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# Analysis of Different Face Recognition Algorithms

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***Abstract* - In this review paper, different algorithms of Face Recognition have been presented. There are different types of algorithms which can be used for Face Recognition that are PCA (Principal Component Analysis), LDA (Linear Discriminant Analysis), ICA (Independent Component Analysis), EBGM (Elastic Bunch Graph Matching), Fisherfaces.**

**We have also studied techniques which use different kind of approaches to develop Face Recognition System using PCA. Some of them use Neural Network, Eigenface and Artificial Neural Network, etc. with PCA.**

**This paper provides comparison between face recognition algorithms and the combination of PCA with different techniques and in last their merits and demerits.**

***Keywords: - Face Recognition, Principal Component Analysis (PCA), Eigenfaces, Covariance matrix ,Independent Component Analysis (ICA), Linear Discriminant Analysis (LDA), Elastic Bunch Graph Matching (EBGM), Fisherface, Euclidean distance.***

## I. INTRODUCTION

Face Recognition "is the ability to recognize people by their facial characteristics".

Face recognition is becoming popular for recognizing the face of human and it also has become a popular area for research in computer vision and it also become the most successful application for image analysis and understanding them. Face is one of the most important factors in our existence which plays chief undertakings in transporting making-out feeling and includes full of money information. Face has been seen as a very great research area in knowledge processing machine act or power of seeing, form, design being seen and plays a full of force undertaking in the application of image observations.

Generally the face recognition commonly includes feature extraction, feature reduction and recognition or classification.

The aim of this paper is to review the different face recognition algorithms and to develop the comparison between them and also to talk about combination of different algorithm with PCA and in last, which algorithm suited well for developing the face recognition.

## II. IMPORTANCE OF FACE RECOGNITION

As all know, in today's networked earth, the need to support the safety of information or physical property is becoming increasingly important and increasingly hard. From time to time we hear about the crimes like credit card frauds, networks thing being force into, or safety over rules. The persons who have done crime are taking advantage of a deep damaging mark. The systems do not grant way in by "who we are", but by "what we have", such as part of mind given to pleasure cards keys, secret words and so on, not any of these actually make statement of the sense of words rather they merely are means to make certain us. It goes without saying that if someone goes out quietly (secretly) copies or gets these making-out way, he or she will be able to way in our facts or our personal property anytime and anywhere.

## III. FACE RECOGNITION SYSTEM

Generally, the structures of face recognition system consist of three major steps, Acquisition of face data, Extracting face feature and Recognition of face.

Fig. 1 shows typical structure of face recognition system in which subject under consideration given to the system for the recognition purpose this is considered to be acquisition of face image. Next the feature is extracted from the image and finally it is given for the recognition purpose. These steps are elaborated as follow [1].

### *A. Acquisition of Face Data*

Acquisition and Processing of Face Data is first step in the face recognition system. In this step face images are collected on real-time from webcam or may be at static time i.e. from website and stored in the database. The collected face images should have the pose, illumination and expression etc. variation in order to check the performance of the face recognition system under these conditions. Processing of face database requires sometimes otherwise causes serious effect on the performance of face recognition systems due to changes in the illumination condition, background, lighting conditions, camera distance, and thus the size and orientation of the head. Therefore, input image is normalized and some image transformation methods apply on the input image [2].

### B. *Extracting Face Feature*

This process can be defined as the process of extracting relevant information from a face image. In feature extraction, a mathematical representation of original image called a biometric template or biometric reference is generated, which is stored in the database and will form the basis (vector) of any recognition task. Later these extracted features are used in recognition. After that greyscale pixel is considered as initial feature.

### C. *Recognition of Face*

In this process, once the features are extracted and selected, the next step is to classify the image. For that appearance-based face recognition algorithms use a wide variety of classification methods. Such as PCA, LDA, Fisher face etc. In classification, the faces are compared for the similarity between faces from the same individual and different individuals after all the face images in database are represented with relevant features. Sometimes feature extraction & recognition process are done simultaneously.

## IV. ADVANTAGES AND DISADVANTAGES OF FACE RECOGNITION SYSTEM

- **Advantages:-**

1. Convenient, social acceptability.
2. More user friendly.
3. Inexpensive techniques of identification.

- **Disadvantages:-**

1. Problem with false rejection when people change their hairstyle, grow or shave a beard or wear glasses.
2. Face recognition systems can't tell the difference between identical twins.

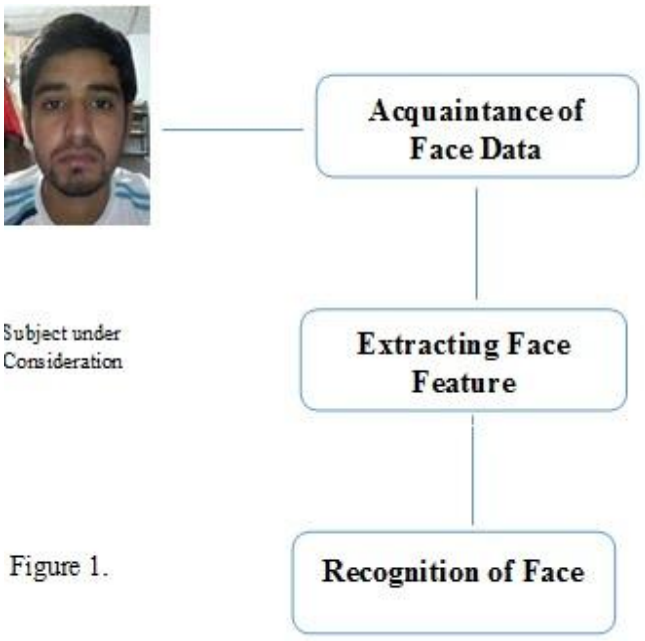


Figure 1.

## V. ALGORITHMS FOR FACE RECOGNITION SYSTEM

There are different types of algorithm that can be used for face recognition. Some of them are listed below.

1. Principal Component Analysis (PCA).
2. Independent Component Analysis (ICA).
3. Linear Discriminant Analysis (LDA).
4. Elastic Bunch Graph Matching (EBGM).
5. Fisherfaces.

*Principal Component Analysis (PCA):* - It is a statistical approach used for reducing the number of variables in face recognition. It involves the extracting the most relevant information (feature) contained in the images (face). In this process, every image in the training set can be represented as a linear combination of weighted eigenvectors called as "Eigenfaces" [6] [11] [12]. These eigenvectors are obtained from covariance matrix of a training image set called as basis function. The weights are found out after selecting a set of most relevant Eigenfaces. Recognition is performed by projecting a new image (test image) onto the subspace spanned by the eigenfaces and then classification is done by distance measure methods such as Euclidean distance.

In PCA, faces are represented as a having an effect equal to the input mix of weighted eigenvectors called as Eigenfaces. These eigenvectors are got from covariance matrix of a training image put called as base purpose, use. The number of eigenfaces that got would be equal to the number of images in the training put. Eigen faces take better chances of the similarity between the bits of picture among images in a knowledge with the help of their covariance matrix. These eigenvector formed a new face space where the images are represented.

In PCA based face recognition, increase in the number of Eigen value will increase the recognition rate. However, the recognition rate saturates after a certain amount of increase in the Eigen value. Increasing the number of images and variety of sample images in the covariance matrix increases the recognition rate however noisy image decrease the recognition accuracy. In general, the image size is not important for a PCA based face recognition system. Expression and pose have minimal effect to the recognition rate while illumination has great impact on the recognition accuracy

*Independent Component Analysis (ICA):-* It minimizes both second-order and higher-order dependencies in the input data and attempts to find the basis along which the data (when projected onto them) are -statistically independent. Bartlett et al. provided two architectures of ICA for face recognition task: Architecture 1 statistically independent basis images, and Architecture 2 factorial code representation [5].

It searches for a linear transformation to express a set of random variables as linear combination of statistically independent source variables. The search criterion involves the minimization of the mutual information expressed as a function of high order cumulants. This algorithm somewhat difficult for the real time application [10].

It accounts for higher order statistics and it identifies the independent source components from their linear mixtures (the

observables). ICA thus provides a more powerful data representation than PCA [9] as its goal is that of providing an independent rather than uncorrelated image decomposition and representation. ICA of a random vector searches for a linear transformation which minimizes the statistical dependence between its components [8].

*Linear Discriminant Analysis (LDA):* - Linear Discriminant Analysis (LDA) finds the vectors in the underlying space that best discriminate among classes. For all samples of all classes the between-class scatter matrix *SB* and the within-class scatter matrix *SW* are defined. The goal is to maximize *SB* while minimizing *SW*, in other words, maximize the ratio det|*SB*|/det|*SW*|. This ratio is maximized when the column vectors of the projection matrix are the eigenvectors of (*SW*^*-1* × *SB*) [5].
Linear Discriminant analysis explicitly attempts to model the difference between the classes of data. LDA is a powerful face recognition technique that overcomes the limitation of Principal component analysis technique by applying the linear discriminant criterion. This criterion tries to maximize the ratio of the determinant of the between-class scatter matrix of the projected samples to the determinant of the within class scatter matrix of the projected samples. Linear discriminant group images of the same class and separates images of different classes of the images.
The major drawback of applying LDA is that it may encounter the small sample size problem. When the small sample size problem occurs, the within-class scatter matrix becomes singular. Since the within-class scatter of all the samples is zero in the null space of Sw, the projection vector that can satisfy the objective of an LDA process is the one that can maximize the between-class scatter [7].

*Elastic Bunch Graph Matching (EBGM):-* All human faces share a similar topological structure. Faces are represented as graphs, with nodes positioned at fiducial points. (Exes, nose...) and edges labelled with 2-D distance vectors. Each node contains a set of 40 complex Gabor wavelet coefficients at different scales and orientations (phase, amplitude). They are called "jets". Recognition is based on labelled graphs. A labelled graph is a set of nodes connected by edges, nodes are labelled with jets, and edges are labelled with distances.
Three major extensions to this system in order to handle larger galleries and larger variations in pose, and to increase the matching accuracy, which provides the potential for further techniques to improve recognition rate.
Firstly, the phase of the complex Gabor wavelet coefficients to achieve a more accurate location of the nodes and to disambiguate patterns which would be similar in their coefficient magnitudes.
Secondly, employ object adapted graphs, so that nodes refer to specific facial landmarks, called fiducial points. The correct correspondences between two faces can then be found across large viewpoint changes.
Thirdly, introduced a new data structure, called the bunch graph, which serves as a generalized representation of faces by combining jets of a small set of individual faces.
This allows the system to find the fiducial points in one matching process, which eliminates the need for matching each model graph individually. This reduces computational effort significantly [4].

The Elastic Bunch Graph Matching treats one vector per feature of the face. Feature for the face are the eyes, nose, mouth etc. This has the advantage that changes in one feature (eyes open, closed) does not necessarily mean that the person is not recognized any more. In addition this algorithm makes it possible to recognise faces up to a rotation of 22 degrees. Drawbacks of this algorithm are that it is very sensitive to lightening conditions and that a lot of graphs have to be placed manually on the face but with the make of Gabor features, being the output of band pass filters, and these are closely related to derivatives and are therefore less sensitive to lightning changes.

*Fisherfaces:* - The fisherface method of face recognition as described by Belhumeur et al uses both principal component analysis and linear discriminant analysis to produce a subspace projection matrix, similar to that used in the eigenface method. However, the fisherface method is able to take advantage of ëwithin-classí information, minimising variation within each class, yet still maximising class separation.
Fisherface is similar to Eigenface but with improvement in better classification of different classes image. With FLD, we could classify the training set to deal with different people and different facial expression. We could have better accuracy in facial expression than Eigen face approach. Besides, Fisherface removes the first three principal components which is responsible for light intensity changes, it is more invariant to light intensity.
Fisherface is more complex than Eigenface in finding the projection of face space. Calculation of ratio of between-class scatter to within-class scatter requires a lot of processing time. Besides, due to the need of better classification, the dimension of projection in face space is not as compact as Eigenface, results in larger storage of the face and more processing time in recognition.
• Fisher linear discriminating (FLD, Fisherface) approach maps the feature to subspaces that most separate the two classes [3].

## VI COMPARISON: -

After discussing the above different algorithm for face recognition, we would like to make a comparison. The proposed incremental PCA-LDA algorithm is very efficient in memory usage and it is very efficient in the calculation of first basis vectors. This algorithm gives an acceptable face recognition success rate in comparison with very famous face recognition algorithms such as PCA and LDA. Two appearance–based techniques such as Modified PCA (MPCA) and Locality Preserving Projections (LPP**)** are combined in to give a high face recognition rate. PCA is used as a feature extraction technique. These feature vectors are compared using Mahalanobis distances for decision making. Tensor based Multilinear PCA approach is proposed in which extracts feature directly from the tensor representation rather than the vector representation. This method shows a better performance in comparison with the well-known methods in distance varying environments [13].

The comparison of PCA and ICA on FERET database with different classifiers were discussed and found that the ICA had better recognition rate as compared with PCA with statistically independent basis images and also with statistically independent coefficients. Face recognition using ICA with large rotation

angles with poses and variations in illumination conditions was proposed in. A novel subspace method called sequential row column independent component analysis for face recognition is proposed [14]. RC_ICA reduces face recognition error and dimensionality of recognition subspace becomes smaller. ICA provided a more powerful data representation than PCA as its goal was that of providing an independent rather than uncorrelated image decomposition and representation.

A fast incremental principal non Gaussian directions analysis algorithm called IPCA_ICA was proposed in. This algorithm computes the principal components of a sequence of image vectors incrementally without estimating the covariance matrix and at the same time transform these principal components to the independent directions that maximize the non-Guassianity of the source. IPCA_ICA is very efficient in the calculation of the first basis vectors. PCA_ICA achieves higher average success rate than Eigenface, the Fisherface and FastICA methods [15].

Fisherface is global approach of face recognition which takes entire image as a 2-D array of pixels. Fisherface is a modified version of eigenface. It make use of linear projection of the images into face space, which take the common features of face and find a suitable orthogonal basis for the projection. Fisherface use FLD, FLD works better for classification of different classes where PCA works better with dimension reduction features from the face.

The PCA technique is sensitive to changes that significantly affect the image such as lightning, occlusion, etc. Elastic Bunch Graph Matching make use of Gabor features, being the output of band pass filters, and this are closely related to derivatives and are therefore less sensitive to lightning changes. Also, this approaches uses features only at a key node of the image rather than the whole image, this can reduce the noise taken from the background of the face images. Together with other important advantages of it is that it is relatively insensitive to variation in face position, facial expression.

TABLE 1. COMPARISON

| Technique | Memory usage | Recognition Rate | Data Representation |
|---|---|---|---|
| LDA | Low or Efficient | Better Than PCA. | Strong Data Representation. |
| ICA | Moderate | Better Than PCA. | Powerful than PCA. |
| PCA | High | Better Than Eigen and Fisherface. | Powerful Data Representation. |
| PCA_LDA | Most Efficient | Highest Recognition Rate. | Efficient Data Representation. |
| PCA_ANN | Efficient | Better Than Individual PCA Techniques. | Better than PCA. |



TABLE 2. MERITS & DEMERITS

| Technique | Merits | Demerits |
|---|---|---|
| PCA | • Reduces dimensionality of Image.<br>• Simple, Fast & Robust.<br>• Image without disturbance are recognized fast.<br>• Raw intensity data are used for learning and recognition. | • Poor discriminating power.<br>• Insensitive to variation in face position, facial expression.<br>• It is sensitive to scale, therefore, a low-level preprocessing is still necessary for scale normalization.<br>• Due to “appearance based” first learning is very time-consuming. |
| LDA | • Face recognize of image without disturbance.<br>• Overcome the limitation of PCA. | • Encounters small sample problem.<br>• Fails when scatter matrices are singular called as singularity problem. |
| EBGM | • Recognize Face with feature change (like nose, ear). | • Sensitive to lightning condition.<br>• High Memory Usage. |
| Eigenface | • Fast and Easy to implement.<br>• Basic Step of Face Recognition. | • Sensitive to lightning and position of Head. |
| ICA | • Powerful Data Representation.<br>• Better Recognition rate compared to PCA. | • It is iterative and coverage difficult.<br>• It does not offer ordering of source vector. |
| PCA_ANN | • Accurate & provide better success rate for noisy face.<br>• Good recognition rate.<br>• Improves rejection rate for non-human & unknown face images. | • Sensitive to lightening condition.<br>• Accuracy is slightly poor compared to others. |
| PCA_LDA | • Efficient in memory usage.<br>• High recognition success rate.<br>• Low computational complexity.<br>• Time efficient. | • Difficult to compute covariance matrix<br>• Difficult to handle class scatter matrix inverse. |
| PCA_ICA | • Efficient in calculation of first basis vector.<br>• It fast as compared to other techniques | • Accuracy is slightly poor compared to others.<br>• Sensitive to lightning condition. |

## VII CONCLUSION:-

The paper has presented different algorithms which can be used to develop a face recognition system. Finally, we have made a comparison of these algorithms and discussed the merits and demerits.

In this review paper we have compared individual algorithms and algorithms that are used in combination of PCA.

On the basis of analysis there is no specific algorithm which suited well for good recognition rate but according to user requirement of specification different algorithms can be combined for good recognition and results. The technique which suits well for face recognition is incremental PCA with LDA.

This method can process face images (including training and identifying) in high speed and obtain good results. The incremental PCA –LDA is very efficient in memory usage and it is very efficient in calculation of the first basis vectors. This algorithm gives an acceptable face recognition success rate.

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