Rank Normalization for Principal Component Analysis Based Face Recognition

Arjun V Mane[#1], Ramesh R Manza[#2], Karbhari V Kale[#3]

[#]*Department of Computer Science & Information Technology,*

Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (MS) India

[1]arjunmane7113@yahoo.co.in, [2]ramesh_manza@yahoo.com, [3]kvkale91@gmail.com

***Abstract*—Principal Component Analysis (PCA) is a statistical technique used for dimension reduction and recognition, & widely used for facial feature extraction and recognition. In this paper, the new rank based feature normalization method is presented for the PCA based face recognition. Experiments based on ORL and Yale face databases have been performed to compare the recognition rate with the traditional PCA by varying the number of input images. It is found that use of rank based feature normalization gives the improved classification result.**

***Keywords*— Security, Biometrics, Face Recognition, Principal Component Analysis, Eigenspace, Similarity Measure**

I. Introduction

Face recognition has been studied extensively for more than 40 years. Now it is one of the most imperative sub-topics in the domain of face research [1]-[4]. Face recognition is a technology which recognize the human by his/her face image. Face recognition can be divided into two core approaches namely, content-based and appearance based [1].

Content-based recognition is based on the relationship between facial features like eyes, mouth & nose etc.

In appearance based recognition the face is treated as a two dimensional pattern of intensity variation. The face matching is done through its underlying statistical regularities.

Principal Component Analysis (PCA) has been proven to be an effective approach for the face recognition [5]-[11]. Sirovich and Kirby (1987 & 1990) used the eigenfaces for efficiently representing the face images using principal component analysis [12], [13]. In 1991 Turk and Penland developed a face recognition system using PCA [7], [6]. Then onwards, systematic empirical evaluations of PCA based face recognition techniques, including View based and Modular PCA [*Pentland et.al. 1994*], Kernel PCA [*Kwang Kim et.al 2002, Ming Yang et.al 2002*], Illumination Normalization Pixel wise Gaussian and PCA [*T Chen et.al 2002*], Image PCA [*Jian Yang et al 2002*], Improved Modular PCA [*RajKiran G et.al 2004*], PCA and MLP and RBF Network[*M Oravec et.al 2004*], 2DPCA [*Jian Yang et.al 2004*], Gabor based Kernel PCA [*Chengjun Liu 2004*], $(2D)^2$PCA [*Daoqiang Zhang et.al 2005*], Generalized 2DPCA [*Hui Kong et.al 2005*], GW + DKPCA [*X Xie et.al 2006*], 2DPCA+FSS & B2DPCA+FSS [*P Sanguansat et.al. 2006*], GW based Modular PCA [*N Gudur et.al 2006*], PCA of Multi-View [*T. Kurita er.al. 2006*], IPCA_ICA [*Issam Dagher et.al. 2006*], Wavelet PCA and SVM[*Hong Wang et.al. 2007*], Image PCA [*Ying Wen et.al. 2007*], Laplacian PCA [*Deli Zhao et.al. 2007*], Curvelet PCA [*T Mandal et.al. 2008*], Wavelet PCA and ANN [*M Mazloom et.al. 2008*], Statistical PCA [*Chunming Li et.al. 2008*], 2DPCA+GF &2DPCA+MGF [*Yi-Chun Lee et.al 2008*], WT + Image PCA [*Yang Jun et.al. 2008*], $(2D)^2$+PCA and WPD [*Dongjian He et.al. 2008*], Contourlet PCA [*Walid Riad et.al. 2008*], WT Weighted Modular PCA [*Minghua Zhao et.al. 2008*] and many.

This paper employed new rank normalization based system. In section II the tradition PCA based face recognition system is discussed. The rank based feature normalization discussed in section III and experimental results are listed in section IV. Finally, sections V conclude and suggest the future scope.

II. PCA

Principal component analysis (PCA) was also called as Eigenface [6]. The following steps summarize the process:

1. Let a face image X(x, y) be a two dimensional mXn array (8-bit Gray Scale) of intensity values. An image may also be considering the vector of dimension mn, so that a typical image of size 112x92 becomes a vector of dimension 10304. Let the training set of images {X1, X2, X3… XN}. The average face of the set is defined by

$$\overline{X} = \frac{1}{N}\sum_{i=1}^{N} Xi \qquad (1)$$

2. Calculate the covariance matrix to represent the scatter degree of all feature vectors related to the average vector. The covariance matrix C is defined by

$$C = \frac{1}{N}\sum_{i=1}^{N}(Xi - \overline{X})(Xi - \overline{X})^T \qquad (2)$$

3. The Eigenvectors and corresponding eigenvalues are computed by using

$$CV = \lambda V \qquad (3)$$

Where V is the set of eigenvectors associated with its eigenvalue λ.

4. Sort the eigenvector according to their corresponding eigenvalues from high to low
5. Each of the mean centred image project into eigenspace using

$$W_i = V_i^T (X_i - \overline{X}) \quad (4)$$

6. In the testing phase each test image should be mean centred, now project the test image into the same eigenspace as defined during the training phase.
7. This projected image is now compared with projected training image in eigenspace. Images are compared with similarity measure (Euclidean). The training image that is closet to the test image will be matched and used to identify.

III. Rank Based Feature Normalization (RN)

Let x be the feature vector of length n extracted from the face image by means of PCA. Rank Feature Normalization (RN) replaces the x_i with the rank R the component would correspond to if the feature components would be ordered in an ascending order.

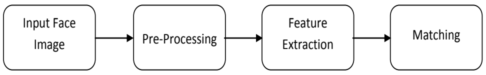

Fig. 1 Traditional Face Recognition System

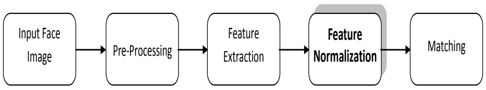

Fig. 2 Proposed Face Recognition System

IV. Experiments

A. *Databases*

The Olivetti Research Lab (ORL) Database [45] of face images provided by the AT&T Laboratories from Cambridge University has been used for the experiment. It was collected between 1992 and 1994 [46]. It contains slight variations in illumination, facial expression (open/closed eyes, smiling/not smiling) and facial details (glasses/no glasses). It is of 400 images, corresponding to 40 subjects (namely, 10 images for each class). Each image has the size of 112 x 92 pixels with 256 gray levels. Some face images from the ORL database are shown in fig 3.

The Yale Face database [47] [48] contains 11 frontal face images of 15 subjects, giving a total of 165 images. Each image has the size of 320 × 243 pixels with 256 gray levels. Lighting variations include left-light, center-light, and right-light. Spectacle variations include with-glasses and without-glasses. Facial expression variations include normal, happy, sad, sleepy, surprised, and wink. Some face images from the Yale face database are shown in fig 4:

Fig. 3. Some Face images from ORL Database

Fig. 4. Some Face images from Yale Database

B. *Experimental Setup*

The experiment has been done on two face databases ORL face database and Yale face database, with different number of training images i.e. five, six, seven, eight, nine, and ten. For testing all the images in the database has been considered. The algorithms developed in MATLAB 7.0. In all the experiments the feature vectors has been calculated using PCA.

C. *Results and Discussion*

The results of the experiment on ORL database has been shown in TABLE I and on Yale Database has been shown in TABLE II and the corresponding graphical representation has been shown in Fig.5 and Fig.6 respectively. From TABLE I and II. We can analyze that the proposed method gives the better recognition rate than the traditional PCA.

TABLE I
RECOGNITION RESULTS FOR ORL DATABASE

	Number of Training Images					
	5	6	7	8	9	10
WN	80.5	83	82.75	85.75	85.25	87
RN	95	93	95.5	97.5	97	99

TABLE II
RECOGNITION RESULTS FOR YALE DATABASE

	Number of Training Images					
	5	6	7	8	9	10
WN	51.52	55.76	63.64	65.45	66.67	66.67
RN	81.21	79.39	82.42	84.24	79.39	81.21

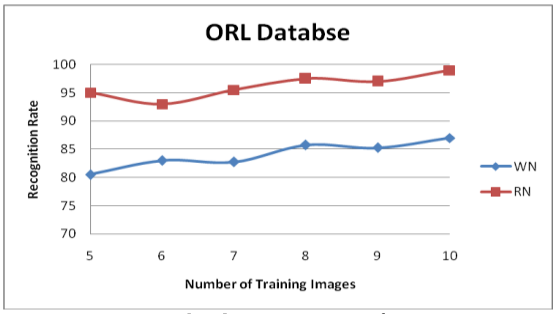

Fig. 5. Graphical Representation of TABLE I

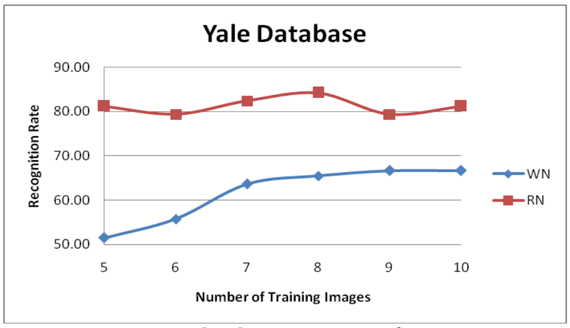

Fig. 6. Graphical Representation of TABLE II

V. CONCLUSIONS

In this paper new rank based feature normalization for principal component analysis based face recognition has been proposed. The experiments were performed on the ORL and Yale Face databases. The experiments show that the proposed method gives better performance with respect to recognition rate. The best performance on ORL database is 99% with 10 training images and on Yale database 84.24% with 8 training images of each person. In future more feature normalization techniques can be used.

REFERENCES

[1] W. Zhao, R. Chellappa, A. Rosenfeld, and P. J. Phillips. "*Face recognition: a literature survey*" ACM Computing Surveys, Vol. 35, No. 4, December 2003, pp. 399–458.

[2] A. S. Tolba, A.H. El-Baz, and A.A. El-Harby "*Face Recognition: A Literature Review*", International Journal Of Signal Processing Volume 2 Number 2 2005 ISSN 1304-4494.

[3] R. Chellappa, C.L. Wilson and C. Sirohey, "*Human and machine recognition of faces: A survey*", Proc. IEEE, vol. 83, no. 5, pp. 705-740, may 1995.

[4] F Ming-Hsuan Yang, David J. Kriegman, and Narendra Ahuja, "*Detecting Faces in Images: A Survey*" IEEE Transactions On Pattern Analysis And Machine Intelligence, Vol. 24, No. 1, January 2002.

[5] M. Turk, "*A Random Walk Through Eigenface*", IEICE Trans. INF. & SYST., Vol. E84-D, No. 12, Dec. 2001.

[6] M. Turk and A. Pentland, "*Eigenfaces for recognition*", *J. of Cognitive Neuroscience*, Vol. 3, No. 1, pp. 71-86, 1991.

[7] M. Turk and A. Pentland, "*Face recognition using eigenfaces*", Proceedings of IEEE, CVPR, pp. 586-591, Hawaii, June, 1991.

[8] I.Craw, N. Costen, T. Kato, and S. Akamatsu, "*How Should We Represent Faces for Automatic Recognition?*" IEEE Trans. on PAMI, Vol. 21, No.8, pp. 725-736, August 1999.

[9] A. Pentland, B. Moghaddam, T. Starner, "*View-based and modular eigenspaces for face recognition*", Proceedings of IEEE, CVPR, 1994.

[10] B. Moghaddam and A. Pentland, "*Face Recognition using View-Based and Modular Eigenspace*", Automatic Systems for the Identification and Inspection of Humans, 2277, 1994.

[11] P. Hall, D. Marshall, and R. Martin, "*Merging and Splitting Eigenspace Models*", IEEE Trans. on PAMI, Vol. 22, No. 9, pp. 1042-1049, 2002.

[12] Sirovich, L. & Kirby, M. "*A low-dimensional procedure for the characterization of human face*", Journal of the Optical Society of America A, Vol. 4, No. 3, pp.519-524 1987.

[13] Kirby, M. And Sirovich, L. "*Application of the Karhunen-Loeve procedure for the characterization of human faces*", IEEE Trans. Patt. Anal. Mach. Intell. Vol. 12, No. 1, pp. 103-107 1990.

[14] A. Pentland, B. Moghaddam, T. Starner, "*View-based and modular eigenspaces for face recognition*", Proceedings of IEEE, CVPR, 1994.

[15] B. Moghaddam and A. Pentland, "*Face Recognition using View-Based and Modular Eigenspace*", Automatic Systems for the Identification and Inspection of Humans, 2277, 1994.

[16] P. Hall, D. Marshall, and R. Martin, "*Merging and Splitting Eigenspace Models*", IEEE Trans. on PAMI, Vol. 22, No. 9, pp. 1042-1049, 2002.

[17] Sirovich, L., Kirby, M. "*Low-dimensional procedure for the characterization of human faces*", Journal of the Optical Society of America. A, Optics and image science, 4 (3), pp. 519-524, 1987.

[18] Kirby, M., Sirovich, L. "*Application of the Karhunen-Loeve procedure for the characterization of human faces*", IEEE Transactions on Pattern Analysis and Machine Intelligence, 12 (1), pp. 103-108, 1990.

[19] Kim, K.I., Jung, K., Kim, H.J. "*Face recognition using kernel principal component analysis*",IEEE Signal Processing Letters, 9 (2), pp. 40-42, 2002.

[20] Ming - Hsuan Yang, "*Kernel eigenfaces vs. Kernel Fisherfaces: Face recognition using kernel methods*", Proceedings of the fifth international conference on automatic face and gesture recognition 2002.

[21] Chen, T., Hsu, Y.J., Liu, X., Zhang, W. "*Principle component analysis and its variants for biometrics*" IEEE International Conference on Image Processing, 1, pp. I/61-I/64 2002.

[22] Yang, J., Yang, J.-Y. "*From image vector to matrix: A straightforward image projection technique-IMPCA vs. PCA*" Pattern Recognition, 35 (9), 2002

[23] Gottumukkal, Rajkiran., Asari, V.K. "*An improved face recognition technique based on modular PCA approach*" Pattern Recognition Letters, 25 (4), pp. 429-436, 2004.

[24] Oravec, M., Pavlovičová, J. "*Face recognition methods based on principal component analysis and feedforward neural networks*" IEEE International Conference on Neural Networks - Conference Proceedings, 1, pp. 437-441, 2004.

[25] Yang, J., Zhang, D., Frangi, A.F., Yang, J.-Y. "*Two-Dimensional PCA: A New Approach to Appearance-Based Face Representation and Recognition*" EEE Transactions on Pattern Analysis and Machine Intelligence, 26 (1), pp. 131-137, 2004.

[26] Liu, C. "*Gabor-based kernel PCA with fractional power polynomial models for face recognition*" IEEE Transactions on Pattern Analysis and Machine Intelligence, 26 (5), pp. 572-581, 2004.

[27] Zhang, D *Daoqiang*., Zhou, Z.-H. *"(2D)^2 PCA: Two-directional two-dimensional PCA for efficient face representation and recognition*" Neurocomputing, 69 (1-3), pp. 224-231, 2005.

[28] Kong, H., Wang, L., Teoh, E.K., Li, X., Wang, J.-G., Venkateswarlu, R. "*Generalized 2D principal component analysis for face image representation and recognition*" Neural Networks, 18 (5-6), pp. 585-594, 2005.

[29] Xie, X., Lam, K.-M. "*Gabor-based kernel PCA with doubly nonlinear mapping for face recognition with a single face image*" IEEE Transactions on Image Processing, 15 (9), pp. 2481-2492, 2006.

[30] Sanguansat, P., Asdornwised, W., Jitapunkul, S., Marukatat, S. "*Class-specific subspace-based two-dimensional principal component analysis for face recognition*" Proceedings - International Conference on Pattern Recognition, 2, art. no. 1699435, pp. 1246-1249, 2006.

[31] Gudur, N., Asari, V. "Gabor wavelet based modular PCA approach for expression and illumination invariant face recognition" Proceedings - Applied Imagery Pattern Recognition Workshop, 2006.

[32] Kurita, T., Hosoi, T., Hidaka, A. "*Principal component analysis of multi-view images for viewpoint-independent face recognition*" Proceedings - IEEE International Conference on Video and Signal Based Surveillance 2006.

[33] Dagher, I., Nachar, R. "*Face recognition using IPCA-ICA algorithm*" IEEE Transactions on Pattern Analysis and Machine Intelligence, 28 (6), pp. 996-1000, 2006.

[34] Wang, H., Yang, S., Liao, W. "*An improved PCA face recognition algorithm based on the discrete wavelet transform and the support vector machines*" Proceedings - International Conference on Computational Intelligence and Security Workshops, pp. 308-311, 2007.

[35] Ying, W., Pengfei, S. "*Image PCA: A new approach for face recognition*" ICASSP, IEEE International Conference on Acoustics, Speech and Signal Processing - Proceedings, 1, pp. I1241-I1244, 2007.

[36] Zhao, Deli., Lin, Z., Tang, X. "*Laplacian PCA and its applications*" Proceedings of the IEEE International Conference on Computer Vision, 2007,

[37] Mandal, T., Wu, Q.M.J. "*Face recognition using curvelet based PCA*" 19th International Conference on Pattern Recognition, ICPR 2008.

[38] Mazloom, M., Ayat, S. "*Combinational method for face recognition: Wavelet, PCA and ANN*" Proceedings - Digital Image Computing: Techniques and Applications, DICTA 2008, pp. 90-95.

[39] Li, C., Diao, Y., Ma, H., Li, Y. "*A Statistical PCA Method for face recognition*" Proceedings - 2nd International Symposium on Intelligent Information Technology Application, 2008, 3, pp. 376-380

[40] Lee, Y.-C., Chen, C.-H. "*Face recognition based on gabor features and two-dimensional PCA*" Proceedings - 4th International Conference on Intelligent Information Hiding and Multimedia Signal Processing, IIH-MSP 2008, pp. 572-576.

[41] Jun, Y., Hong-Zhao, Y., Xiu-Qiong, Z., Zhi-Sheng, G. "*Face recognition based on wavelet transform and image principle component analysis*" Proceedings of the International Conference on Computer and Electrical Engineering, ICCEE 2008, pp. 354-357

[42] He, D., Zhang, L., Cui, Y. "*Face recognition using (2D)2 PCA and wavelet packet decomposition*" Proceedings - 1st International Congress on Image and Signal Processing, CISP 2008, 1, pp. 548-553

[43] Boukabou, *Walid Riad*., Bouridane, A. "*Contourlet-based feature extraction with PCA for face recognition*" Proceedings of the NASA/ESA Conference on Adaptive Hardware and Systems, AHS 2008, pp. 482-486

[44] Zhao, M., Li, P., Liu, Z. "*Face recognition based on wavelet transform weighted modular PCA*" Proceedings - 1st International Congress on Image and Signal Processing, CISP 2008, 4, pp. 589-593

[45] The ORL Database of Faces, Available: http://www.uk.research.att.com/facedatabase.html

[46] N. Belhumeur, J. P. Hespanha, and D. J. Kriegman. "Eigenfaces vs. fisherfaces: recognition using class specific linear projection", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 19(7):711–720, July 1997.Fgfgg

[47] The Yale database, Available: http://cvc.yale.edu/

[48] F. Samaria and A. Harter. "*Parameterisation of a stochastic model for human face identification*", In *2nd IEEE Workshop on Applications of Computer Vision*, Sarasota, FL, 1994.