

Face Recognition Using PCA (Principal Component Analysis) and LDA (Linear Discriminant Analysis) Techniques

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Abstract: image processing field is becoming more popular for the security purpose in now days. It has many sub fields and face recognition is one from them. Many techniques have been developed for the face recognition but in our work we just discussed two prevalent techniques PCA (Principal component analysis) and LDA (Linear Discriminant Analysis) and others in brief. These techniques mostly used in face recognition. PCA based on the eigenfaces or we can say reduce dimension by using covariance matrix and LDA based on linear Discriminant or scatter matrix. In our work we also compared the PCA and LDA.

Keywords: Face recognition, PCA, LDA, eigenvectors, eigenface.

I. INTRODUCTION

Image processing is method to convert an image into digital form and perform some operations on it. The purpose of these operations is to get the enhanced or best quality of the image or to extract some useful feature or information from it. In which input is image, any video frame or photograph and output may be image or some features related to image. Image processing is a method to convert 3D images into 2D images. We can also say that it is an improvement of pictorial information for human interpretation and processing of image data for storage, transmission and representation for autonomous machine perception.

Here we have a question in mind that what is a digital image because we use this term when we discuss about image processing. A digital image is a representation of a two-dimensional image as a finite set of digital values called picture element or pixels. Pixels values typically represent gray levels, colors, heights, opacities etc. Here we are going to discuss some face recognition techniques

For image processing, there are very popular field in these days are face recognition

Face recognition is the process of identifying one or more people in image or videos. Many techniques and algorithm for face recognition typically extract features and compare them to a database or knowledge base to find the best match.

It is important part of many biometric, security, and surveillance system, as well as image and video indexing systems. Face is the index of mind. It is a complex multidimensional structure and requires an intelligent computing technique for recognition. While using automatic system for face recognition, computers are easily confused by changes in illumination, variation in poses and change in angles of faces. Various techniques are being used for security, law enforcement and authentication purposes which includes areas in detective agencies and military purpose.[1]

We can recognize faces with computer vision using variety of models including.

- a) Extract feature and boosted learning algorithm.
- b) Principal component analysis model such as eigenfaces.
- c) Neural network models such as dynamic link matching.
- d) Template matching.

II. PCA (PRINCIPAL COMPONENT ANALYSIS)

PCA is a dimensionality reduction technique which is used for compression and recognition problems. It is also known as Eigenspace Projection or Karhunen-Loeve Transformation. The main goal of PCA is the dimensionality reduction, therefore the eigenvectors of the covariance matrix should be found in order to recognize the faces. [8] [9]

Some steps to find the principal component are as follows:

- 1) Create a training set and load it. Training set consist of total M images and each image is of N*N.
- 2) Convert the face images in the training set to face vector .we denoted it by X_i
- 3) Normalize the face vector:
 - a) Calculate average face vector.
 - b) Subtract average face vector from each face vector.

Normalize means to remove the common features in images and the faces left behind only with unique features. These common features are average face vector and denoted by ψ after that subtract mean (average) face vector from each face vector to get normalized face vector.

Normalized face vector $\Phi_i = X_i - \psi$

4) Find eigenfaces with the help of covariance matrix C.

$C = AA^T$ here $A = \{\Phi_1, \Phi_2, \dots, \Phi_m\}$ these are normalized face vectors.

Now $A = N^2 * M$

Because dimensions of M images are $N * N$

$$C = A \quad A^T$$

$$C = N^2 * M \quad M * N^2$$

Here C will become $N^2 * N^2$ dimensions that is very large.

For eg. $M=100$ and dimensions $N * N=50 * 50$

Then $N^2 = 2500$

So covariance matrix become $C=2500 * 2500$

That means here 2500 eigenvectors generated it is large amount. But we need to find K significant eigenfaces because principal of PCA based face recognition is represent each image in training set is linear combination of K selected eigenfaces. Where $K \leq M$ and

$M=100$ so to find 100 or less than 100 selected features from 2500 it need huge amount of calculation.

5) Calculate eigenvectors from a covariance matrix with reduced dimensionality.

Here we use formula $C=A^T A$ (this covariance with the reduced dimensionality)

$$C = A^T \quad A$$

$$C = M * N^2 \quad M * N^2$$

Here C will be of $M * M$ dimensions means $100 * 100$

Eigenvectors are 100 these are reduced from 2500

6) Select K best eigenfaces, such that $K < M$ and can represent the whole training set.

7) Convert lower dimensional K eigenvectors into original face dimensionality $U_i = AV_i$

Here $U_i =$ ith vector in higher dimension space and $V_i =$ ith vector in lower space dimension.

By reducing dimensionality we do not only reduce computation but also reduce noise.

8) Represent the each face image a linear combination of all K eigen vectors and each face from the image can be represented as a weighted sum of K eigenfaces + mean or average face.

$$\Omega_i = \begin{pmatrix} W_1 \\ W_2 \\ \vdots \\ W_{ku} \end{pmatrix}$$

Weighted vector Ω_i is the eigenface representation of the ith face. Weight vector for each is calculated.[6]

9) Now recognition using PCA

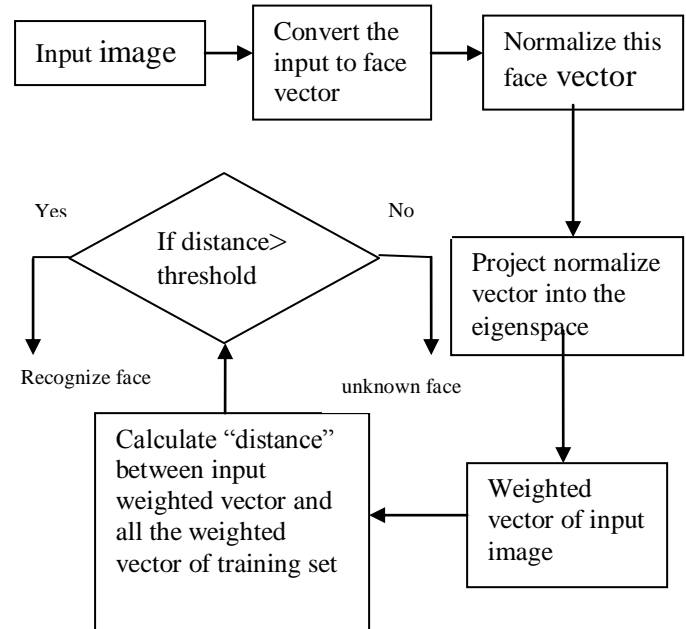


Fig. 1. Principal Component Analysis

III. LDA (LINEAR DISCRIMINANT ANALYSIS)

Linear Discriminant Analysis (LDA) is also a dimensionality reduction technique which is used for classification problems. Another name of LDA is Fisher's discriminant analysis and it searches those vectors in the underlying space that are the best discriminant among classes. LDA combine the independent feature which leads the largest mean differences between the desired classes. LDA is a linear transformation after the transformation features are separate. It can be achieved through scatter matrix analysis. The goal of LDA is to maximize the between-class scatter matrix measure and minimizing the within-class scatter matrix measure. LDA is a derived form of Fisher linear classifier it maximizes the ratio of the between- and within-class scatters. It is widely used in face recognition community. But there are some problems in LDA one is small size problem the number of training samples is less than the sample's dimensionality so the within-class scatter matrix is singular and the Linear Discriminant Analysis (LDA) method cannot be applied directly. To remove this problem there are certain methods one of them is fisherface it combines the both PCA and LDA to make a within class scatter matrix non singular or we can say that in this method in preprocessing we use PCA which discard the null space of within class matrix for dimensionality reduction but some time these null spaces contain important information that may be lost.[3][4] There are 5 general steps for performing a linear discriminant analysis.

1. Compute the d -dimensional mean vectors for the different classes from the dataset.
2. Compute the scatter matrices (between-class and within-class scatter matrix). For all samples of all classes the between class scatter matrix S_B and the within-class scatter matrix S_W are defined by:

$$S_B = \sum_{i=1}^c M_i (x_i - \mu) \cdot (x_i - \mu)^T$$

$$S_W = \sum_{i=1}^c \sum_{x_k \in X_i} (x_k - \mu_i) \cdot (x_k - \mu_i)^T$$

Where M_i is the number of training samples in class i , c is the number of distinct classes, μ_i is the mean vector of samples belonging to class i and X_i represents the set of samples belonging to class i with x_k being the k -th image of that class. S_W represents the scatter of features around the mean of each face class and S_B represents the scatter of features around the overall mean for all face classes.

3. Compute the eigenvectors (e_1, e_2, \dots, e_d) and corresponding eigenvalues ($\lambda_1, \lambda_2, \dots, \lambda_d$) for the scatter matrices.

The goal is to maximize S_B while minimizing S_W , in other words, maximize the ratio $\det[S_B]/\det[S_W]$. This ratio is maximized when the column vectors of the projection matrix (W) are the eigenvectors of $S_W^{-1} \cdot S_B$.

4. Sort the eigenvectors by decreasing eigenvalues and choose k eigenvectors with the largest eigenvalues to form a $d \times k$ -dimensional matrix W (where every column represents an eigenvector).

5. Use this $d \times k$ eigenvector matrix to transform the samples onto the new subspace. This can be summarized by the mathematical equation: $y = W^T \times x$ (where x is a $d \times 1$ -dimensional vector representing one sample, and y is the transformed $k \times 1$ -dimensional sample in the new subspace).[7]

IV. DIFFERENCES BETWEEN PCA AND LDA

- LDA is based on a single face image as input. That means LDA can perform face recognition for a single input image; hence it does not consider multiple input images.
- Whereas PCA is based on multiple face images as input. Hence it considers multiple input images.
- PCA is less sensitive where as LDA is more sensitive.
- PCA takes very less computational time where as LDA takes more computational time.
- To get Eigen value using LDA algorithm, calculation of within-class scatter matrix and between-class scatter matrix are needed. But in PCA only one step to get eigenvalue in PCA algorithm, which is to calculate one scatter matrix. Therefore LDA algorithm needs more time than PCA to extract feature.
- PCA can be described as an "unsupervised" algorithm, since it "ignores" class labels and its goal is to find the directions (the so-called principal components) that maximize the variance in a dataset. In contrast to PCA, LDA is "supervised" and computes the directions ("linear discriminants") that will represent the axes that maximize the separation between multiple classes.
- Although it might sound that LDA is superior to PCA for a multi-class classification task where the class labels are known, this might not always be the case. For example, comparisons between classification

accuracies for image recognition after using PCA or LDA show that PCA tends to outperform LDA if the number of samples per class is relatively small.

- PCA finds the axes with maximum variance for the whole data set where LDA tries to find the axes for best class separability.[2]

V. CONCLUSION

In this paper, a survey on the PCA and LDA and comparison of both on the basis of their merits and demerits. We analysed that how PCA and LDA work on images and compared both techniques and found that PCA is best as compare to LDA. LDA can give the effective results combining with PCA. Both techniques are used for the dimensionality reduction and both are influential in applications like security, surveillance etc.

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