IRACST - International Journal of Computer Science and Information Technology & Security (IJCSITS), ISSN: 2249-9555
Vol.6, No1, Jan-Feb 2016

FACE RECOGNITION USING PCA AND RBF NEURAL NETWORK

Sapna Tyagi
Computer Science & Engineering
Inderprasth Engineering College
Ghaziabad, India

Kumud Kundu
Computer Science & Engineering
Inderprasth Engineering College
Ghaziabad, India

Abstract— **In this paper, the characteristic features called 'eigenfaces' are extracted from the stored images using which the system is trained for subsequent recognition of new images. We first use k-means clustering, to cluster the similar images of database. Second, Principal Component Analysis (PCA) is applied to the cluster images for dimensionality reduction. The performance of PCA-based face recognition techniques is based on various parameters such as distance classifier, selecting the number of eigenfaces. After the extraction of feature vectors, automated face recognition system requires correct classification of input facial image. The proposed system tested on AT&T database. Test results gave 98.33% recognition rate.**

***Keywords- Face Recognition, k-means clustering, PCA, RBF neural network*.**

Introduction

Humans often use faces to recognize individuals, and advancements in computing capability over the past few decades now enable similar recognitions automatically. A method that can verify or identify a person from a digital image is named face recognition. Early facial recognition algorithms used simple geometric models, but the recognition process has now matured into a science of sophisticated mathematical representations and matching processes. Major advancements and initiatives in the past 10 to 15 years have propelled facial recognition technology into the spotlight. As a special study of pattern recognition, face recognition has proved to be very useful in daily life such as for security access control systems, content-based indexing, and bank teller machines. The research of face recognition has great theoretical value involving subject of pattern recognition, image processing, computer vision, machine learning, and physiology and so on, and it also has a high correlation with other biometrics recognition methods.

I. LITERATURE REVIEW

Face Recognition has been an interesting issue for both neuroscientists and computer engineers dealing with artificial intelligence (AI). A healthy human can detect a face easily and identify that face, whereas for a computer to recognize faces, the face area should be detected and recognition comes next. Hence, for a computer to recognize faces the photographs should be taken in a controlled environment; a uniform background and identical poses makes the problem easy to solve.

This review examines some of the current literature in the area of autonomous face recognition.

Face recognition research over the past several years falls into two categories:

- Features based
- Holistic approach (or whole face).

Face recognition using features was first attempted by L. D. Harmon in the early 1970s. He extracted features from profiles to identify the faces. His features were defined as the distance from the tip of the nose to the mouth, the distance from the nose to the chin, the distance from the eyes to the nose and other similar measurements. In addition to Hannon's method, other types of face recognition using feature involves segmenting a face and then extracting features from the segments. Whatever the method, face recognition using features continues today with researchers all over the world.

The second category of face recognition is the holistic approach. Research in face recognition has moved towards a holistic point of view with researchers at the Massachusetts Institute of Technology (M1T), the University of California San Diego (UCSD) and AFIT The holistic approach still involves extracting features, but the features, which are extracted using some type of principal component analysis, are now taken from the entire face image, not just segments or profiles. This research is based on the holistic approach and it is what will be discussed in the following sections.

A. Recent Approaches to Face Recognition

Face recognition has been an active research area over last 30 years. This research spans several disciplines such as image processing, pattern recognition, computer vision, and neural networks. It has been studied by scientists from different areas of psychophysical sciences and those from different areas of computer sciences. Engineers studying on machine recognition of human faces deal with the computational aspects of face recognition. Face recognition has applications mainly in the fields of biometrics, access control, law enforcement, and security and surveillance systems.

B. Human Face Recognition

When building artificial face recognition systems, scientists try to understand the architecture of human face recognition system. Focusing on the methodology of human face recognition system may be useful to understand the basic system. However, the human face recognition system utilizes

more than that of the machine recognition system which is just 2-D data. The human face recognition system uses some data obtained from some or all of the senses; visual, auditory, tactile, etc. All these data is used either individually or collectively for storage and remembering of faces. In many cases, the surroundings also play an important role in human face recognition system. It is hard for a machine recognition system to handle so much data and their combinations. However, it is also hard for a human to remember many faces due to storage limitations. For a human face recognition system the important feature is its parallel processing capacity.
The issue "which features humans use for face recognition" has been studied and it has been argued that both global and local features are used for face recognition. It is harder for humans to recognize faces which they consider as neither "attractive" nor "unattractive".
Both holistic and feature information are important for the human face recognition system.
Studies suggest the possibility of global descriptions serving as a front end for better feature based perception. Chellappa et al (1995). If there are dominant features present such as big ears, a small nose, etc. holistic descriptions may not be used. Also, recent studies show that an inverted face (i.e. all the intensity values are subtracted from 255 to obtain the inverse image in the grey scale) is much harder to recognize than a normal face.

C. Machine Recognition of Faces

Although studies on human face recognition were expected to be a reference on machine recognition of faces, research on machine recognition of faces has developed independent of studies on human face recognition. Chellappa et al. (1995) posited that, during 1970's, typical pattern classification techniques, which use measurements between features in faces or face profiles, were used. During the 1980's, work on face recognition remained nearly stable. Since the early 1990's, research interest on machine recognition of faces has grown tremendously. The reasons may be;
- An increase in emphasis on civilian/commercial research projects,
- The studies on neural network classifiers with emphasis on real-time computation and adaptation, - The availability of real time hardware,
- The growing need for surveillance applications.
One of the methods to extract features in a holistic system is applying statistical methods such as Principal Component Analysis (PCA) to the whole image. PCA can also be applied to a face image locally; in that case the approach is not holistic.
With the problem being a classification problem, training the face recognition system with images from the known individuals and classifying the newly coming test images into one of the classes is the main aspect of the face recognition systems. This problem seems to be easily solved by humans where limited memory can be the main problem; whereas the problems for a machine face recognition system are:

1. Facial expression change
2. Illumination change
3. Aging
4. Pose change
5. Scaling factor (i.e. size of the image)
6. Frontal vs. profile
7. Presence and absence of spectacles, beard, moustache etc.
8. Occlusion due to scarf, mask or obstacles in front.

D. Template Matching

Template matching is conceptually related to holistic approach which attempts to identify faces using global representations. These types of methods approach the face image as a whole and try to extract features from the whole face region and then classify the image by applying a pattern classifier. A simple version of template matching is that a test image represented as a two-dimensional array of intensity values is compared using a suitable metric, such as the Euclidean distance, with a single template representing the whole face. There are several other more sophisticated versions of template matching on face recognition. One can use more than one face template from different viewpoints to represent an individual's face.

E. Feature-based Approaches

Face can be recognized by extracting the relative position and other parameters of distinctive features such as eyes, mouth, nose and chin. The system described the overall geometrical configuration of face features by a vector of numerical data representing position and size of main facial features. First, they extracted eyes coordinates. The interocular distance and eyes position is used to determine size and position of the areas of search for face features. In these areas binary thresholding is performed, system modifies threshold automatically to detect features. In order to find their coordinates, discontinuities are searched for in the binary image. They claimed that, their experimental results showed that their method is robust, valid for numerous kind of facial image in real scene, works in real time with low hardware requirements and the whole process is conducted automatically.

F. Neural Network based Approaches

Artificial Neural Network (ANN) is a powerful tool for pattern recognition problems. The use of neural networks (NN) in faces has addressed several problems: gender classification, face recognition and classification of facial expressions. One of the earliest demonstrations of NN for face recalls application which was reported in Kohonen's associative map. Using a small set of face images, accurate recall was reported even when input image is very noisy or when portions of the images are missing.

II. DESIGN OF PROPOSED MODEL

A. K-MEANS CLUSTERING:-

Cluster analysis is one of important tools of scientific research and has been used extensively. The aim of clustering is to

group all the data points into several clusters according to the similarity measures. It maximizes the same class with high similarity and minimizes the inhomogeneity with low similarity. K-means is a well -known clustering algorithm and plays a very important role in distance metric. Typically, the K-means algorithm determines the distance between an object and its cluster centroid by Euclidean distance measure.

A set of n objects x_i, i=1, 2, 3, ……., n; are to be partitioned into K groups C_j, j= 1, 2, 3, ……, n. The objective function, based on the Euclidean distance between an object x in group j and the corresponding cluster centroid Cj, can be defined by equation (1):

$$J = \sum_{j=1}^{K} \sum_{i=1}^{n} \left\| x_i - C_j \right\|^2$$

where,

'$||x_i - C_i||$' is the Euclidean distance between x_i and C_j.

'*n*' is the number of data points.

'*K*' is the number of cluster centers.

Algorithmic steps for k-means clustering:-

1) Randomly select '*K*' cluster centers.

2) Calculate the distance between each data point and cluster centers.

3) Assign the data point to the cluster center whose distance is minimum from all the cluster centers.

4) Recalculate the new cluster center.

5) Recalculate the distance between each data point and new obtained cluster centers.

6) If no data point was reassigned then stop, otherwise repeat from step (3).

B. PRINCIPLE COMPONENT ANALYSIS (PCA)

Principal component analysis (PCA) was invented in 1901 by Karl Pearson. It is a linear transformation based on statistical technique. PCA is one of the most popular appearance-based methods used mainly for dimensionality reduction in recognition and compression problem. PCA is a powerful tool for face recognition which is multidimensional. Statistical techniques have been widely used for face recognition to extract the abstract features of face. Principle Component Analysis is a main technique used for data reduction and feature extraction.

By means of PCA one can transform each original image of the training set into a corresponding eigenface. If one uses all the eigenfaces extracted from original images, one can reconstruct the original images from the eigenfaces exactly the same or can use only a part of the eigenfaces. Then the reconstructed image is an approximation of the original image. However, losses due to omitting some of the eigenfaces can be minimized. This happens by choosing only the most important features (eigenfaces).

The step by step instructions for the recognition of faces using Principal Component Analysis (PCA) are as follows:

STEP 1: Prepare the Data: The first step is to obtain a set S with M face images. Each image is transformed into a vector of size N and placed into the set.

STEP 2: Obtain the Mean:After obtaining the set, the mean of the image has to be obtained

STEP 3: Subtract the Mean from Original Image

The difference between the input image and the mean image has to be calculated and the result is stored.

STEP 4: Calculate the Covariance Matrix

STEP 5: Calculate the Eigenvectors and Eigenvalues of the Covariance Matrix and Select the Principal Components.

C. RADIAL BASIS FUNCTION NEURAL NETWORK (RBFNN):-

We have used RBF neural networks for classifying the images due to its simple structure and faster learning abilities. RBNF consists of 3 layers an input layer a hidden layer an output layer.

The hidden units provide a set of functions that constitute an arbitrary basis for the input patterns. Hidden units are known as radial centers and represented by the vectors c_1; c_2; _ _ _ ; c_h transformation from input space to hidden unit space is nonlinear whereas transformation from hidden unit space to output space is linear dimension of each center for a p input network is p *X* 1.

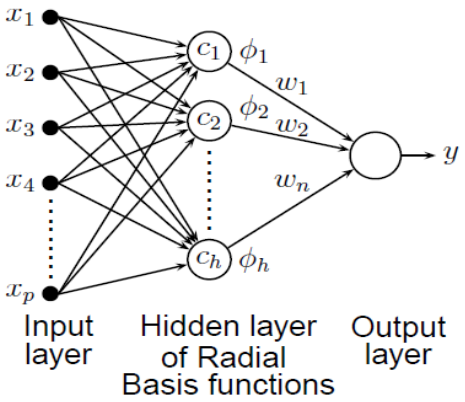

Figure: Radial Basis Function Network

The radial basis function in the hidden layer produces a significant non-zero response only when the input falls within a small localized region of the input space. Each hidden unit has its own *receptive field* in input space.

An input vector x_i which lies in the receptive field for center c_j , would activate c_j and by proper choice of weights the target output is obtained. The output is given as

$$y = \sum_{j=1}^{h} \phi_j w_j, \qquad \phi_j = \phi(\|x - c_j\|)$$

w_j : weight of jth center, : some radial function.

III. EXPERIMENTAL RESULTS

A. Data Collection

In this experiment we use AT&T face database for tests. In this database there are 10 different images of each of 40 distinct subjects. Separate directories were merged into one folder. The subjects were sitting at approximately the same distance from the camera. Each image is indexed 1 to 10 for the 10 images per person. In all, a total of 400 images make up the database for this experiment. For the purposes of recognition and testing the performance of the algorithm, the dataset is divided into two: the training set and testing set.
The recognition rates, with different number of eigenfaces and hidden layer neurons in neural network system are implemented. Divide the whole database into the training set and test set; there are 7 training images per person. The eigenface method is very sensitive and the mismatches occur for the images.

B. Algorithm Performance

To calculate the accuracy rate during the testing stage, each image in the testing set is compared into the eigenface of the training set and the index of the image with the smallest Euclidean distance is assumed to be a match, otherwise a mismatch. This process is repeated for the remaining images of the test set. However, during matching with the test set, the algorithm is prone to errors which perhaps maybe due to the variation in the images. To check for this error of the algorithm, all the images found to match the training set are counted and their total match divided by the total number of images in the test set and their percentage is recorded. Thus,

$$\text{accuracy rate} = \frac{\text{No.of matches found}}{\text{No.of test images}} \text{ x } 100\%$$

In this thesis, an accuracy rate of 98.333% was achieved with an error margin of 1.667%.

C. Performance Evaluation

All the test image are gone through the k-means clustering, PCA and RBFNN. In this experiment we tested the recognition rate for PCA& clustering, PCA and then RBFNN. This process undergoes through several steps. First, the loaded database is normalized to obtain zero mean image and to get the principle component. After getting the feature variation k-means clustering is performed using the Euclidean distance as a measure of similarity. For training RBF neural network, bring the values of normalized reduced matrix into the same range and the accuracy will be calculated.

Table 1 shows a comparative analysis of elapsed time.

S.NO.	Techniques	Elapsed Time (*seconds*)
1.	Loading Database	11.7127
2.	PCA+ k-means Clustering	0.1362
3.	PCA	0.1655
4.	RBF Neural Network (*for Training*)	0.6821
5.	Test Accuracy of RBF-NN	0.005831

Table 2 shows a comparative analysis of the best obtained recognition rates of the mentioned trainings for the RBFNN.

S.NO.	Techniques	Recognition Rate (%)
1.	PCA+ k-means Clustering	90%
2.	PCA	93.33%
3.	RBFNN	98.33%

The above shows that the accuracy rate is quite high that is 98.33%. The advantages of the proposed methods are high accuracy and low CPU time. Also, in order to increase the recognition rate we use the PCA before using the RBFNN. The PCA can create independent and informative data and increase the accuracy from 90% to 93.33%.

CONCLUSION

In this paper, we implemented the face recognition method using k-means clustering, Principal Component Analysis (PCA) and RBF neural network approach. The system successfully recognized the human faces and worked better in different conditions of face orientation up to a certain limit. We used these algorithms to construct efficient face recognition method with a high recognition rate. Proposed method consists of three parts:-
Firstly, we propose a clustering algorithm to prevent training samples with large variations from being clustered in the same class. This process guarantees optimal projection direction. Secondly, dimension reduction using PCA that main features that are important for representing face images are extracted. Lastly, for classification the RBF neural network is used. Simulation results on three benchmark face databases show that our system achieves high training and recognition speed, as well as high recognition rate. Experimental results show a high recognition rate equal to 98.333% which demonstrated an improvement in comparison with previous methods. The new face recognition algorithm can be used in many applications such as security methods.

REFERENCES

[1] AT&T Laboratories, Cambridge, UK, "The ORL Database of Faces" (Now At&T "The Database of Faces"), Available [Online]: http://www.cl.cam.ac.uk/research/dtg/attarchive/pub/data/att_faces.zip [November, 16, 2008], 1994.

[2]. Simon Haykin, "Neural Networks: a comprehensive foundation," Prentice-Hall, Inc., Upper Saddle River, New Jersey (1999).

[3]. Zhang Xiaozheng, Gao Yongsheng, "Face recognition across pose: A review", *Pattern Recognition*, Vol. 42, No. 11, pp: 2876 – 2896, 2009.

[4]. T.K.Kim,J.Kittler, "Design and fusion of pose-invariant face-identification experts", *IEEE Transactions on Circuits Syst. Video Technol.* , Vol. 16, No. 9, pp: 1096–1106, 2006.

[5]. ZIAD M. HAFED AND MARTIN D. LEVINE," *Face Recognition Using the Discrete Cosine Transform*", International Journal of Computer Vision 43(3), 167–188, 2001.

[6]. Meng Joo Er,Weilong Chen, and Shiqian Wu," *High-Speed Face Recognition Based on Discrete Cosine Transform and RBF Neural Networks*" IEEE TRANSACTIONS ON NEURAL NETWORKS, VOL. 16, NO. 3, MAY 2005.

[7]. Rabia Jafri and Hamid R. Arabnia," *A Survey of Face Recognition Techniques*", Journal of Information Processing Systems, Vol.5, No.2, June 2009.