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Face Recognition Using Principal Component Analysis

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Abstract— Face recognition is one of the most relevant applications of image analysis. It's an efficient task (true challenge) to build an automated system with equal human ability to face recognised. Face is a complex 3D visual model and developing a computational model for face recognition is a difficult task. The paper presents a methodology for face recognition based on information theory approach of coding and decoding the face image. Proposed methodology is combination of two stages – Feature extraction using principle component analysis and recognition using the feed forward back propagation Neural Network. The proposed method has been tested on Oracle Research Laboratory (ORL) face database containing 400 images (40 classes). A recognition score for the test lot is calculated by considering almost all the variants of feature extraction. The test results gave a recognition rate of 99.50%.

***Keywords*—Face recognition, Principal component analysis (PCA), Artificial Neural network (ANN), Eigenvector, and Eigenfaces.**

1. INTRODUCTION

The face is the primary focus of attention and plays a major role in identification and establishing the uniqueness of a particular person from the rest of the human society. In spite of so many faces in the human society, there is remarkable ability of a human eye to recognized one face from another. A human can recognize thousands of faces learned throughout the lifetime and identify familiar faces at a glance even after years apart. This ability of human eye is quite effective, even though there are changes in the visual stimulus due to aging of a person, expression and change of looks due to glasses, beards or in hair style. There are many approaches such as security purpose, credit card verification, criminal identification etc. where the identification of a face plays an important role. A slight recognition of a particular person will be much better, in these kind of fields, than not even recognizing at all. Although it is clear that people are good at face recognition, but it's not obvious that a human brain can encoded or decoded for every face. Human face recognition has been studied for more than twenty years. Developing a suitable program which can be used digitally in recognizing a face is a quite challenging task, because human faces are complex and are different from each other in every aspect. So, developing such a kind of program is a difficult task in this digital world, which may involve earlier techniques, which was used for recognition of faces, to make it reliable. For face identification the starting step involves extraction of the relevant features from facial images. A big challenge is how to quantize facial features so that a computer should be able to identify a face. The study carried out by many researchers over the past several years indicates that certain facial characteristics are used by human beings to identify faces. Principle component analyses (PCA) is a classic tool widely used in the appearance based approaches for dimensionality reduction and feature extraction in most of the pattern recognition application. Hau T. Ngo et al. described a flexible and efficient architecture for real-time face recognition system based on modular Principal component Analysis method in an environment of FPGA, they showed that modular PCA improves the accuracy of face Recognition when face images have varying expression and illumination. The architecture was able to perform face recognition in 11ms for a database with 1000 face images [1].Boualleg proposed a new hybrid method for the face recognition by combining the neural networks with the Principal Component Analysis [2]. Sajid I et al. presented a High performance FPGA based Face recognition system, where they used fixed point technique with software hardware co-design methodology which reduces cycle and provides the flexibility in face[3].Hossein Sahoolizadeh proposed a new face recognition method based on PCA(principal Component Analysis) LDA(Linear Discriminant Analysis) and Neural Network. The proposed method was tested on orl database for face. Experimental results on this database rabel the effectiveness of the proposed method for face recognition with less misclassification in comparison with previous methods [4]. Sathaporn Visakhasart presented new multipipelined architecture for face recognition system on FPGA. This architecture helps to reduce the recognition time through its pipeline process and also encourage the reduction in hardware resources [5]. Karim has been developed the image processing and recognized the faces using PCA based face recognition techniques. And also implement based on MATLAB program to identify the face using Indian database and face recognition data. Matching unknown image with known image, different techniques like sum of absolute difference (SAD), Sum of squared difference (SSD), normalized cross correlation (NCC) etc. The performance of PCA-based face recognition system is

quite satisfactory [6]. Janarbek Matai et al. presented FPGA-based Real-Time Face Recognition System in which they design full face detection and recognition system on FPGA vertex 5. They used haar data for detection and Eigen[7]. Mohod approach rate the face recognition problem as an intrinsically two dimensional (2D) recognition problem rather than requiring recovery of 3D geometry, proceeds advantage of the fact that faces are normally upright and thus may be described by a small set of 2D characteristic views [8]. Rala M. Ebied describe a method of feature Extraction using PCA and Kernel-PCA for Face Recognition in which they investigates the nonlinear kernel function to improvement the principal component analysis (PCA) for feature extraction. The experiments carried out to investigate the performance of Kernel-PCA by comparing it with the performance of the PCA. Two kernel functions are used with the kernel-PCA, polynomial and Gaussian functions, to check which one achieved a better performance. The k-nearest neighbor classifier with Euclidean distance is used to investigate the performance of the Kernel-PCA and PCA for classification step [9]. Manal Abdullah study to optimize the time complexity of PCA (Eigenface) that does not affects the recognition performance [10].

There are two basic methods for recognized the face. The first method is based on feature extraction vectors from the basic parts of a face feature such as eyes, nose, mouth, and chin, with the assist of deformable templates and extensive mathematics. Then the key information from the basic parts of face is gathered and converted into a feature vector. Yullie and Cohen [11] used deformable templates in contour extraction of face images.

Another method is based on the information theory concepts viz. principal component analysis (PCA) method. In this method, information that best describes a face is derived from the entire face image. Based on the Karhunen-Loeve developed in pattern recognition, Kirby and Sirovich [12,13] used principal component analysis to efficiently represent the pictures of faces. Any face image could be around reconstructed by a small collection of weights for each face and a standard face picture, that is, eigen picture. The weights are obtained by projecting the face image onto the eigen picture. In mathematics, Eigenfaces are the set of eigenvectors which are the set of feature vector or characteristic used in the computer vision problem of human face recognition. The principal component of the distribution of faces or the eigenvectors of the covariance matrix of the set of face image is the Eigenfaces. Each face can be represented exactly by a linear combination of the Eigenfaces [14]. The best M eigenfaces construct an M dimension (M-D) space that is called the "face space" which is same as the image space. Turk and Pentland [15] proposed a face recognition method based on the Eigenfaces approach. Gumus , Ergun [16] present an evaluation of using various method for face recognition. According to their experiment the classification accuracy increasing dimension of training data set, chosen feature extraction-classifier pairs. Agarwal,M., [17] present a methodology for face recognition based on information theory approach of coding and decoding the face image.The Proposed method is connection of two stages-feature extraction using Principal component analysis and recognition using the feed forward back propagation neural network.

In this paper an unsupervised pattern recognition scheme, which is independent of excessive geometry and computation is proposed for a face recognition system. The system is implemented based on Eigenfaces, PCA and ANN. PCA for face recognition is based on the information theory approach in which the relevant information in a face image is extracted as efficiently as possible. Further ANN was used for classification. Neural Network notion is used because of its ability to learn from observed data.

Advantage and disadvantage of PCA

The advantages of PCA are listed below:

1) Lack of redundancy of data given the orthogonal components.

2) Reduced the complexity in face images grouping with the use of PCA

3) Smaller database representation since only the trainee images are stored in the form of their projections on a reduced basis.

4) Noise reduction since the maximum variation basis is chosen and so the small variations in the back ground are ignored automatically.

5)2DPCA over 1DPCA is that the feature vector is now two-dimensional so the problem of dimensionality is greatly reduced.

Table 1. The features of PCA are shown in the table below.

Feature	Principal component analysis
Discrimination between classes	PCA manages the entire data for the principal components analysis without taking into consideration the fundamental class structure.
Applications	PCA applications in the significant fields of criminal investigation are beneficial
Computation for large datasets	PCA does not require large computations
Direction of maximum discrimination	The directions of the maximum discrimination are not the same as the directions of maximum variance as it is not required to utilize the class information such as the within class scatter and between class scatter
Focus	PCA examines the directions that have widest variations
Supervised learning technique	PCA is an unsupervised technique.
Well distributed classes in small datasets	PCA is not as powerful as other methods.

Disadvantages of PCA are:

1) The covariance matrix is difficult to be evaluated in an accurate manner.

2) The simplest invariance could not be captured even by the PCA unless the training data explicitly provides this information.

3) PCA is a less sensitive to different training data set.

4) Computationally expensive and complex with the increase in data size.

5) Time complexity is high.

2. PROPOSED TECHNIQUE

The proposed technique is based on coding and decoding of face images with emphasis on the significant of local and global features of face. In this proposed method the relevant information in a face image is feature extracted, encoded and then compared with a face database of models and then classified with ANN. The primary advantage of the proposed method is independent of any judgment of features like open/closed eyes, different facial expressions images, with and without Glasses. The model of the face recognition system shown in Fig 1:

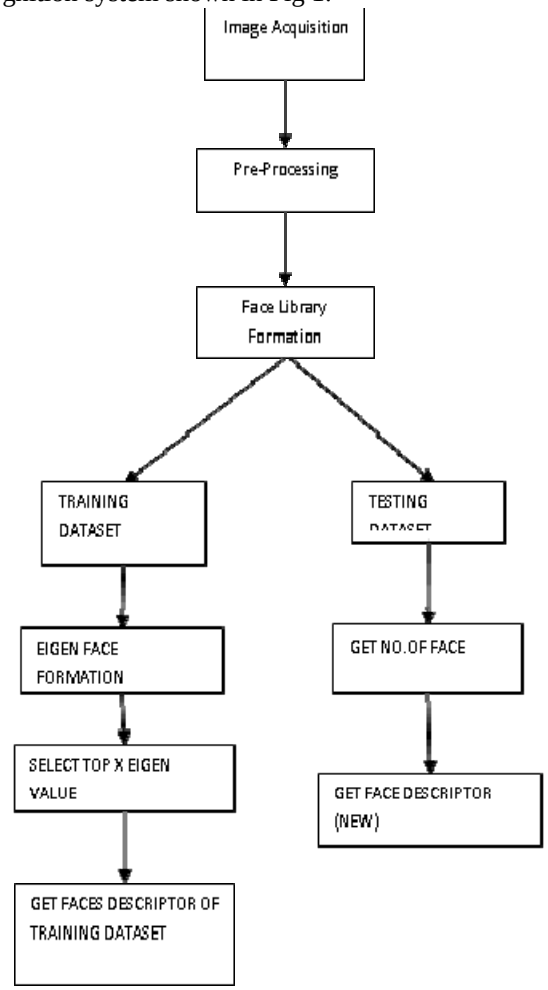

Fig. 1 – Face Library Formation and getting face Descriptor

3. PREPROCESSING AND FACE LIBRARY FORMATION

Image size normalization, histogram equalization and conversion into gray scale are used for preprocessing of the face image. This process automatically reduce every face image to X*Y pixels (based on user request) and distribute the intensity of face images (histogram equalization) in order to improve face recognition performance. In the system Face images are stored in a face library. Every exertion such as training set or Eigen face formation is performed on this face library. The face library is further divided into two sets – training dataset(60% of individual image) and testing dataset (rest 40% images). The process is described in Fig. 1.

Get the Face Descriptor Using Eigen Face

The face library entries are normalized. Eigenfaces are calculated from the training set and stored the data. An number of face can be represented exactly in terms of a linear combination of Eigenfaces. The face can also be approximated using only the best M eigen faces, that mean the largest eigen values. It interpretation for the most variance within the set of face images. Best M Eigenfaces span an M-dimensional subspace which is called the "face space" of all possible images. For calculating the Eigenfaces, the proposed PCA algorithm by Kirby and Sirovich [18,17] was used. It includes the calculation of the average face space and further the difference of average with each face. The difference covariance matrix (C) is used to compute for the dataset. The covariance matrix between two sets of data reveals how much the sets correlate. Based on the statistical technique called as PCA, the number of eigenvector for covariance matrix can be reduced from N (the number of pixels in image) to the number of images in the training dataset.

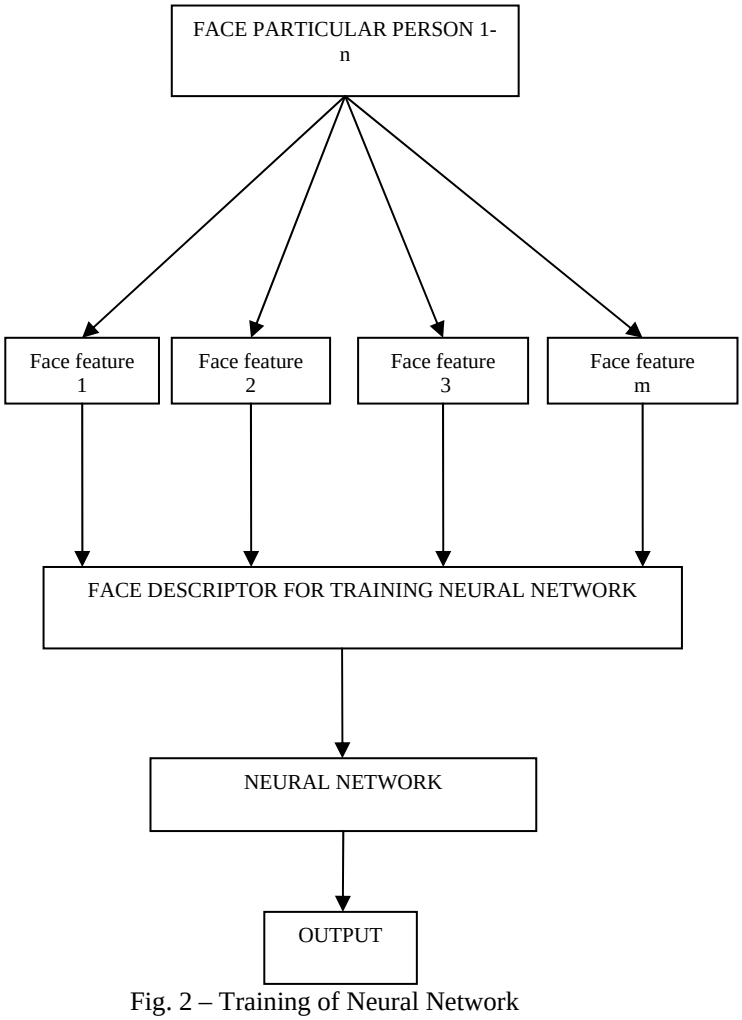

Fig. 2 – Training of Neural Network

Training of Neural Networks

Only one ANN is used in which the no. of face descriptor in the database are used an input to train the network. [19]. During training of the ANN's, the faces signifier that belong to same person are used as positive examples for the person's network (such that network gives 1 as output), and negative examples for the different network. Fig. 2 shows schematic diagram for the networks training

Simulation *of ANN for Recognition*

New test image is taken for recognition (from test dataset) and set face images signifier is calculated from the Eigenfaces (M) found before. These new signifier are given as an input to one network; further these networks are simulated. Contrast the simulated results and if the maximum output exceeds the predefined approach level, then it is assert that this new face belongs to the recognized person with the maximum output (fig. 3)

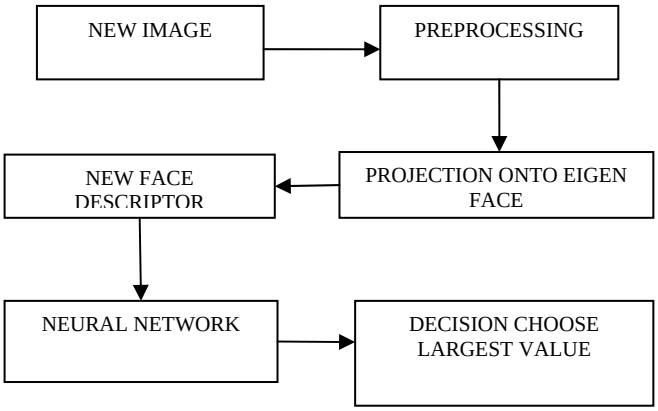

Fig. 3 – Testing of Neural Network

4. EXPERIMENT

The proposed method is tested on ORL face database. Database has more than set of image of an individual's face with different conditions like expression, illumination etc. There are ten different images of each of 40 perceptible subjects. Each image has the size of 112 x 92 pixels with 256 grey levels. For some subjects, the images were taken at assorted times, varying the lighting, facial expressions (open / closed eyes, smiling / not smiling) and facial details (glasses / no glasses). Each images were taken against a dark homogeneous background with the subjects in an upright, frontal position (with tolerance for some side movement). A view image of the Face Database is available (Fig. 5). The original pictures of 112 x 92 pixels have been resized to 56 x 46 so that the input space has the dimension of 2576.

Eigenfaces are calculated by using PCA algorithm and experiment is performed by varying the number of eigenfaces used in face space to calculate the face descriptors of the images. The numbers of network used are equal to number of subjects in the database.

The initial parameters of the Neural Network used in the experiment are given below:

- Type**:** Feed forward back propagation network
- Number of layers**:** 3 (input, one hidden, output layer)
- Number of neurons in input layer : Number of eigenfaces to describe the faces
  - Number of neurons in hidden Layer 10
    - Number of neurons in output Layer 1.
- Transfer function of the ith layer**:** Tansig
- Training Function**:** Trainlm
- Number of epochs used in training**:** 100
- Performance function**:** mse

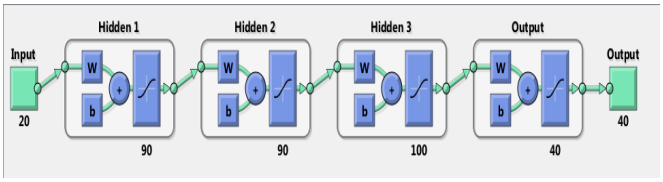

Fig.4: Network Architectur

Since the one network is equal to the number of people in the database, therefore forty networks, one network was created. Among the ten images, first 6 of them are used for training the neural networks, then these networks are tested and their properties are updated. The trained networks would be used later on for recognition purposes. For testing the whole database, the faces used in training, testing and recognition are changed and the recognition performance is given for whole database. The complete face recognition process is shown in Fig. 5.

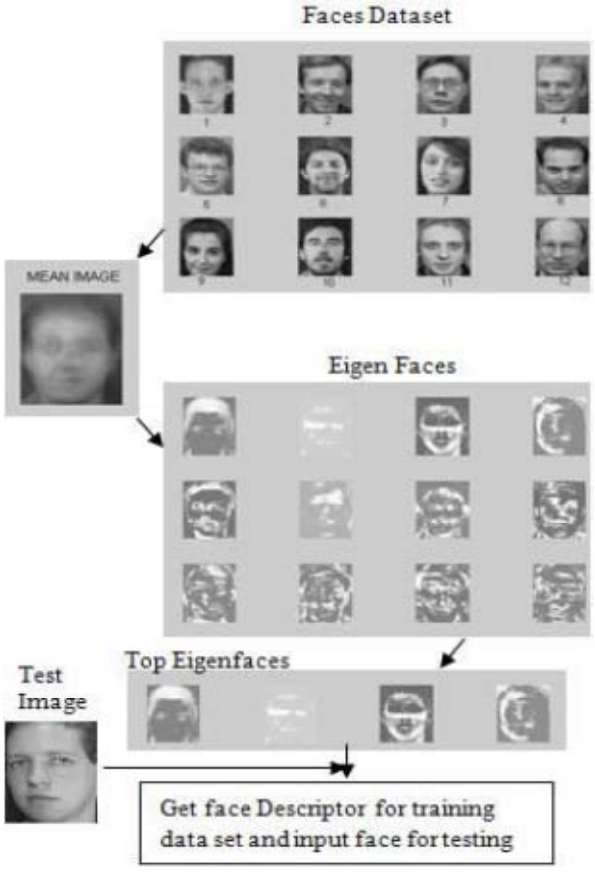

Fig. 5 – A complete process of PCA, Eigenface and ANN based faced recognition system

5. ANALYSIS

The proposed technique is analyzed by varying the number of eigenfaces used for feature extraction. The face recognition performance is shown in Table I. The result derived from proposed method is compared with the other techniques which are 1.

K-means [20], 2. Fuzzy Ant with fuzzy C-means. [20] Comparison of the result has been tabulated in Table I.Table II: Recognition score of Face recognition using PCA and ANN.

TABLE 1: Recognition Score Of face recognition using PCA and ANN (Training)

No.Of Face	Network Architecture	MSE	Percentage of classification	Iteration
20	80	0.0573	87.5000	234
	90 90 100	0.0160	99.500	208
	90 90 100 100 100	0.0101	99.235	115
30	80	0.1287	34.5833	97
	90 90 100	0.0214	99.5833	166
	90 90 100 100 100	0.0613	87.9167	246
40	80	0.0742	79.1667	147
	90 90 100	0.0301	97.0833	140
	90 90 100 100 100	0.0224	99.1667	119
50	80	0.1336	29.1667	74
	90 90 100	0.0322	97.0833	196
	90 90 100 100 100	0.0248	99.1667	148
60	80	0.1387	24.1667	85
	90 90 100	0.0460	93.7500	95
	90 90 100 100 100	0.0325	97.9167	150
70	80	0.1306	34.5833	92
	90 90 100	0.0470	92.0833	162
	90 90 100 100 100	0.0352	96.6667	162
80	80	0.0612	86.6667	117
	90 90 100	0.0675	83.333	120
	90 90 100 100 100	0.0319	96.6667	155
90	80	0.0686	81.6667	117
	90 90 100	0.0583	87.0833	96
	90 90 100 100 100	0.0338	96.2500	135
100	80	0.1213	41.6667	67
	90 90 100	0.0269	98.333	122
	90 90 100 100 100	0.0435	93.7500	139

TABLE 2: Recognition Score Of face recognition using PCA and ANN (Testing)

No. of Face	Network Architecture	MSE	Percentage of classification
20	80	0.0344	89.3300
	90 90 100	0.0289	93.120
	90 90 100 100 100	0.0201	94.135
30	80	0.1287	31.6533
	90 90 100	0.0214	92.6833
	90 90 100 100 100	0.0613	81.1167
40	80	0.0742	71.1367
	90 90 100	0.0301	90.0833
	90 90 100 100 100	0.0224	94.1067
50	80	0.1336	22.2867
	90 90 100	0.0322	92.5033
	90 90 100 100 100	0.0248	94.2607
60	80	0.1387	22.0667
	90 90 100	0.0460	90.6500
	90 90 100 100 100	0.0325	91.0167
70	80	0.1306	31.4833
	90 90 100	0.0470	88.0833
	90 90 100 100 100	0.0352	92.6667
80	80	0.0612	86.6667
	90 90 100	0.0675	81.333
	90 90 100 100 100	0.0319	89.5667
90	80	0.0686	76.5867
	90 90 100	0.0583	81.1833
	90 90 100 100 100	0.0338	86.2500
100	80	0.1213	36.6667
	90 90 100	0.0269	92.333
	90 90 100 100 100	0.0435	85.7500

CONCLUSION

The paper presents a face recognition approach using PCA and Neural Network techniques. The result is compared with several techniques and proposed technique gives a better recognition rate then the other techniques. In the Table.1 can see the recognition rate by varying the eigenfaces and the maximum recognition rate obtained for the whole dataset is 99.500. M Eigenfaces (u_i) of highest eigenvalue are actually needed to fabricate a complete basis for the face space.

The Eigenfaces method is very sensitive to head orientations, and most of the distinct occur for the images with large head orientations. By choosing PCA as a feature selection technique (for the set of images from the ORL Database of Faces), one can reduce the space dimension from 2576 to 50 (equal to no. of selected eigenfaces of highest eigenvalue).

REFERENCES

1. Ngo. H. T, Gottumukkal. R , and Asari. V. K, "A flexible and efficient hardware architecture for realtime face recognition based on eigenface," in IEEE Computer Society Annual Symposium on VLSI, 2005.
2. Boualleg. A. H., Bencheriet Ch, and Tebbikh. H, "Automatic Face recognition using neural network-PCA." In *Information and Communication Technologies, 2006. ICTTA'06. 2nd*, vol. 1, pp. 1920-1925. IEEE, 2006.
3. Sajid. I., Ahmed M. M., Kresimir Delac, Mislav Grgic, Sonja Grgic," Independent Comparative Study of PCA, ICA, and LDAon the I. Taj, M. Humayun, and F.Hameed,"Design of high performance fpga based face recognition system," in PIERS Proceedings, Cambridge, USA, July 2-6, 2008, pp.504-510
4. Sahoolizadeh. A , Hossein.B , Zargham Heidari, and Hamid Dehghani.C "A new face recognition method using PCA, LDA and neural network." *International Journal of Computer Science and Engineering* 2, no. 4 (2008): 218-223.
5. Sathaporn Visakhasart, Orachat Chitsobhuk, "Multi- Pipeline architecture for face recognition on FPGA,"International Conference on digital Image Processing, 2009, pp.152-156.
6. Karim,T.F,Lipu,M.S.H, Rahman, M.L., & Sultana ,F.Face Recognition Using PCA-based method. In advanced Management Science (ICAMS) 2010.IEEE International Conference on (Vol.3,pp.158-162).
7. Janarbek Matai, Ali Irturk and Ryan Kastner," Design and Implementation of an FPGA-based Real-Time Face Recognition System", in IEEE International Symposium on Field Programmable Custom Computing Machines, 2011, pp 97-100.
8. Mohod, Prakash S., and Kalpna C. Jondhale. "Face Recognition Using PCA. "*International Journal of Artificial Intelligence and Knowledge Discovery* 1, no. 1 (2011): 25-28.
9. Rala M. Ebied," Feature Extraction using PCA and Kernel-PCA for Face Recognition", in The 8th International Conference on INFOrmatics and Systems Computational Intelligence and Multimedia Computing Track , 2012 ,pp mm72-mm77
10. Abdullah, Manal, Majda Wazzan, and Sahar Bo-saeed. "Optimizing Face Recognition Using PCA." *arXiv preprint arXiv:1206.1515* (2012).
11. Yuille, Alan L., Peter W. Hallinan, and David S. Cohen. "Feature extraction from faces using deformable templates." *International journal of computer vision* 8, no. 2 (1992): 99-111.
12. Kirby, Michael, and Lawrence Sirovich. "Application of the Karhunen-Loeve procedure for the characterization of human faces." *Pattern Analysis and Machine Intelligence, IEEE Transactions on* 12, no. 1 (1990): 103-108.
13. Sirovich, Lawrence, and Michael Kirby. "Low-dimensional procedure for the characterization of human faces." *JOSA A* 4, no. 3 (1987): 519-524.
14. Moon, Hyeonjoon. "Biometrics person authentication using projection-based face recognition system in verification scenario." In *Biometric Authentication*, pp. 207-213. Springer Berlin Heidelberg, 2004.
15. Turk, Matthew, and Alex Pentland. "Eigenfaces for recognition." *Journal of cognitive neuroscience* 3, no. 1 (1991): 71-86.
16. Gumus,Ergun,et.al., " Evaluation of Face Recognition Techniques Using PCA,Wavelet and SVM ",Expert System with Application 37.9(2010) : 6404-6408.
17. Agarwal, Mayank, Himanshu Agrawal, Nikunj Jain, and Manish Kumar. "Face recognition using principle component analysis, eigenface and neural network." In *Signal Acquisition and Processing, 2010. ICSAP'10. International Conference on*, pp. 310-314. IEEE, 2010.
18. Kirby, Michael, and Lawrence Sirovich. "Application of the Karhunen-Loeve procedure for the characterization of human faces." *Pattern Analysis and Machine Intelligence, IEEE Transactions on* 12, no. 1 (1990): 103-108.
19. Victor-Emil and Luliana-Florentina, "*Face Recognition using a fuzzy – Gaussian ANN*", IEEE 2002. Proceedings, Aug. 2002 Page(s):361 – 368.
20. Wijaya.S.L, M. Savvides, and B. V. K. V. Kumar, "*Illumination-tolerant face verification of low-bitrate JPEG2000 wavelet images with advanced correlation filters for handheld devices*," Applied Optics, Vol.44, pp.655-665, 2005.
21. Gong, Shaogang, Stephen J. McKenna, and Alexandra Psarrou. *Dynamic vision: from images to face recognition*. Imperial College Press, 2000.
22. Acosta, Emiliano, Luis Torres, Alberto Albiol, and Edward Delp. "An automatic face detection and recognition system for video indexing applications." In *Acoustics, Speech, and Signal Processing (ICASSP), 2002 IEEE International Conference on*, vol. 4, pp. IV-3644. IEEE, 2002.
23. Manjunath, B. S., Rama Chellappa, and Christoph von der Malsburg. "A feature based approach to face recognition." In *Computer Vision and Pattern Recognition, 1992. Proceedings CVPR'92., 1992 IEEE Computer Society Conference on*, pp. 373-378. IEEE, 1992.
24. Demuth, Howard, and Mark Beale. "*Neural network toolbox for use with MATLAB*." (1993).