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# Biometric Face Recognition using Principal Component Analysis

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**Abstract -** *Biometric Face Recognition, a technology being used worldwide is of immense importance as it helps in ensuring public safety, preventing crimes and also improves customer experience in several fields. It is a software application which is capable of identification or distinct verification of an individual by analyzing and then comparing the pattern projected by the person's facial contours. This paper discusses the construction of a face recognition system using Principal component analysis (PCA) which is a statistical approach used to reduce the number of variables and complications which could occur during the process of face recognition while extracting the foremost relevant information from the image of the face being recognized. A training database of around 200-300 images belonging to different individuals is being used from an open source named face94 for carrying out the face recognition by comparing these images to the face to be recognized. This recognition is done by projecting a new test image onto the subspace which is then classified by measuring the minimum Manhattan distance.*

***Key Words***: Biometric Face Recognition, Principal component analysis, Content Based Image Retrieval, Image Processing, Manhattan distance, Machine Learning

## 1. INTRODUCTION

Biometric face recognition systems are a part of the facial imaging process and over the previous couple of years face recognition has become a well-liked research area in computer vision, pattern recognition, and plays a serious role in image data analysis and understanding. It's the overall opinion that advances within computer vision research will provide useful insights as to how the human brain functions. Face recognition is one among the few biometric methods that is both highly accurate and has very less intrusiveness. The main ideology behind this technique is to present the system with the details of a specific face and to differentiate it from the massive number of stored faces with some real time variations also.

Face recognition includes three main processes: -

1. Feature extraction - extracting the foremost prominent features present within the image that creates it easily distinguishable from the opposite images.
2. Face reduction - A process that reduces the massive size images into small easily presentable images of proper size, also ensuring to not damage knowledge present within the image.
3. Feature recognition - A process of selecting a correct classifier, in our case the Manhattan distance classifier to classify the feature of images present within the trained database and therefore the given test image.

Since the given face data is usually of a really high dimension, proper care must be taken to decide on the effectively distinguishable features for extraction and reduction. Hence Principal component analysis, being simple, fast and having capacity to learn quickly is the best fit method for feature extraction and reduction without damaging the data. Facial extraction in face recognition requires large computational cost because of complex calculation. Face features reduce memory in symbolic feature computation time, for example colour and intensity in numerical terms. Features in the image are usually not directly related with the part of the image. The feature is an extraction algorithm on face images. Feature extraction provides a set of features in the classification process, reduces input data, minimizes redundancy, and produces dimensional representations.

A set of eigenfaces is derived from most of the eigenvectors because there is a decomposition process in the covariance matrix of face images that are converted to vectors. A collection of eigenfaces form a face representation space on a smaller dimension than a face image. Normalized interfacial relationships can be represented by covariance matrices. Covariance of the matrix can produce an eigenvector by decomposing its eigenvector. The principal component analysis (PCA) is used to simplify data with linear transformations and then forming new coordinates with maximum variation. PCA consists of a collection of eigen-vectors. It calculates the covariance matrix from several parts in a set of training face images.

## 2. RELATED WORKS

Biometric face recognition is considered to be one of the most effective ways to ensure security and authentication of the user. This is mainly because unlike the other methods used (such as email verification, passwords and fingerprint identification in some cases), face recognition uses unique dynamic and mathematical patterns. The motivation behind this project is the increasing importance and developments in the field of biometric face recognition in today's World. Face

detection in general is an important process as it can help capture and analyse human faces in pictures or videos which prove to be of great importance for preventing major crimes and robberies. Content based image retrieval can help in extracting the prominent features from the various stored images and comparing it to the image containing the face of the person to be recognized. This is being done with the help of a statistical approach named Principal Component Analysis and Manhattan Distance.

[1] This paper is about the comparison of performance of face recognition using Normalized Principal Component Analysis (N-PCA) and Principal Component Analysis (PCA). The Eigenfaces method is one of the most widely used linear statistical techniques. It can be described as classifying a known or unknown face after matching it with stored known individuals as a database. NPCA is basically an extension over linear PCA. It includes normalization of images to remove the lightning variations and background effects. Also, singular value decomposition (SVD) is used in place of eigenvalue decomposition (EVD).

The steps performed in this paper are -

1. Collection of Images to make the Database.
2. Checking if the image is grey or coloured and calculating its mean and Standard Deviation.
3. Normalization of images.
4. Calculating Train Centred Images: Subtracting the mean from column vector matrix of training images in order to obtain the centred images.
5. Calculating Eigenvectors and values, creating Eigen faces, calculating Train Weights and storing them in Sink for further comparison.
6. Applying Euclidean distance classifier and Face is recognised.

The experimental results obtained in this paper showed that N-PCA gives a better recognition rate as compared to PCA. It has been calculated for Indian face database for 80:20 Ratio of Train to Test images. Accuracy for PCA is 92.50% , whereas for N-PCA it is 93.75%.

[2] This paper presents a proposal of a new hybrid method for the recognition of faces by combining the neural networks with the principal component analysis. Using the geometrical approach, a preliminary classification of the faces is carried out by PCA before using a neuronal technique called PMC. The results were then compared with those of the PCA and PMC technique. Steps followed are -

1. Collection of images for the database.
2. A short outline on the extraction of the primitives of each face which is based on the geometrical aspect.
3. The extraction of faces comprising nose, eyes and mouth. By making a simple sweeping of the matrix image to research the position of the pixels having a maximum of energy to locate the eyes.
4. To locate the nose and the mouth, use space-time information in order to characterize the points having recorded the strongest variation of intensity during the sequence.
5. In PCA, calculate the correlation coefficient eigenvalues, and eigenvectors and arrange them in descending order. 200 images with 8 dimensions were used where each dimension represents a distance marking one of the features of the face.
6. For improving the rate of recognition and rate of rejection, the hybridization of PCA and NN was recalled. Instead of providing the 8 neurons distance, the 8 parameters of PCA are provided.
7. Comparison of PCA and NN methods as well as their hybridization.

The experimental result concluded that the hybrid method is much better than those obtained by using one of two methods PCA or NN individually. Thus, in the hybrid method, the rate of recognition and rate of rejection for the projection base is 99% and 1%, and for the test base 94.5% and 5.5% respectively.

[3] In this paper, recognition is done by comparing the characteristics of the new face to be recognised to that of the known individuals in the database. This model is used for the recognition of either frontal or nearly frontal faces. In the face localization part, the eyeballs and mouth endpoint will be obtained. While extracting features, the distance between eyeballs and mouth endpoint will be calculated. Totally six values are given to the Neural Network recognizer. The final recognition is then performed by using Neural Networks, namely Back Propagation Networks and Radial Basis Function networks.

The training using back propagation algorithm takes place in basically three steps-

1. Feed forward of input training patterns.
2. Back propagation of errors.
3. Updation of weights and biases.

The performance of face recognition by the proposed method is then tabulated based on the experiments performed on a number of images.

[4] This paper implemented a facial recognition system with PCA and eigenface approach. A principal component analysis on facial recognition problems is studied and facial recognition based eigenface technique was proposed. The test is performed on PNG image and JPEG images, which gave a good facial classification even though it possessed constraints on varying image sizes. The eigenface approach provided a highly practical solution to facial recognition problems.

Steps involved in Eigen Face method:

1. Subtract Test Image with Train Image
2. Calculate Covariance value

3. Calculate Eigenvalue and Eigenvector
4. Do the Projection

Steps involved in PCA:

1. Subtract Test Image with Train Image
2. Calculate covariant value
3. Calculate Eigenvalue and Eigenvector
4. Calculate the covariance matrix
5. Calculate feature vector of the test image
6. Compute the Euclidean distance
7. Find the face class with minimum Euclidean distance

[5] This paper deals with the history of PCA and the ideas of PCA. It also discusses the technique of PCA with examples. Principal Component Analysis is a powerful statistical technique. PCA is used to find optimal ways combining variables into a small number of subsets. Principal Component Analysis is useful as data reduction but not for understanding the structure of the data.

The technique of PCA discussed in this paper has a 2-D facial image that can be represented as a 1-D vector by concatenating each row (or column) into a long thin vector.

Steps followed here:

1. Get data
2. Subtract the mean
3. Calculate covariance matrix
4. Calculate the eigenvectors and eigenvalues of the covariance matrix
5. Choosing components and forming a feature vector
6. Deriving the new data set

## 3. METHODOLOGY

Algorithm –

1. Preparation of database for training and testing.

   1.1. We have taken images from the face94 dataset. From this dataset, we manually segregated the images into a training dataset and a testing dataset. 20 random people were chosen from this dataset and 10 images each of these individuals were used for training purpose and testing purpose. So, the training dataset and the testing dataset both have 200 images.

2. Images are resized to a 1-D vector.
3. Training

   3.1. Selecting the value of L (most significant eigenvalues).

   3.2. Projecting all images to PCA space.

   3.3. Calculate the average face vector and subtract it from the original face images.

   3.4. Calculate the covariance matrix, using which its eigenvalues and eigenvectors are calculated.

   3.5. Keep only L eigenvectors of the L largest eigenvalues.

   3.6. Transformed dataset is obtained which is much smaller than the original image dataset.

4. Testing

   4.1. Query image is selected.

   4.2. It's projected to the PCA space and then compared with each image in the transformed dataset.

   4.3. After performing the similarity check, the image index of the image having the least distance is extracted from the image dataset and the image is shown as the output image. The distance formula used is L1 (Manhattan) distance.

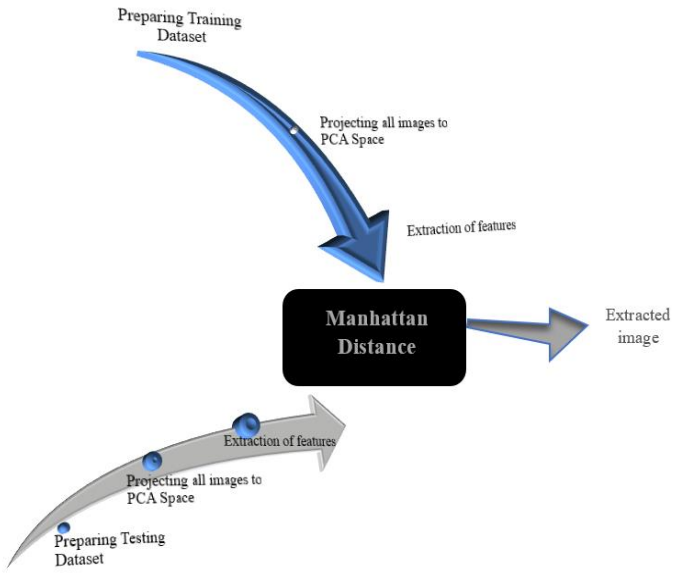


**Fig -1**: Architecture diagram

## 4. CONCLUSIONS

In this paper, we have successfully developed a system for biometric face recognition using Principal Component Analysis which is a very powerful technique statistically. PCA is very useful for data reduction by combining the variables into a small number of subsets. On testing the system, it was found that the extracted image matched with the face of the person in the query image. It can be concluded that on increasing the number of eigenvalues, the rate of face recognition also increases. On introducing partially distorted images for testing, the results obtained were also satisfactory. Thus, as this system is easy to implement, is computationally less expensive and has a great accuracy, it can be used for the purpose of biometric facial recognition.

For future work, we could work on a system for recognizing faces extracted from video inputs rather than still images as used in this project.

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