INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

A REVIEW OF PCA AND LDA METHODSFOR FACE RECOGNITION

JAYASHRI R. DHAGE[1], PRASHANT L. PAIKRAO[2]

1. Electronics Engineering Department, M.Tech. in Electronics System and Communication, Government College of Engineering Amravati.
2. Electronics Engineering Department, Assistant Professor, Government College of Engineering Amravati.

Accepted Date: 05/03/2015; Published Date: 01/05/2015

Abstract: Face recognition systems play a vital role in many applications of computer vision and image processing including surveillance, biometrics and security. An automated face authentication system has been an active research subject for several decades. A face authentication system consists of two face processing tasks, such as face detection and face recognition. The original input image has a very high dimension, so a dimensionality reduction technique is usually applied before a classification task is performed. Eigenface method using Principle Component Analysis (PCA) is one of the most popular methods for face recognition. This algorithm has several advantages; one is reducing the image dimension, and the other is providing a compact feature for representing a face image. By applying PCA for dimension reduction before Linear Discriminant Analysis (LDA) for classification, a new algorithm is developed which is called Fisherface algorithm. Sir R. A. Fisher had successfully classified the flowers by using the concept of LDA. Hence this algorithm is called Fisherface algorithm as it uses LDA to classify the different face images into different classes. This algorithm is insensitive to extreme variation in lighting and facial expression. Finally Euclidean distance vector concept is used to recognize face from available database.

Keywords: LDA, PCA, Eigenface, Fisherface

Corresponding Author:MS. JAYASHRI R. DHAGE

PAPER-QR CODE

Access Online On:

www.ijpret.com

How to Cite This Article:

Jayashri R. Dhange, IJPRET, 2015; Volume 3 (9): 313-322

INTRODUCTION

Human face recognition is currently an active research area in a Computer Vision Community. Many papers have been published in recent years as it has wide application in the fields like criminal identification, security and surveillance systems. Early commercial services like Google Goggles, Google Glass for object recognition, automatic face tagging in Facebook, Microsoft Photo Gallery face recognition. All these services need a face recognition system in non ideal condition like light intensity variation and facial expression variation.

PCA gives very good results in the field of compression but is not good technique for the purpose of classification. However, PCA (a feature extraction method) can be used for recognition purpose when data samples are less in number (no need of classification). PCA is not ideal for classification purpose since it is too sensitive to undesirable changes in illumination and facial expression. In order to build a face recognition system which is unaffected by undesirable changes in illumination and facial expression we need a method which supports classification. LDA is one of the most popular method in face recognition system. LDA (a feature extraction method) is derived from the idea presented by Fisher in 1936. Fisher used LDA method to classify flowers. LDA has successfully been used in many statistical pattern recognition problems. This technique maximizes the ratio of the determinant of between-class scatter matrix and within-class scatter matrix.

Generally original input image has high dimensions which are to be reduces before classification is performed. PCA for dimension reduction can be used in conjunction with LDA for classification to build a face recognition system. This face recognition system is insensitive to changes in illumination and facial expression as well as it does not suffer from small size problem. Other methods available for face recognition system are Boosting colour feature and Elastic graph matching theory. Typical face recognition system based on fisherface approach is represented by fig.1.

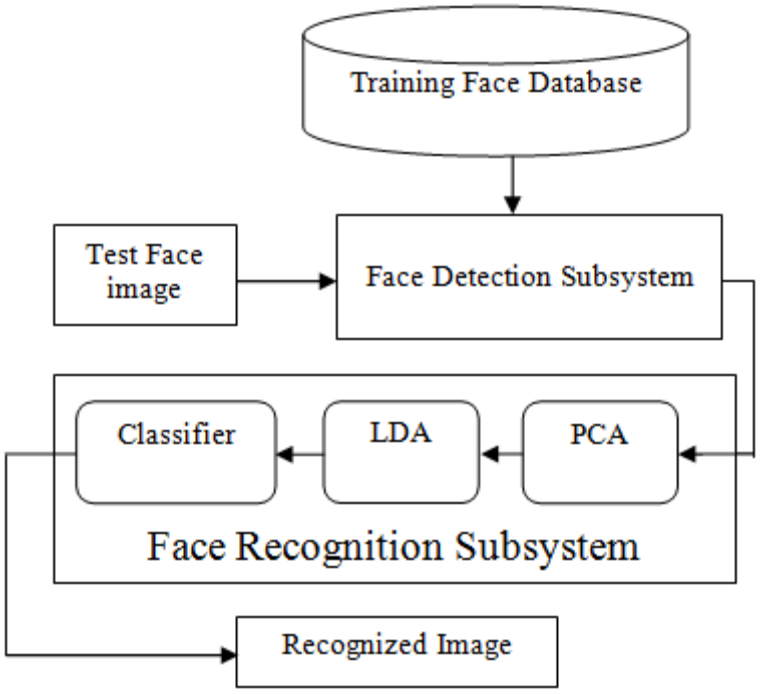

Fig. 1 Typical Architecture Face Recognition system

In today's world with ever increasing population, increasing crowds at public places such as railway station, bus stands banks etc. pose very serious security threat to civilian life. There arises a need to secure day to day public life. This security to civilians can be provided by suitable biometric face recognition system. Out of many biometric identification systems such as iris recognition, finger print recognition etc., the face recognition system shows good implementation ability. Moreover people do publically accept to take their photograph at places where security is required.

I. origin

During 1964 and 1965, Woody Bledsoe along with Helen Chan Wolf and Charles Bisson had started working on automated facial recognition. They worked on using computers for facial recognition. As funding for their work was provided by unnamed intelligence agency, that did not allow much publicity, so little of their work is publically available. In 1966 Bledsoe stated the following difficulty while working on face recognition problem.

Great variability in head rotation and tilt, lighting intensity and angle, face expression, aging, etc. makes face recognition difficult. Successful face recognition by machine allows little or no

variability in these quantities. Correlation or pattern matching method which is often used by researcher on unprocessed optical data, is certain to fail when there is great variability. This happens because two images of the same person with variation have low Correlation between them.

Further this work was continued at the Stanford Research Institute primarily by Peter Hart in 1966. After observing that the computer consistently outperformed humans in face recognition Peter Hart said that "It really worked". The same system have been developed by many other Universities including University of Bochum in Germany, University of southern California in USA, Massachusetts Institute of Technology and the University of Maryland around 1997.United States Army Research Laboratory funded the system developed by Bochum University. Software belonging to that system was sold as ZN-Face. Customer of that software was Deutsche Bank and various airport operators.

II. Eigen face

For the first time in 1987 Sirovichi and Kirby showed that PCA could be used to extract basic features of face images from a collection of face images[9]. PCA, also known as KL Transform is generally used for pattern recognition task. They also stated that PCA and KL transform generally have application in analysis of signals in time domain. They demonstrated that any particular face can be economically presented in terms of best co-ordinate system known as `Eigenpicture'.

Matthew Turk and Alex Pentland expanded the above work and developed the Eigen- face Method for the purpose of face recognition in 1990[8]. Their work is particularly based on information theory approach, in which face images are decomposed into small set of characteristic feature images called as `Eigenfaces'. Face Recognition is performed by projecting a test face image into subspace evaluated by Eigenfaces and then classifying the face by comparing the position of test face image in that subspace with the position of known face image in training set. They achieved face recognition under widely varying conditions like straight on view, 45 degree view and profile view. Face recognition system, they have adapted outperformed other face recognition schemes available at that time in terms of speed, simplicity, sensitivity to small or gradual changes in face images. Covariance of N-tuple vector of image vectors is given by (1).

$$C = \frac{1}{N}\sum_{i=1}^{N}(s_i - \bar{m})(s_i - \bar{m})^T = AA^T \qquad (1)$$

Average of all image samples which is also called as mean image is given by (2).

$\bar{m} = \frac{1}{N}\sum_{i=1}^{N} s_i$ (2)

Where $A = [\Phi_1, \Phi_2, \Phi_3, \ldots\ldots, \Phi_N]$ [refer (1)] and each face image in training set differs from mean image by vector given by $\Phi_i = s_i - \bar{m}$. High dimensional space is represented by low dimension space by calculating Eigen values of $A^T A$ (i.e N number of eigen values) matrix rather than AA^T matrix given in (1). N number of Eigen values of $A^T A$ matrix is nothing but the N largest Eigen values of AA^T matrix. By keeping K best Eigen values(generally largest among N) and corresponding Eigen vector , each face image sample in training set and test face image can be represented by linear combination best K Eigen vectors. Euclidean distance between test face image and training face image gives matching percentage based on which recognition procedure can be performed.

Mark Richardson in 2009 stated that, PCA is a technique which uses mathematical tools to transform a number if possibly correlated variable into smaller number of variable named as principle components[10]. According to Richardson the origin of PCA lies in multivariate data analysis and is an important result derived from applied linear algebra. PCA is generally a first step in data analysis task. It also has wide range of applications other than face recognition, e.g. de-noising signals, blind source separation and data compression. PCA uses vector space to reduce the dimension of large data set by mathematically projecting the original data set in such a way that the many variable present in data set can be converted to a few variables. Reduced dimension of data allows to spot similar pattern in data.

III. fisherface

Linear Discriminant Analysis (LDA) , a statistical method often used for dimensionality reduction and classification. Sir R. A. Fisher published a paper in 1936 on the topic “The use of multiple measurements in taxonomic problems”, in which he used LDA method to classify the flowers.

In 1996 at European Conference on Computer Vision, P. N. Belhumeur, J. P. Hespanhaand D. J. Kriegman published a paper on the topic of Eigenface vs Fisherface [7]. By using pattern classification approach, they have develop a face recognition system which is insensitive to change in illumination and facial expression. They have used a Fisher Linear Discriminant projection method to produced well separated classes in a low dimension subspace. There method gives satisfactory results even in case of varying illumination and facial expression. For the purpose comparison, they had tested Eigenface technique on same database and demonstrate that the Fisherface method has significantly lower error rates in compare with Eigenface technique.

Main objective of Fisherface method adopted in [1] is to maximize the ratio of between class scatter matrix (S_b) to within class scatter matrix (S_w). Between class scatter matrix S_b and within class scatter matrix S_w are given by (3) and (4) respectively.

$$S_b = \sum_{i=1}^{c} N_i(\overline{m_i} - \overline{m})(\overline{m_i} - \overline{m})^T \quad (3)$$

$$S_w = \sum_{i=1}^{c} \sum_{s_k \in S_i} (s_k - \overline{m_i})(\overline{m_i} - \overline{m})^T \quad (4)$$

$\overline{m_i}$ used in (3) and (4) is mean of all the sample in class S_i and N_i is number of samples in class S_i . Optimal projection V_{opt} can be selected to maximizes the ratio of determinant of between class scatter matrix (S_b) and within class scatter matrix (S_w), if and only if S_w follows non-singularity condition.

$$V_{opt} = \arg\max \frac{|V^T S_b V|}{|V^T S_w V|} = [v_1, v_2, v_3, v_3, \ldots\ldots, v_m] \quad (5)$$

V_{opt} in (5) is obtained by set of generalized eigen vector of S_b and S_w corresponding to m largest eigen values given by $\{v_m | \ i = 1,2,3 \ldots\ldots\ldots m\}$.

i.e. $S_b v_i = \lambda_i S_w v_i$ (6)

Value of m can go up to c-1 (c is number of classes). Number of sample in training is generally smaller than the number pixel present in an image which leads to singular S_w. Because of this singularity problem , V will be selected such that S_w of projected samples becomes zero. In order to avoid this singularity problem V_{opt} is selected in the following way

$$V_{opt}^T = V_{fld}^T V_{pca}^T \quad (7)$$

Where $V_{pca} = \arg\max |V^T S_t V|$ (8)

S_t is given by covariance matrix C in (1) and $S_t = S_b + S_w$

$$V_{fld} = \arg\max \frac{|V^T V_{pca}^T S_b V_{pca} V|}{|V^T V_{pca}^T S_w V_{pca} V|} \quad (9)$$

In order to solve small size problems Li-Fen Chen, Hong-Yuan Mark Liao, Ming-Tat Ko, Ja-Chen Lin, Gwo-Jong Yu propose a new LDA-based technique based on Fisher criteria in 2000[6]. They proved that the most expressive vectors derived in the null space of within class scatter

matrix using PCA are equal to optimal discriminant vectors derived in the original space using LDA. This small size problem occurs whenever the number of sample is smaller than dimension of single sample, then sample scatter matrix may become singular. Because of this execution of LDA may encounters computational diffculties.

A novel Gabor-Fisher classifier(GFC) for a face recognition was introduced by Chengjun Liu, Harry Wechsler in 2002[5]. In this paper, first augmented Gabor feature vectors are derived from the Gabor wavelet representation of face images. These Gabor feature are then applied to enhanced Fisher linear discriminant analysis (EFLD). Novelity of their work is concealed in developing GFC for solving multiclass problem. They compared the result of combination of GFC and Eigen face with the combination of GFC and Fisher face. Sixty two features have been used to get 100 percent accuracy by GFC on 6000 FERET frontal faces of 200 subjects. Gabor feature exhibits desirable characteristics of spatial locality and orientation selectivity, which gives the biological relevance and computational properties of it.

In 2005, Xiao-Yuan Jing, Chen Lu, and David Zhang propose an uncorrelated Fisherface approach (UFA) to improve the Fisherface method in these two area i.e. Face and Palm print Recognition [4]. They showed Experimental results on different image databases demonstrate that UFA outperforms the Fisherface method and the uncorrelated optimal discrimination vectors (UODV) method.

For the hardware implementation of face recognition system, there is a need of an algorithm which consume less memory and is computationally less intensive [3]. This can be done by reducing feature per person. In order to fulfill this requirement Tomoaki Takano, Yohei Fukumizu and Hironori Yamauchi in 2009 proposed a Gabor Pseudo Fisher classifier (GPFC). Basically GPFC is based on GFC but difference between GPFC and GFC lies in the way the two calculates fisherfaces. They have used Generic database instead of gallery database , which is generally used for calculating Fisherfaces. The traditional Fisherface method needs several gallery images per person, while GPFC method needs only one gallery image per person. As it calculates Fisher face in Generic database at one time only, it reduces a computational cost.

L-Fisher face method for face recognition was introduced by Cheng-Yuan Zang Zhang, Qiu-Qi Ruan in 2010[2]. They proposed LFDE method which is based upon manifold learning face recognition approach . LPP and UDP preserves local structure of images which is very important for real world application. But these two methods suffer from limitations like they de-emphasize the discriminant information of images, which is a requirement of face recognition system when the images are badly clustered in data space. Whereas LDA method preserve

global geometric structure of images in transformed low dimensional space by emphasizing discriminant information. In this paper authors have proposed LFDE method which combines the advantage of both the approaches. This method finds a local structure of data as well as extracts discriminant information for pattern representation and classification. In other words they have considered local within class scatter and between class scatter of the samples in their proposed method.

In 2010, Seiyed Mohammad Seyedzade, Sattar Mirzakuchaki, Amir Tahmasbi try to Combine Symlet decomposition method, fuzzy integral and Fisher Face algorithm for face recognition[1]. They have proposed their work in three sections.

1. First they have used wavelet transform to extract intrinsic facial feature. Wavelet transform is capable of multiresolution decomposition.

2. The result of wavelet decomposition are further operated upon by LDA to calculate Corresponding Fisherfaces.

3. Finally fuzzy integration is used as a last step in order to obtain perfect match.

The low frequency band and the high frequency band components performed different roles is the classification task. The low frequency components contribute to the global description while the high frequency components contributes to finer details required in the identification task

IV. observation

Eigenface method is not complex and computationally less intensive whereas Fisherface method is complex and computationally intensive. Both Eigenface and Fisherface methods performs very well , when test image is exactly similar to one of the training image. But Eigenface method proves to be insufficient when there is a change in illumination and facial expression. Both Eigenface and Fisherface are feature extraction methods but as Eigenface does not support classiffcation (which is of prime importance while recognizing faces) when the number of samples in the data base are very large we need to turn our attention to Fisherface approach for such data bases.

ACKNOWLEDGMENT

I would like to thank my guide P. L. Paikrao, Assistance Professor, Electronics Engineering Department, for providing necessaryguidance for the completion of thispaper. I would also like

to thank all teachers and staff memberof Electronics and Telecommunication Department for directly or indirectly extending their help to complete this task.

REFERENCES

1. Seyed Mohammd Seyedzade, Sattar Mirzakuchaki, Amir Tahmasbi, "Using Symlet Decomposition Method, Fuzzy Integral and Fisherface Algorithm for Face Recognition", Second International Conference on Computer Engineering and Applications, IEEE DOI 10.1109/ICCEA.2010.173,2010.

2. Cheng-Yuan Zhang, Qiu-Qi Ruan "Face Recognition Using L-Fisherfaces", Journal Of Information Science And Engineering 26,1525-1537, 2010.

3. Tomoaki Takano, Yohei Fukumizu and Hironori Yamauchi, "Face Recognition System using Gabor Pseudo Fisherface Method for Embedded LSI Applications", International Workshop on Nonlinear Circuits and Signal Processing,NCSP'09, Waikiki, Hawaii, March 1-3, 2009.

4. Xiao-Yuan Jing, Chen Lu, and David Zhang, "An Uncorrelated Fisherface Approach for Face and Palmprint Recognition", Springer-Verlag Berlin Heidelberg,ICB2006, LNCS 3832, pp. 682 687, 2005.

5. Chengjun Liu , Harry Wechsler, "Gabor Feature Based Classi_cation Using the Enhanced Fisher Linear Discriminant Model for Face Recognition", IEEE Trans. Image Processing,11, no. 4, pp. 467-476, 2002.

6. Li-Fen Chen, Hong-Yuan Mark Liao, Ming-Tat Ko,Ja-Chen Lin, Gwo-Jong Yu , "A new LDA-based face recognition system which can solve the small sample size problem", Pattern Recognition Society. Published by Elsevier Science Ltd,1713-1726, 2000.

7. P. N. Belhumeur, J. P. Hespanha, and D. J. Kriegman, "Eigenfaces vs. Fisherfaces: Recognition using class specific linear projection", IEEE Transactions on Pattern Anal- ysis and Machine Intelligence, vol. 19, pp. 711720, July 1997.

8. M. Turk and A. Pentland, "Eigenface for Face Recognition", Journal Of Cognitive Neuro-science, vol 3,NO 1, 1991.

9. L. Sirovich, M. Kirby, "Low-dementional procedure for the characterization of human faces" ,Journal of Optical Society of America, vol 4,NO 3,march 1987.

10. Mark Richardson, "Tutorial on Principal Component Analysis", may 2009.