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Face Detection Using Principal Component Discriminant Analysis

Gaurav Gupta
Student, Department of Electronics and Communication Engineering
Maharishi Markandeshwar University (M M U)
Sadopur-134007, Ambala (Haryana)

Deepak Dhadwal
Assistant Professor, Department of Electronics and Communication Engineering
Maharishi Markandeshwar University (M M U)
Sadopur-134007, Ambala (Haryana)

ABSTRACT

Face recognition is an active and important research from past many years. This process includes face tracking, expression finding and many more. In the beginning it was not possible to detect the face with the local structure. But now with the modern methods like LPP, it is now possible to preserve locality also. In a database having hundreds of images it is quite difficult to detect a face with less amount of time or having a high recognition rate with high accuracy. In this process it is very important to first register the locations of images. But it is very challenging to maintain such a database because of illumination invariance, pose invariance, noise invariance, shift invariance and scale invariance. All the unknown images those are present in the database will be registered by using Image Registration Algorithm. For this purpose Fourier Mellin Transform is used. This registration algorithm attempt to align a pattern image over a reference image and presented by Qin-sheng Chen et al (Dec 1994, pp 1156-1168)[14] to match a two dimensional image to a scaled and rotated reference image. Fourier rotational and Fourier scaling properties are used to find the movement of rotation and scaling. This algorithm will give the features which are invariant to scaling, rotation and translation. And phase correlation technique is used to for recovering translation parameters. The main problem of face recognition is high dimension space which is to be reduced by dimension reduction technique. This low dimension subspace can be achieved by using dimension reduction techniques like Principal component analysis, Linear Discriminant analysis and Locality Preserving Projection (LPP). So the aim of this paper is to first reduce the dimension of all the images present in the database and then search the required image from the given database.

Keywords

Eigen Value, Laplacian Faces, a Priori Laplacian, Linear Projective Projection, Face Biometric.

1. INTRODUCTION

Face recognition is an important part of image analysis and the area of research for face recognition is computer vision or pattern recognition. It is a method to automatically identify individuals using their characteristics. It is one of the applications of image processing and image analysis. Face recognition has mainly applications in the fields of biometrics, access control and security and surveillance systems. Biometrics is a method to identify individuals using their physiological characteristics. Biometric technologies include Face Recognition, Finger Print Identification, Hand Geometry Identification, Iris Identification, Voice Recognition, Signature Recognition, Retina Identification and DNA Sequence Matching. Face recognition has become an important issue in many applications such as security systems, criminal identification and credit card verification.

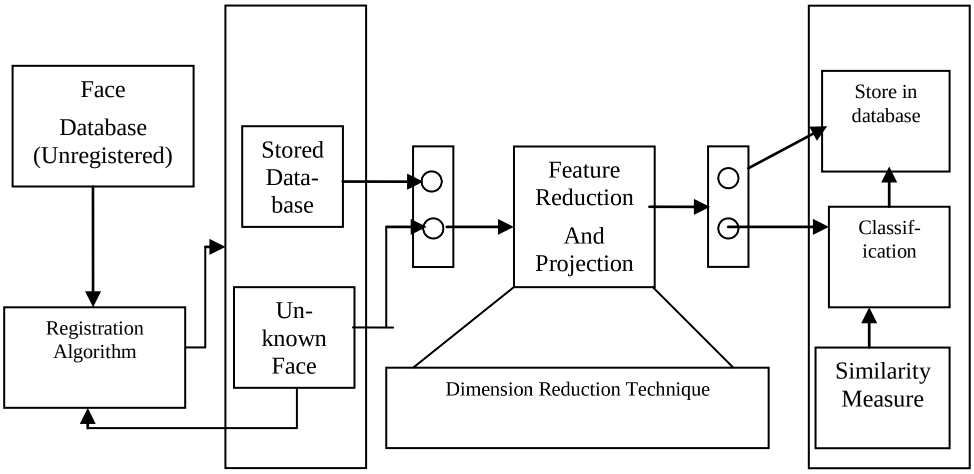

Figure 1 Block Diagram of Face Recognition System

Although it is clear that people are good at face recognition, it is not at all obvious how faces are encoded or decoded by the human brain. Unfortunately developing a computational model of face recognition is quite difficult, because faces are complex, multi-dimensional visual stimuli (Gaurav and Rahul, 2012) [1]. Therefore, face recognition is a very high level computer vision task.

The first step of human face identification is to extract the relevant features from facial images. Research in this field primarily intends to generate sufficiently reasonable familiarities of human faces so that another human can correctly identify the face. The question naturally arises as to how well facial features can be quantized. If such a quantization if possible then a computer should be capable of recognizing a face given a set of features.

The block diagram of system is shown in Figure 1 which explains about the step by step procedure for Training and Testing of face images. The initial step is the Registration of images present in database using a Fourier Mellin (B. Srinivasa Reddy and B. N. Chatterji, 1996, pp 1266-1271)[13] Transform. For typical image registration problems, the sources of differences between two images fall into four categories: differences from occlusion, differences of alignment, differences from noise and Differences due to change. Once all images are registered in the database, they are applied to dimension reduction block and Feature Reduction and Projection Block where the most important dimension are kept and then for classification it goes to classification block where different similarity measures are used to classify the test image. Finally the image will store in the database (N.p.) [17]

2. BACKGROUND STUDY

Locality Preserving Projection (X. He and P. Niyogi, 2003) [5] approach of using Laplacian faces for recognition was developed by Xiaofei He et al (Shuicheng Yan, Yuxiao Hu, Partha Niyogi, and Hong-Jiang Zhang, March 2005, pp 328-340)[3]. This approach is an alternate to Principal Component Analysis. It is linear and may be conducted in original space. It will preserve the locality and produce the Laplacian Faces. In this method the unwanted variations are completely eliminated.

A generally used dimension reduction technique like PCA (A. X. Guan, and H. H. Szu, 1999, pp 1016-1027)[10] and LDA (M. Martinez and A.C. Kak, Feb. 2001, pp 228-233)[7] aim to preserve the global structure but in LPP local structure is also preserved. This method will start the procedure to first produce the low dimension (L. Sirovich, and M. Kirb, March 1987, pp 519-524)[16] subspace and then recognize the face among the database. However, in Identity retrieval applications, the local structure is more important. So Locality Preserving Projection (LPP) is used for learning a locality preserving subspace. It obtains a face subspace that best detects the required face. The objective function of LPP is:

$$\min \sum (y_i - y_j)^2 \, S(i,j)$$

Where y_i and y_j are the image i and j in reduced Dimension space and S is the weight matrix in which weight S (i,j) are according to similarity between i^{th} and j^{th} image in original dimension space.

The minimization of objective function can be achieved by posing this problem as Eigen Value problem.

$$y_i = W^T X_i$$

$$F = \frac{1}{2}\sum_{ij}(y_i - y_j)^2 S(i,j)$$

$$F = \frac{1}{2}\sum_{ij}(W^T X_i - W^T X_j)^2 S(i,j)$$

$$F = \sum_{ij} W^T X_i S(i,j) X_i^T W - \sum_{ij} W^T X_i S(i,j) X_j^T W$$

$$F = \sum_{i} W^T X_i D(i,i) X_i^T W - W^T X S X^T W$$

$$F = W^T XDX^T W - W^T XSX^T W$$

$$F = W^T XLX^T W$$

where $D(i,i) = \sum_j S(i,j)$ ie sum of rows(columns)and L=D-S.

The larger the value of D (i,i) (corresponding to y_i) is, the more "important" is y_i. The Transformation vector W that minimizes the objective function is given by the minimum eigen value (W. Zhao, A. Krishnaswamy, R. Chellappa, D. L. Swets, and J. Weng, 1998, pp 336-341)[11] solution to the generalized eigen value problem:

Finally, the minimization problem reduces to finding

$$\arg\min_{W} XLX^T W$$

Under constraint $XDX^T W = 1$

$$XLX^T W = \lambda XDX^T W \qquad (1)$$

The solution of this equation will give the optimum value of W which will minimize the objective function. This W will be the transform vector from N^2 Dimension to lower dimension. The basis images (vectors) are called LAPLACIAN faces as they are derived from Laplace Beltrami operator. This method is also called appearance based face recognition method.

2.1 Algorithm

Apply the PCA (M. Kirby, and L. Sirovich, Jan 1990, pp 103-108)[15] to all images in database so as to reduce the dimension from N^2 to lower dimension M ($M \ll N^2$).

1) Create a Binary graph in which value will be '1' for K nearest Neighbors **a**nd '0' for others. In K nearest approach Graph is generated using K nearest Neighbor in original Domain.
2) Assign weights to the branches which are connected to each other. The weight matrix S can be of various types which are discussed in next section.
3) From Weight matrix S calculate D and L matrix.
4) Solve the eq. (1) for W and Select lowest k no. of Eigen (Vectors K. Etemad, and R. Chellappa, 1996, pp 2148-2151)[12]
5) Transpose whole Database into lower k dimension subspace.

2.1.1 Face recognition using laplacian faces

Whenever a new face comes:

1) Transpose it with same W vector.

2) Apply Nearest Neighbour Pattern classification (Shashua, A. Levin, and S. Avidan, Aug. 2002)[6] approach to retrieve identity of the person from database.

2.1.2 Similarity matrix

1) Binary face

In this Similarity matrix is Binary one with weights equal to "One" if it is nearest neighbour or a class member otherwise "Zero".

$$S(i,j) = 1 \text{ if Nearest neighbour}$$
$$= 0 \text{ otherwise}$$

2) Euclidean

In this case weight will be more if they are close in Euclidean Space i.e. inversely proportional to Euclidean Distance. It lies between 0 and 1.

$$S(i,j) = \exp(-(X_i - X_j)^2 / t) \quad \text{if Nearest neighbor}$$
$$= 0 \quad \text{otherwise}$$

where t is suitable constant.

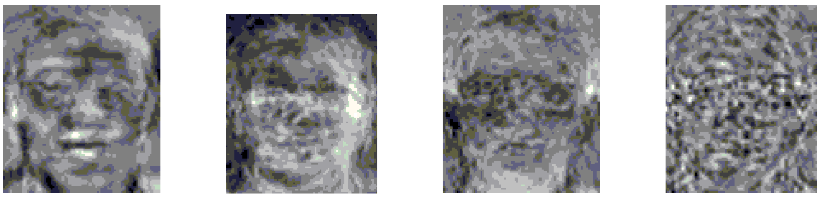

Figure 2 Top Four Laplacian Faces

3. RELATED WORKS

In PRIORI LAPLACIAN APPROACH (Gaurav Gupta and Vishal Gupta, July-August 2011)[2] the Laplacian is used but prior knowledge of each face to its class is used, which removes the Nearest Neighbor search from the Laplacian. The removal of this step enhances its capability in terms of time. So it is a combination of Laplacian and LDA in which LPP tries to preserve the local structure and LDA tries to match the face using Mahalanobis Distance. The objective function is

$$\min \sum (y_i - y_j)^2 \, S(i,j) \qquad (2)$$

$$G(i,j) = 1 \quad \text{if face } i \text{ and } j \text{ are of same class}$$
$$= 0 \quad \text{otherwise}$$

$$S(i,j) = \exp(-(X_i - X_j)^2 / t) \quad \text{if class member}$$
$$= 0 \quad \text{otherwise}$$

Where *S(i,j)* is the similarity measure between two images *i* and *j* and *y* is the image in reduced dimension space. In this case 2-D Graph *G* is a Binary

Graph, which has '1' as its value if two images are class member otherwise '0'. After this the similarity measure is computed for class members only. Then equation (2) is solved for Basis vectors which are further used to project the original images to reduced dimension space. If any test face comes that is reduced to the same space using same vectors. In reduced dimension space the test face is classified to one of the given class using Mahalanobis distance. This method is having a good recognition rate as compared to linear preserving locality.

Figure 3 shows the best basis faces for the database from which all the faces can be reconstructed. For this after a particular number there is no improvement in the recognition rate. So again the proper number of vectors is to be chosen for better performance.

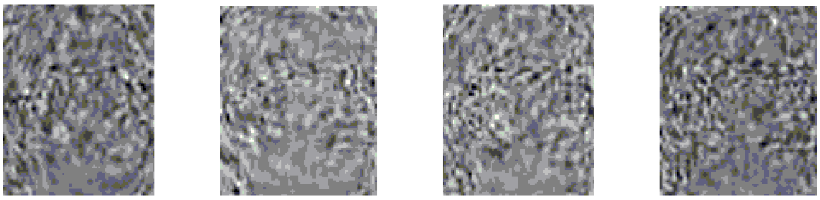

Figure 3 Top four priori Laplacian Faces

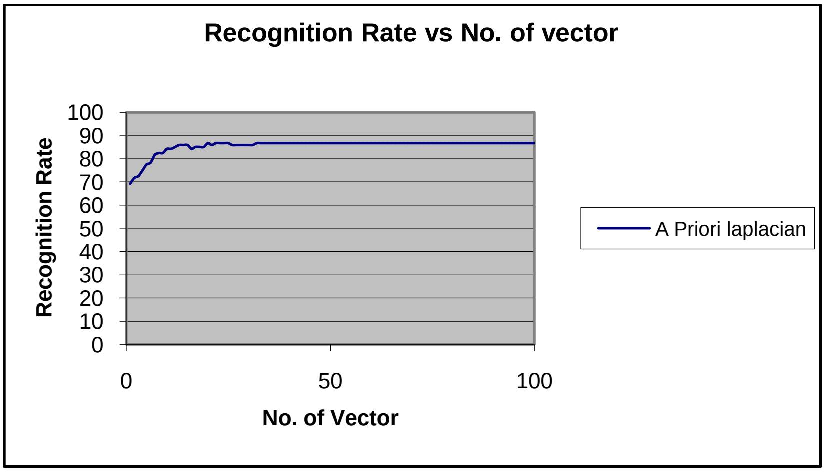

Figure 4 Recognition Rate vs No. of Vector for a *priori* Laplacian

4. METHODOLOGY

In Principal Component Discriminant Analysis (PCDA) approach, initially all the images are transformed into reduced dimension space by using Principal Component Analysis. The reduction in dimension is such that most of energy is still present so there is no loss in information. Then using prior knowledge of the class of each image LDA is applied this actually reduces the computation time of between class and within class matrices. This method will provide the best recognition rate. The transformation vector is computed in a combined manner as explained.

W_{pcda} is given by

$$W_{pca} = \arg\max_{W} \left| W^T S_T W \right|$$

(3)

$$W_{fld} = \arg\max \frac{\left| W^T W_{pca}^T S_B W_{pca} W \right|}{\left| W^T W_{pca}^T S_W W_{pca} W \right|} \tag{4}$$

$$W_{pcda}^T = W_{fld}^T W_{pca}^T \tag{5}$$

$$W_{pcda} = \arg\max \frac{\left| W^T W_{pca}^T S_B W_{pca} W \right|}{\left| W^T W_{pca}^T S_W W_{pca} W \right|} \tag{6}$$

The advantage of combining these two for computing faces in reduced dimension space is the reduction in time consumption. This reduction in time occurs due to reduction in dimension which in turns reduced the time required to compute S_B and S_w as compare to LDA. The enhancement in recognition rate is also better as compare to alone PCA or LDA. The solution of equation (6) is Eigen vector solution

$$W_{pca}^T S_B W_{pca} W_i = \lambda_i W_{pca}^T S_W W_{pca} W_i \quad i = 1, 2, \ldots\ldots, m \tag{7}$$

The top Eigen vectors of eq (7) will be the optimum vectors to transpose the whole database. Then standard Mahalanobis distance is applied to know the exact class of the test image.

5. RESULTS

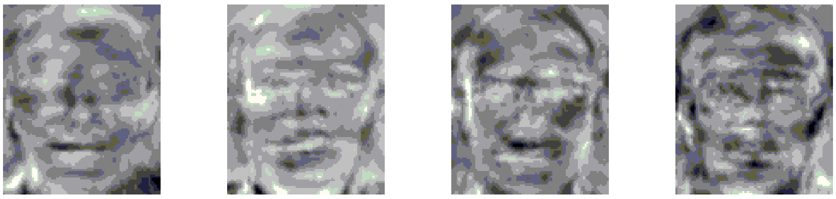

Figure 5 Top Four Images for PCDA

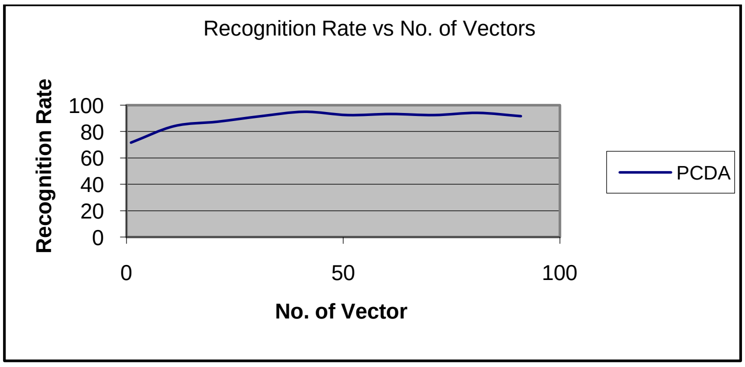

Figure 6 Recognition Rate vs No. of Vector for PCDA

6. CONCLUSIONS

The various ways of dimension reduction methods like Linear Preserving Projections, a Priori Laplacian and Principal Component Discriminant Analysis are introduced here in this paper and then try to detect the nonlinear structure in manner of linear subspace learning. These all methods are used here for face analysis and are a part of feature reduction and projection. In reference to Laplacian faces this concept which uses labeled samples, a different and effective similarity measure works very well on the database for the purpose of recognition of identity of a person. The accuracy rate also increases due the effect of class concept. Also the computational complexity is reduced due to no more searches for k nearest neighbor for each sample. This comparison shows that PCDA is best in terms of recognition rate among all the discussed techniques. The results can be taken on P4 2.2Ghz, Microsoft Windows XP Professional with MATLAB 7.1 as the platform.

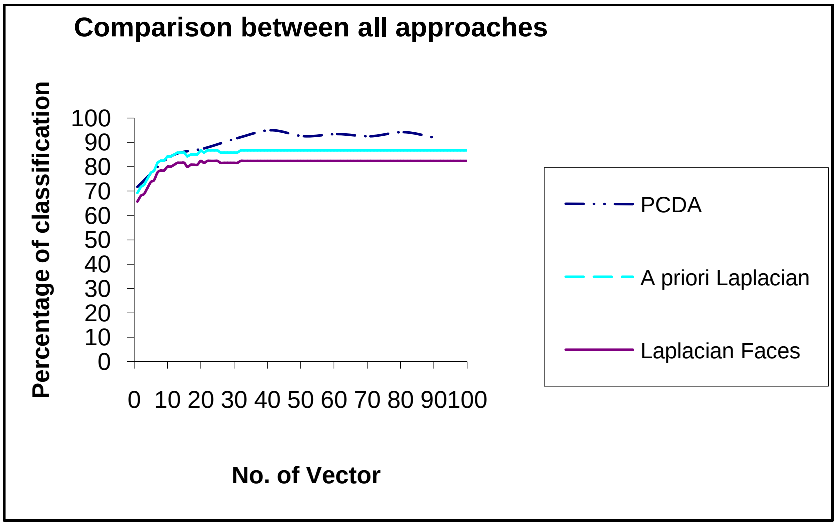

Figure 7 Comparison of three approaches w.r.t. No. of Eigen vectors

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