1. Introduction

Face Recognition System is a computer based digital technology and is an active area of research. The Face Recognition System has various applications like various authentication systems, security systems and searching of persons etc. These applications are cost effective and save the time. Moreover the face database can be easily designed by using any image of the person. In past few years various face recognition techniques are purposed with varied and successful results.

The Principal Component Analysis (PCA) is one of the most successful techniques that have been used in image recognition and compression. PCA is a statistical method under the broad title of factor analysis. The purpose of PCA is to reduce the large dimensionality of the data space (observed variables) to the smaller intrinsic dimensionality of feature space (independent variables), which are needed to describe the data economically. This is the case when there is a strong correlation between observed variables.

The jobs which PCA can do are prediction, redundancy removal, feature extraction, data compression, etc. Because PCA is a classical technique which can do something in the linear domain, applications having linear models are suitable, such as signal processing, image processing, system and control theory, communications, etc.

Face recognition has many applicable areas. Moreover, it can be categorized into face identification, face classification, or sex determination. The most useful applications contain crowd surveillance, video content indexing, personal identification (ex. driver’s licence), mug shots matching, entrance security, etc. The main idea of using PCA for face recognition is to express the large 1-D vector of pixels constructed from 2-D facial image into the compact principal components of the feature space. This can be called eigenspace projection. Eigenspace is calculated by identifying the eigenvectors of the covariance matrix derived from a set of facial images(vectors).

In this paper, the features of the face images are extracted by creating the feature vectors of maximum varied face points and computing s Covariance column matrix using PCA. These faces are projected onto the face space that spans the significant variations in the face images stored in the database [7]. These feature vectors are the eigenvectors of covariance matrix and having the face like appearance so that we call them eigenfaces which are used as input to train the Artificial Neural Networks. The learning of the correlated patterns between the input face images is one of the useful properties of Artificial Neural Networks. After training the Artificial Neural Networks, we tested it with known and unknown face images for success and rejection rate analysis. Database used in this work contains 400 different face images of 40 persons resized to 112×92 pixels.

1. Related Works

Feature extraction of the human faces by PCA based eigenface approach reduces the high dimensional space into very low dimensions. There are various successful methodologies are purposed in past decades. In 1990, Kirby and Sirovich [5] have shown that the face images can be represented in terms of a best coordinate system termed as "eigenfaces". These are the eigenfunctions of the average covariance of the ensemble of faces. They also purposed that even for large number of faces, the small number of eigenfaces needed. In 1991, M.A. Turk and A.P. Pentland [7] proposed a face recognition method based on the eigenfaces representation of faces. Various feature extraction methods for face images purposed in last years as Linear Discriminant Analysis (LDA), Kernel methods, Evolutionary Pursuit (EP) Support Vector Machine (SVM) and Artificial Neural Networks(ANN). LDA is a supervised learning algorithm. LDP features are obtained by computing the edge response values in all eight directions at each pixel position. All projected samples will form the maximum between-class scatter and the minimum within-class scatter simultaneously in the projective feature space. Each face is represented as a collection of LDP codes for face recognition process [10].

Evolutionary Pursuit (EP) is a genetic algorithm which resolves the problem of the dimension of the solution space. It is an eigenspace-based adaptive approach that searches for the best set of projection axes in order to maximize a fitness function, measuring at the same time the classification accuracy and generalization ability of the system [9].Kernel methods provide a generalization of linear methods. Direct non-linear manifold schemes are explored to learn this non-linear manifold [11]. Support Vector Machine (SVM) finds the hyperplane that separates the largest possible fraction of points of the same class on the same side, while maximizing the distance from either class to the hyperplane. PCA is first used to extract features of face images and then discrimination functions between each pair of images are learned by SVMs [12]. Artificial Neural Networks (ANN) is a very robust and powerful classification technique that has been used to approximate real-valued, discrete-valued and vector-valued functions from various examples [13]. In 1990, Fleming and Cottrell [14] train the system by back propagation using nonlinear units. Learning ability of neurons is used to analyse the different face distances and the parts of backgrounds by training the network.

This proposed work explains a complete face recognition system by combining the Principal Components Analysis (PCA) based feature extraction with Artificial Neural Networks (ANN) based detection system for improving the success rate and defining the rejection rate. The work is shown using 40 face images database with MATLAB simulation

1. Feature Extraction

Features of the face images are extracted using PCA in this purposed methodology. PCA is dimensionality reduction method and retain the majority of the variations present in the data set. It capture the variations the dataset and use this information to encode the face images. It computes the feature vectors for different face points and forms a column matrix of these vectors. PCA algorithm steps are shown in Fig. 1.



Fig.1 PCA Feature extraction block diagram

PCA projects the data along the directions where variations in the data are maximum. The algorithm is follows as:

1. Assume the m sample images contained in the database as **A1, A2, A3………Am.**
2. Calculate the average image, Ø, as: **Ø= Σ Al /M,** where 1< L<M, each image will be a column vector the same size.
3. The covariance matrix is computed as by **C = ATA** where **A = [O1 O2 O3….Om]**.
4. Calculate the eigenvalues of the covariance matrix **C** and keep only **k** largest eigenvalues for dimensionality reduction as **λk = Σmn=1(UKT On)**.
5. Eigenfaces are the eigenvectors UK of the covariance matrix C corresponding to the largest eigenvalues.
6. All the centered images are projected into face space on eigenface basis to compute the projections of the face images as feature vectors as: **w** = **UTO** = **UT** (**Ai** - **Ø**), where 1< i<m.

PCA method computes the maximum variations in data with converting it from high dimensional image space to low dimensional image space. These extracted projections of face images are further processed to Artificial Neural Networks for training and testing purposes

1. Psudo Code for Computing of PCA:

* Principal component analysis (PCA) extracts facial features for recognition
* Transforms face images into a small set of characteristic feature images called eigenfaces
  + i.e main function of PCA is to reduce the higher dimensional dataset (MxN) to less dimensional data set(PxN), where P<M,
  + In our implementation
    - M = 10304, N = 400, P = 9 (Nine principal components)
    - So reducing 10304x400 to 9x400 is the goal.
* Finding eigen vectors and eigen values
  + [U,D] = eig(covariance); U is Principal component matrix,
  + extract diagonal of matrix as vector
  + eigValue = diag(D);
  + sort the variances in decreasing order
  + [eigValue,IX]=sort(eigValue,'descend')
  + L\_eig\_vec=U(:,IX); sorted principal components of size 400x400
* Finding eigen faces
  + Eigenfaces = A \* L\_eig\_vec(:,1:dim); here dim = 9, i.e we are only taking 9 principal components
  + Eigenfaces = 10304X9 (i.e MxN \* NxP = MxP)
* Projecting each images using eigenfaces and mean
  + Take each image from original data set n subtract with mean and multiply with eigenfaces
  + Difference = Data(:,i) – Mn ( taking each image vector n making mean centered)
  + Difference = 10304x1
  + Projected image = Eigenfaces'\*Difference ; ( transpose of eigen faces and the difference to get the projected Image. )
  + Projected image = 9x1 ( 9x10304\*10304x1 = 9x1)
  + Above stepes to be repeated for all imagages
  + Final Dataset we get from PCA is
    - Final Projected images is = 9x400
  + I.e From 10304x400 = 9x400

1. Artificial Neural Networks

As the human brain consist of complex interconnected neurons to process the different task. This neuron does not depend on each other and work in asynchronous manner. They can resolve the complex and noisy data problems. Artificial Neural Networks (ANN) learns the correlated patterns of input and target values. ANN is inspired by the human biological nervous system.

For Face Recognition purpose, the learning process of ANN is used with back propagation algorithm. Back Propagation is a feed forward supervised learning network. There are many types of ANN like Multilayered Perceptron, Kohonen networks and Radial Basis Function. The multilayered feed forward neural networks consist of the three layers as input layer, hidden layer and output layer as shown in Fig. 2. These layers of processing elements make independent computation of data and pass it to another layer. The computation of processing elements is completed on the basis of weighted sum of the inputs. The output is compared with the target value and the mean square error is calculated which is processed back to the hidden layer to adjust its weights. This process occurs iteration for each layer to minimize the error by repeatedly adjusting the weight of each layer. Hence, it is called the back propagation. The iteration process carried on until the error falls below the tolerance level.



Fig. 2 The basic architecture of multilayered ANN

The multilayered ANN has the different layers of processing elements. In face recognition system using ANN, the model works in the following frames:-

**Input to Feed Forward Network:** First, the parameters are selected for required Neural Networks operation i.e. the number of input layers, hidden layers and output layers. These input neurons receive the inputs signal from the training data of face images. Each input has its own weights.

**Back Propagation and weight Adjustment:** - The input layer processes the data to the hidden layer which computes the data further and passes it to the output layer. Output layer compare it with the target value and obtain the error signals. These errors are sent back for adjusting the weights of each layer to minimize the error as shown in Fig. 3



Fig. 3 Back Propagation of multilayered ANN

1. Implementation Process

In this work, the features of the face images are extracted using PCA which extracts the variations in the features of face images which contains the highest information with decomposed dimensions



Fig. 4 Basic blocks for Face Recognition

Extracted features compute the eigenfaces which are taken as input to the Artificial Neural Networks to train the neural networks. For testing purpose, the eigenface of the tested image is provided as input to the trained neural networks and it finds the best match considering the threshold value for rejecting the non-human and unknown face images

1. *Training the ANN with Input Face Images* Back Propagation feed forward Artificial Neural Network (ANN) is used for training the input face images. The computed eigenfaces of the input face images are fed to the neural networks. The number of neural networks taken based on the number of different input face images. As we have taken the 9 networks for nine different face images. The parameters selected for the ANN are mentioned in Table I. After setting the parameters neural networks are trained with eigenfaces of the input images via input layer, hidden layer and output layer. Each eigenface image distance is compared with each other. The eigenfaces images of same person have the zero distance between them and output is taken as 1 otherwise output taken as 0.The mathematical function values for each eigenface image are used to compare the eigenface images. In this work, the mathematical function Log-sigmoid is used as mentioned in the Table I. For the eigenfaces of same person, the specific neural network provides the output as 1 and for the eigenfaces of other person it provides the output as 0. Now, only the known faces are recognized as output 1.Hence, Neural Network forms an Identity matrix for different face images using the outputs 1’s and 0’s as shown in Fig. 5.

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Fig. 5 Identity Matrix for Trained Face Images

The errors in the output layer are sent back to the previous layers and update the weights of these layers which minimize the error. The momentum and learning rate parameters counts the updates from previous iterations and recalculates the new updated output. The iteration used is 1000 and the errors are minimized to value 0.001

1. *Testing the ANN with Tested Face Image* For face recognition, the eigenfaces images of the test face image is calculated by feature extraction based on PCA. This eigenface image is fed to the each trained neural network. The tested eigenface is compared with the eigenfaces of the trained neural network for best match using the Log-sigmoid function values. As the threshold value is set which is the 25% of the best distance. If the minimum distance between the tested eigenface image and the trained input eigenface image is less than the threshold value, then the output of specific network is 1 and the trained eigenface image is selected from the Identity matrix described in Fig. 5 as an output image and further recognized as a resulted face image otherwise the test face image is rejected as non-human or unknown face image.
2. Results: TBA
3. References:

[1] Kolhandai Yesu, Kaveri Chetia and Himadri Jyoti Chakravorty.’’ Innovative Feature Extraction Method for Artificial Neural Network Based Face Recognition” 978-1-4577-0748-3/12,IEEE- 2012.

[2] Khashman, A, "Intelligent Face Recognition: Local versus Global Pattern Averaging", In Lecture Notes in Artificial Intelligence, 4304, Springer-Verlag, 2006, pp. 956 -961.

[3] RaphaeÈ l FeÂ raud, Olivier J. Bernier, Jean-Emmanuel Viallet, and Michel Collobert.” A Fast and Accurate Face Detector Based on Neural Networks”, IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE, VOL. 23, NO. 1, JANUARY 2001.

[4] Alex Pentland, Baback Moghaddam, and Thad Starner, “View-Based and Modular Eigenspaces for Face Recognition”, IEEE Conf. on Computer Vision and Pattern Recognition, MIT Media Laboratory Tech. Report No. 245 1994.

[5] Kirby, M., and Sirovich, L., "Application of the Karhunen-Loeve procedure for the characterization of human faces", IEEE PAMI, Vol. 12, pp. 103-108, (1990).

[6] Sirovich, L., and Kirby, M., "Low-dimensional procedure for the characterization of human faces", J.Opt. Soc. Am. A, 4, 3,pp. 519-524,(1987).

[7] Turk, M., and Pentland, A., "Eigenfaces for recognition", Journal of Cognitive Neuroscience, Vol. 3, pp. 71-86, (1991).

[8] Kohonen T.,(1989). Self-organization and associative memory. Berlin: Springer-Verlag.

[9] C. Liu, H. Wechsler, Evolutionary Pursuit and Its Application to Face Recognition, IEEE Trans. on Pattern Analysis and Machine Intelligence, Vol. 22, No. 6, June 2000, pp. 570-582.

[10] Li-Fen Chen,Hong-Yuan Mark Liao,Ming-Tat Ko,Ja-Chen Lin and Gwo-Jong Yu,” A new LDA-based face recognition system which can solve the small sample size problem” Pattern Recognition 33,The journal of Pattern Recognition Society (2000) ,pp 1713-1726.

[11] F.R. Bach, M.I. Jordan, Kernel Independent Component Analysis, Journal of Machine Learning Research, Vol. 3, 2002, pp. 1-48.

[12] G. Guo, S.Z. Li, K. Chan, Face Recognition by Support Vector Machines, Proc. of the IEEE International Conference on Automatic Face and Gesture Recognition, 26-30 March 2000, Grenoble, France, pp. 196-201.

[13] T.Mitchell, Machine Learning, *McGraw Hill*, 1997.

[14] Fleming,M. & Cottrell, G. (1990). Categorization of faces using unsupervised feature extraction. *Proceedings of IJCNN-90, 2.*

[15] Adjoudj Réda and Dr Boukelif Aoued,”Artificial Neural Network-Based Face Recognition”, IEEE- 2004.