PCA, LDA and that of PCA+LDA**

| Images | Algorithm | Recognition(%) |
|---|---|---|
| 100 | PCA | 91 |
| 100 | LDA | 94 |
| 100 | PCA+LDA(proposed) | 98 |

Using AT&T dataset of images the accuracy of PCA and LDA algorithm is measured. The algorithm was applied to AT&T dataset of 100 training images of 20 persons taking 5 images of each person. The accuracy of FACE RECOGNITION using PCA alone was found to be 91%, the accuracy of LDA alone was found to be 94% and that of proposed method was found to be 98%.

## CONCLUSIONS

Development of new technologies has increased the computational power of computers which has made it possible to build more complex systems. Face recognition technology has evolved drastically. For many more decades to come face recognition system will be a hot topic for scientists to work on. Many techniques have already been proposed but they are face from being the best. Different environmental constraints affect any face recognition system. Uncontrolled environmental condition face recognition systems will be of great help in many applications.

In this paper, an efficient Face recognition system based on PCA and LDA is proposed. Using these two combination of methods have given me accuracy of 98 percent. This project on Face Recognition has given me an opportunity to study many face recognition algorithms that were used and being currently used. This paper has also provided me with the knowledge that combining two or more methods increases the accuracy of Face recognition system.

## REFERENCES

[1] KI Kim, K Jung and HJ Kim, Face Recognition Using Kernel Principal Component Analysis, IEEE Signal Processing Letters, **2002**, 9 (2), 40-42.
[2] MA Trunk and AP Pentland, Face Recognition using Eigen faces, *IEEE Computer Society Conference Computer Vision and Pattern*, **1991**, 3 (1), 586-591.
[3] Lu Juwei, KN Plataniotis and AN Venetsanopoulos, Face Recognition using LDA- Based Algorithm, *IEEE Transactions on Neural Networks*, **2003**, 14 (1), 195–200.
[4] MS Bartlett, JR Movellan and TJ Sejnowski, Face Recognition using Independent Component Analysis, *IEEE Transactions on Neural Network*, **2002**, 13(6), 1450-1464.
[5] GH Golub and HA van der Vorst, Eigenvalue Computation in the 20$^{th}$Century, *Journal of Computational and Applied Mathematics*, **2000**.
[6] A Vinay, Vinay S Shekhar, KN Balasubramanya Murthy and S Natarajan, Face Recognition using Gabor Wavelet Features with PCA and KPCA, *Elsevier 3$^{rd}$ International Conference on Recent Trends in Computing*, **2015**, 650.
[7] SH Yoo, SK Ho and W Pedrycz, Design of Face Recognition Algorithm Realized with Feature Extraction from LDA, *IEEE*, **2013,** 655.
[8] Sukaya Sagarika Meher and Pallavi Maben, Face Recognition and Facial Expression Identification using PCA, *IEEE International Advanced Computing Conference*, **2014,** 978.
[9] Firoz Mahmud, Mst. Taskia Khatun, Syed Tauhid Zuhori, Shyla Afroge, Mumu Aktar, Biprodip Pal, Face Recognition using Principle Component Analysis and Linear Discriminant Analysis, *International Conference on Electrical Engineering and Information Communication Technology, Bangladesh*, **2015**.
[10] Yangjie Zhang, Wei Cao and Lingli Wang, Face Recognition Algorithm Based on Local Binary Pattern on FPGA, *11$^{th}$ IEEE International Conference ASIC (ASICON),* **2015**.
**[11]** Ramu Endluri, Mohith Kathait and KC Ray, Face Recognition using PCA on FPGA based Embedded Platform, *International Conference on Control, Automation, Robotics*, Jaipur, India, **2013.**