July - Sep © 2015 Transactions; 2(7): 330-336

International Journal of Research and Applications

ISSN (online): 2349-0020 ISSN (print): 2394-4544 http://www.ijraonline.com/

Research Article

A Novel Face Recognition Approach Using Modular PCA with Neural Networks

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DOI:
http://dx.doi.org/
10.17812/IJRA.2.7(57)2015

Manuscript:
Received: 2nd July, 2015
Accepted: 30st Aug, 2015
Published: 19th Sep, 2015

Publisher:
Global Science Publishing Group, USA
http://www.globalsciencepg.org/

ABSTRACT

Face recognition facilitates a questioning problem in the area of image processing and artificial intelligence. It has achieved a great deal of importance from the last few years because of its uses in various streams. Face recognition techniques can be divided into many categories based on the face data acquisition methodology: methods that deal with images and videos. In this paper, overviews of some of the methods are provided. This paper also mentions an idea of the novel technique that is Face Recognition using Modular PCA with Neural Networks for the efficient face recognition technology. By using the individual PCA method will not provide the accurate recognition rate as it only reduces the dimensionality of the image and fasters the recognition but it cannot solve the illumination problems. Neural networks method alone also gives better accuracy and recognition rate but it cannot determine the expressions of the face. Therefore, by combining PCA with its modules to the Neural networks will give a better performance of face recognition in all aspects.

Keywords: Face recognition system, Principal components Analysis (PCA), Modular PCA Artificial Neural network (ANN), Back Propagation Algorithm.

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IJRA - Year of 2015 Transactions:
Month: July - September
Volume – 2, Issue – 7, Page No's:330-336
Subject Stream: Computers

Paper Communication: Author Direct

Paper Reference Id: IJRA-2015: 2(7)330-336

DOI: 10.17812/IJRA.2.7(57)2015

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eISSN : 2349 - 0020
pISSN : 2394 - 4544

COMPUTERS RESEARCH ARTICLE

A Novel Face Recognition Approach Using Modular PCA with Neural Networks

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ABSTRACT

Face recognition facilitates a questioning problem in the area of image processing and artificial intelligence. It has achieved a great deal of importance from the last few years because of its uses in various streams. Face recognition techniques can be divided into many categories based on the face data acquisition methodology: methods that deal with images and videos. In this paper, overviews of some of the methods are provided. This paper also mentions an idea of the novel technique that is Face Recognition using Modular PCA with Neural Networks for the efficient face recognition technology. By using the individual PCA method will not provide the accurate recognition rate as it only reduces the dimensionality of the image and fasters the recognition but it cannot solve the illumination problems. Neural networks method alone also gives better accuracy and recognition rate but it cannot determine the expressions of the face. Therefore, by combining PCA with its modules to the Neural networks will give a better performance of face recognition in all aspects.

Keywords: Face recognition system, Principal components Analysis (PCA), Modular PCA Artificial Neural network (ANN), Back Propagation Algorithm.

I. INTRODUCTION

A Biometric-based technology involves the identification of a person based on physical characteristics such as face, fingerprints, palm, iris, retina, ear and voice. Working with face recognition is different than other biometrics because face is a complex and multi dimensional aspect. So, face recognition is a very high level computer vision task [1].

Face recognition seems to be a very good source of providing many advantages over other biometric methods, a few of which are: Almost all the other biometric technologies need some action by the user, i.e., the user used to keep his hand on a static object for finger detection and has to stand in a fixed position in front of a camera for iris or retina identification. However, face recognition can be done without any external action of the user. Face images can be captured from a distance by a camera. This is mainly useful for security and surveillance purposes. There will be some problems with other techniques that related to hands and fingers may not be detected accurately at the time of upper tissue of the skin was damaged. Iris and retina identification require expensive equipment. Voice recognition also cannot be detected properly due to the background noises in public places and any network issues on a phone line and unnecessary noise while recording tape. Signatures can also be modified or forged. Anyhow, facial images can be easily recognized with few cameras. By using the face as the basic biometric for a

person identification is not an easy task. We have to use many algorithms and techniques to recognize a face based on the features. For detecting a face there are some aspects which need to be fulfilled they are pose and illumination variations and can also detect the expression of the person.

Face recognition is used mainly for two tasks:
1. Verification: when an unknown person's face image is given with his identity details and deciding whether the person is valid or not.
2. Identification: when a face image of an individual is given and it is compared with the image in the database to determine the identity of a person.

There are many application areas in which face recognition can be exploited for these two purposes, a few of which are given below.
• Security (access control to buildings, airports/seaports, ATM machines and border checkpoints, network security, email authentication on multimedia applications).
• Surveillance (a huge number of CCTVs can be used to look for known criminals, drug offenders, etc. and when the criminal is captured then the information will be given to the authorities.

• Person's identity verification (electoral registration, banking, electronic commerce, identifying newborns, national IDs, passports, drivers' licenses, employee IDs).
• Criminal justice systems (booking systems, post-event analysis, forensics).
• Image database investigations (searching image databases of licensed drivers, benefit recipients, missing children, immigrants and police bookings).
• "Smart Card" applications (maintaining a database of facial images, the face can be stored in a smart card, bar code or magnetic stripe, authentication of which is performed by matching the live image and the stored template).
• Multi-media environments with adaptive human computer interfaces (behavior monitoring at childcare or old people's centers, recognizing a customer and assessing his needs).
• Video indexing (labeling faces in video).
• Witness face reconstruction.

2. RELATED WORK

Principal Component Analysis
The PCA algorithm has been widely applicable for performing face recognition. PCA is an unsupervised technique, so the method does not depend on class information [4]. The faces were approximately reconstructed and can be performed using a weighted combination of eigenvectors, which was proposed by Sirovich and Kirby, 1987. The weights that are accessed by the given image in the form of eigen images are taken as global facial features. In an extension to that, Kirby and Sirovich (1990) included the inherent symmetry of faces in the eigen pictures.

The basic idea of eigen faces is that all face images are similar in all configurations and they can be described in its basic face images. Based on this idea, the eigen faces method is as follows:
a) We suppose the training sets of images are Γ1, Γ2, Γm with each image is I (x, y). Convert each image into set of vectors and new matrix (m×p), where m is the number of training images and p is x × y.

b) Find the mean face:

$$\varphi = \frac{1}{m}\sum_{i=1}^{m} \Gamma i \qquad (1)$$

c) Calculate the mean-subtracted face:

$\Phi i = \Gamma i - \Psi$, $i = 1, 2, \ldots, m$ (2)

A = [Φ1,Φ2 ,…,Φ*m*] is the mean-subtracted matrix vector with its size *Amxp*.

d) By implementing the matrix transformations, the vectors matrix is reduced by:

$$Cmxn = Amxp \times A_m^T \qquad (3)$$

Where *C* is the covariance matrix and *T* is transposing matrix.

e) Find the eigenvectors, Vmm and eigenvalues, λm from the C matrix using

Jacobi method and the eigenvectors by highest eigenvalues. Jacobi's method is chosen because its accuracy and reliability are higher than other method.

f) Apply the eigenvectors matrix, Vmm and adjusted matrix, Φm. These vectors determine linear combinations of the training set images to form the eigenfaces, Uk by:

$Uk=\Phi_n V_{kn}$ $k=1,2\ldots,m$ (4)

Instead of using m eigenfaces, $m'\_<\_m$ which we consider the image provided for training are more than 1 for each individual or class. m' is the total class used.

g) Based on the eigenfaces, each image have its face vector by:

$Wk= Tk\ U\ (\Gamma -\Psi)$, $k = 1,2,\ldots,m'$ (5)

and mean subtracted vector of size (p×1) and eigen faces is Upm'. The weights form a feature vector:

$\Omega T = [w1, w2\ldots\ wm']$

h) A face can be reconstructed by using its feature, ΩT vector and previous eigen faces, Um′ as :

$\Gamma' = \Psi +\Phi f$ (6)

Where $\Phi_f = \sum_{i=1}^{m} w_i U_i$.

Problems of PCA Approach

The tests conducted on various subjects in different environments shows that this approach has limitations over the variations in illumination, size and in the head rotation, otherwise this method gives very good recognition of faces(>85% success rate). A noisy image or partially occluded face leads the reduction in the recognition performance.

3. PROPOSED SYSTEM:

Problem Definition:

PCA algorithm performs well for reducing dimensionality but it cannot recognize for images of illumination and poses. So, by dividing the image into modules and calculating the eigen values individually and then by integrating all will give accuracy and for classification and recognition we can perform back propagation neural network algorithm. The recognition performance increases due to the increase in face images in the training set. This is because more sample images can characterize the classes of the subjects better in the face space. Hence it is concluded that this method has an acceptance ratio of more than 90% and the execution time of only a few seconds. Main advantage of this back propagation algorithm is that it can identify the given image as a face image or non face image and then recognizes the given input image. So to attain the better performance in accuracy and speed and also to solve the problems of illumination and pose variations of the face images this paper will provide the solution. Thus the back propagation neural network classifies the input image as recognized image. The Back Propagation Neural Network algorithm with MPCA is more accurate and quick than PCA alone.

Modular PCA:

The PCA based face recognition method is not very effective under the conditions of varying pose and illumination, since it considers the global information of each face image and represents them with a set of weights [7]. If the face images were divided into smaller regions and the weight vectors are computed for each of these regions, then the weights will be more appropriate of the local information of the face. When there is a variation in the pose or illumination, only some of the face regions will vary and the rest of the regions will remain the same as the face regions of a normal image. Hence weights of the face regions will not affect by varying pose and illumination will closely match with the weights of the same person's face regions under normal conditions. Therefore it is confirmed that by applying the modular PCA approach an improved recognition rates can be obtained.

In this method, each image in the training set is divided into N smaller images. Hence the size of each sub-image will be $L^2=N$. These

sub-images can be represented mathematically as

$$I_{ij}(m,n) = I_i\left(\frac{L}{\sqrt{N}}(j-1)+m, \frac{L}{\sqrt{N}}(j-1)+n\right) \quad \forall i,j$$

where i varies from 1 to M, M being the number of images in the training set, j varies from 1 to N, N
being the number of sub-images. Fig.1 shows the result of dividing a face image into four smaller images for N ¼ 4.
The average image of all the training sub-images is calculated as

$$A = \frac{1}{M \cdot N} \sum_{i=1}^{M} \sum_{j=1}^{N} I_{ij}$$

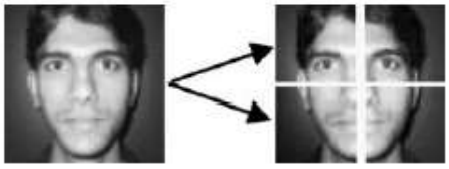


Fig.1. A face image divided into N smaller images, where N ¼ 4.

To normalize each training sub image by subtracting it from the mean as

$$Y_{ij} = I_{ij} - A \quad \forall i,j$$

From the normalized sub-images the covariance matrix is calculated as

$$C = \frac{1}{M \cdot N} \sum_{i=1}^{M} \sum_{j=1}^{N} Y_{ij} \cdot Y_{ij}^{\mathrm{T}}$$

Next we find the eigenvectors of C that are associated with the M0 largest eigenvalues. We represent the eigenvectors as E1; E2; . . . ; EM0.The weights are computed from the eigenvectors as given below:

$$W_{pnjK} = E_K^{\mathrm{T}} \cdot (I_{pnj} - A) \quad \forall p,n,j,K$$

where K takes the values 1; 2; . . . ;M0, n varies from 1 to C, C is the number of images per individual, and p varies from 1 to P, P is the number of individuals in the training set. Weights are also computed for testing sub-images using the eigenvectors as shown in the below equation:

$$W_{\text{test } jK} = E_K^{\mathrm{T}} \cdot (I_{\text{test } j} - A) \quad \forall j,K$$

Mean weight set of each class in the training set is computed from the weight sets of the class as shown below:

$$T_{pjK} = \frac{1}{\Gamma} \sum_{K=1}^{M'} \sum_{n=1}^{\Gamma} W_{pnjK} \quad \forall p,j$$

Next the minimum distance is calculated as

$$D_{pj} = \frac{1}{M'} \sum_{K=1}^{M'} \left| W_{\text{test } jK} - T_{pjK} \right|$$

$$D_p = \frac{1}{N} \sum_{j=1}^{N} D_{pj}$$

For a particular value of p, the corresponding face class in the database images is the closest match to the test image. Hence the test image is recognized as belonging to the p^{th} face class.

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. Artificial Neural Networks (ANN) processes the mutually related 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, 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 performed 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 if the error is not minimum and to adjust its weights. This process contains 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 is continued until the error minimizes.

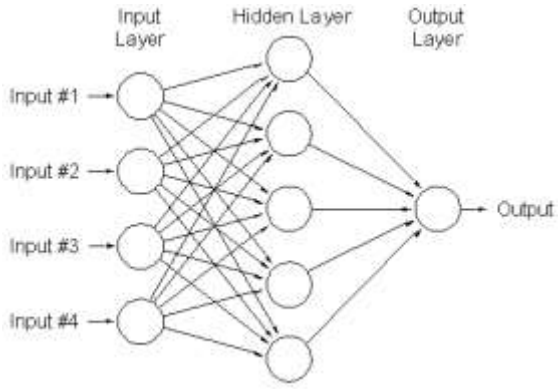


Fig.2. Multilayered Neural Network

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 weight.

◎◎Back Propagation and weight Adjustment: - The input layer processes the data and sends to the hidden layer which in turn computes the data and passes it to the output layer. Output layer compare it with the target value and gets the error signals. These errors are sent back to the hidden layer for adjusting the weights of each layer and performs the function to minimize the error.

Mathematical Function:

It performs the mathematical operation on the output layer. The functions can be threshold function, log-sigmoid and Tangent hyperbolic function. If the output values of the function are similar to the output values of the Tested face, the face is detected. Hence, the Neural Networks provides the response to the input which is similar to the training data.

4. IMPLEMENTATION OF PROPOSED SYSTEM

In this paper, we have taken the database of 9 persons. In this dataset two non-face images and two unknown face images are taken for checking the rejection rate. The images are cropped and resized to 180×200 pixels having 36000 dimensional image space. The face images are taken at different lighting conditions, facial expressions, hairstyles, poses and viewing conditions. For testing purpose 13 images are used including the non-human and unknown face images. Fig. 3 shows the colored face images of 9 individuals and their grey-scale converted images. The implementation process is performed by using MATLAB language as it is efficient for computing mathematical calculations as it includes matrices and some functions.

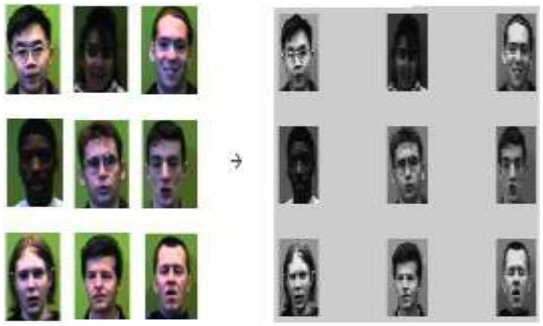


Fig.3. Colored face images are converted into Grey-scale

The eigenvectors are calculated and are divided into modules then the distance was calculated and are given as inputs to the input layer of the neural network. The projections of the face images as the feature vectors.

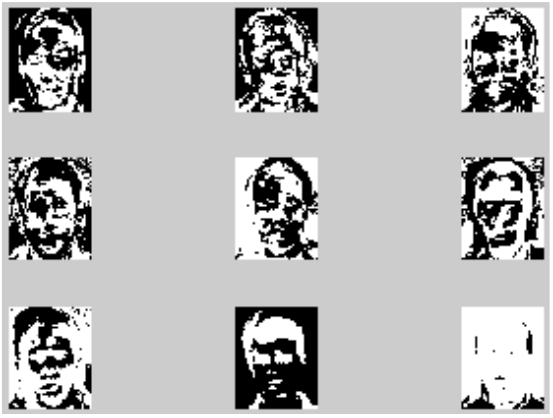


Fig.4. Projection of Face Images

We have given a learning rate of 0.4. It counts the 1000 iterations with learning rate of 0.4 and training continues until the mean square error reaches at a threshold level set at 0.001. These trained networks are used for testing purpose. In testing face the eigenface projections of test image and the trained Neural Networks face images are compared as specified in implementation part.

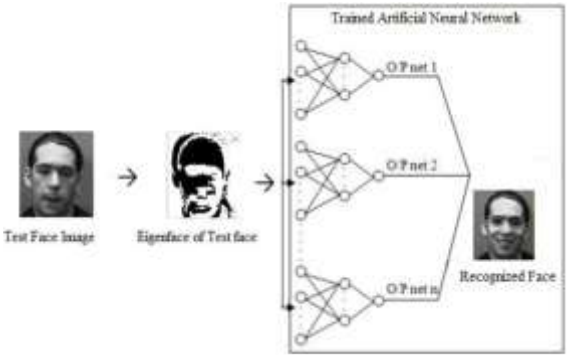


Fig.5. The entire Proposed System

Testing the Artificial Neural Networks with known Face Image with different expressions and testing of the non-human face images and unknown face images are rejected.

5. EXPERIMENTAL RESULTS AND DISCUSSIONS

In this Project, There are 16 persons in the face image database, each having 27 distinct pictures taken under different conditions (illuminance, poses, and head scale). The training images are chosen to be those of full head scale, with head-on lighting, and upright head tilt. The initial training set consists of 15 face images of 8 individuals, i.e. 2 images for one individual (M=15). I have taken a database of 15 images to test the Face Recognition and these are the images that are already trained by the proposed method. The input image which is used for testing will also be trained by the proposed system and the both images are now compared for matching. In this method we can achieve a better performance in Face Recognition and also can overcome the illumination problems and pose variation problems with the accuracy of 95%. The image will be recognized in very short time so, that the speed will also increased by this method. The results are as follows.

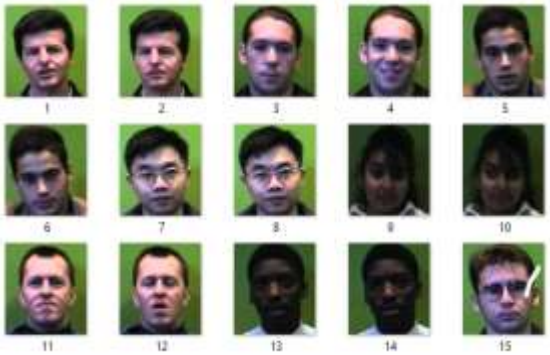
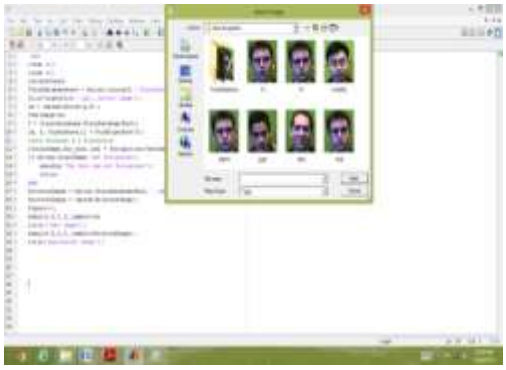
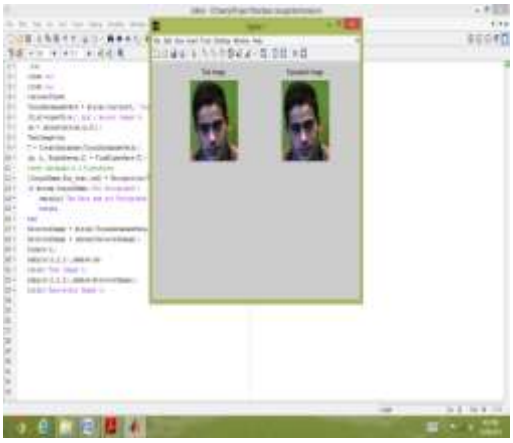


Fig.6. Different images of the Database

Step 1. This shows that the main file when set to run, it opens the file location of the image from the computer.



Step 2. This shows that the input test image has a perfect match with the database image. Hence the recognition was successful within no time and with accuracy.



Step 3. This shows that input test image which was taken for comparison was not in the database. Hence the image was not recognized.

Comparison of existing methods with proposed Face Recognition System:

Methodology	PCA based Face Recognition system	Neural networks based Face Recognition	Proposed Face Recognition System
Time Consumption	0.2sec (for given 15 images)	0.5sec(for given 15 images)	0.7sec(for given 15 images)
Illumination Problems	Yes	Yes	No
Pose variation problems	Yes	Yes	No
Recognition Rate	90.9%	94.5%	95.45%

CONCLUSION AND FUTURE SCOPE:

In this paper, Back propagation feed forward Artificial Neural Networks with feature extraction using Modular PCA is proposed for face recognition. The proposed face recognition system works with high accuracy and provides better success rates. The mean square error converges to 0.001 as set tolerance level and it can be reduced further by increasing the iterations using Log-sigmoid and Tan-sigmoid functions. Results show that when lightening variations are large then it is difficult to count the image distance due to introduced biases in distance calculations. The proposed algorithm works better than individual PCA based Face Recognition System even in illumination and background variations. This work also improves the rejection rate for non-human and unknown face images. In future, we will apply the local features extraction methods with Artificial Neural Networks for further improvements in the research of Face Recognition System and also thinking to detect the gender of the person. This method provides the maximum accuracy of about 95.45% for applied database.

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