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Face Recognition Based on PCA Algorithm

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Abstract - This paper is proposed the face recognition method using PCA with neural network back error propagation learning algorithm .In this paper a feature is extracted using principal component analysis and then classification by creation of back propagation neural network. We run our algorithm for face recognition application using principal component analysis, neural network and also calculate its performance by using the photometric normalization technique: Histogram Equalization and comparing with Euclidean Distance, and Normalized correlation classifiers. The system produces promising results for face verification and face recognition. Demonstrate the recognition accuracy for given number of input pattern.

Keywords - Face recognition, neural network, Back Propagation, Principle Component Analysis, Histogram Equalization, Euclidean Distance.

I. INTRODUCTION

Human sees so many people's face repeatedly in his life. Whenever they meet someone, he remembers peculiar facial features of that person with the feature extraction process rather than whole face. So they will recognize facial image naturally. Of course, this feature extraction process is unconscious activity and is unknown process to us. In human face profiles, the shape and size of eyes, nose, mouth and their relationship have been commonly used as feature. With correctly extracted features we can easily recognize humane face. However, shadow hair, glasses, and noise or rotation of a face may distort the face shape[1]

The task of recognition of human faces is quite complex. The human face is full of information but working with all the information is time consuming and less efficient. It is better get unique and important information and discards other useless information in order to make system efficient. Face recognition systems can be widely used in areas where more security is needed. Like Air ports, Military bases, Government offices etc. Sirovich and Kirby had efficiently represented human faces using principal component analysis[2]. M.A. Turk and Alex P. Pentland[3] developed a near real time Eigen faces system for face recognition using Euclidean distance. A face recognition system can be considered as a good system if we extract the with the help of Principal Component Analysis and for recognition back propagation Neural Network are used. In this paper we give a new approach to recognize the faces in less training time and less training patterns (images). Face recognition system consists of face verification, and face

recognition tasks. In verification task, the system knows a priori the identity of the user, and has to verify this identity, that is, the system has to decide whether the a priori user is an impostor or not. In face recognition, the a priori identity is not known: the system has to decide which of the images stored in a database resembles the most to the image to recognize. The primary goal of this paper is to present the performance evaluation carried out through neural network for face verification.

II. OVERVIEW OF THE SYSTEM

The proposed face recognition system consists of two phases which are the enrollment and recognition/verification phases as depicted in Fig. 1.[4]. It consists of several modules which are Image Acquisition, Face Detection, Training, Recognition and Verification. In image processing session, the image acquisition, feature extraction and data normalization are performed.

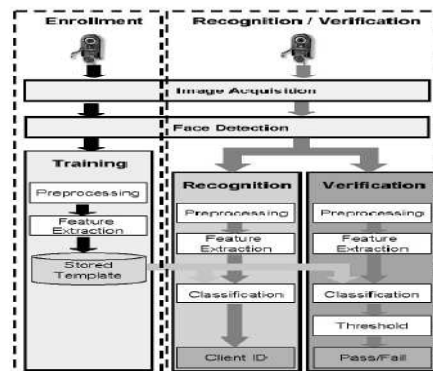


Fig. 1 : Block Diagram of Face Recognition System

2.1. Enrollment phase: The image is taken using a web camera and stored in a database. Next, the face image is detected and trained. During training, the face image is preprocessed using geometric and photometric normalization. The features of the face image are extracted using several feature extraction techniques. The features data is then stored together with the user identity in a database.

2.2. Recognition/verification phase: A user's face is once again acquired and system uses this to either identify who the user is, or verify the claimed identity of the user. While identification involves comparing the acquired biometric information against templates corresponding to all users in the database, verification involves comparison with only those templates corresponding to claimed identity. The recognition/verification phase comprises of several modules which are image acquisition, face detection, and face recognition/verification.

2.2.1. Image acquisition/face detection module: Image acquisition module is to seek and then extracts a region which contains only the face. Face detection is used to detect face and to extract the information related to facial features. The image will then be resized and corrected geometrically and it will eliminate the background and scene which are unrelated to the face so that it is suitable for recognition/verification.

2.2.2. Face recognition/verification module: The face recognition module contains of preprocessing, feature extraction, and classification sub-modules. The input to the face recognition/verification module is the face image, which is derived from two sources from the camera or from the database. Each image is preprocessed to get the geometric and photometric normalized form of the face image. During feature extraction, the normalized image is represented as feature vectors. The result of the classification for the recognition purpose is determined by matching the client index with the client identity in the database.

2.2.2.1 Preprocessing: The purpose of the preprocessing module is to reduce or eliminate some of the variations in face due to illumination. It normalized and enhanced the face image to improve the recognition performance of the system. The preprocessing is crucial as the robustness of a face recognition system greatly depends on it. By using the normalization process, system robustness against scaling, posture, facial expression and illumination is increased. The photometric normalization techniques are used in histogram filtering.[5][6]

Histogram Equalization: Histogram equalization is the most common histogram normalization or gray level transform, which purpose is to produce an image with

equally distributed brightness levels over the whole brightness scale. It is usually done on too dark or too bright images in order to enhance image quality and to improve face recognition performance. It modifies the dynamic range (contrast range) of the image and as a result, some important facial features become more apparent.

The steps to perform histogram equalization are as follow:

1. For an $N \times M$ image of G gray-levels, create two arrays H and T of length G initialized with 0 values.
2. Form the image histogram: scan every pixel and increment the relevant member of H -- if pixel X has intensity p , perform

$$H[p] = H[p] + 1 \quad (1)$$

3. Form the cumulative image histogram H_c ; use the same array H to store the result.

$$H[0] = H[0]$$

$$H[p] = H[p-1] + H[p]$$

$$\text{For } p = 1, \dots, G-1.$$

4. Set

$$G - 1$$

$$T[p] = H[p] \quad (2)$$

$$MN$$

Rescan the image and write an output image with gray-levels q , setting $q = T[p]$.

2.2.2.2 Feature Extraction: The purpose of the feature extraction is to extract the feature vectors or information which represents the face. The feature extraction algorithms used is Principal Component Analysis (PCA)

Principal component analysis (PCA): PCA for face recognition is based on the information theory approach. It extracted the relevant information in a face image and encoded as efficiently as possible. It identifies the subspace of the image space spanned by the training face image data and decorrelates the pixel values. The classical representation of a face image is obtained by projecting it to the coordinate system defined by the principal components. The projection of face images into the principal component subspace achieves information compression, decorrelation and dimensionality reduction to facilitate decision making. In mathematical terms, the principal components of the distribution of faces or the eigenvectors of the covariance matrix of the set of face images, is sought by treating an image as a vector in a very high dimensional face space[7][8][9].We apply PCA on this database and get the unique feature vectors using the following

method .Suppose there are P patterns and each pattern has t training images of m x n configuration.

- The database is rearranged in the form of a matrix where each column represents an image.
- With the help of Eigen values and Eigen vectors covariance matrix is computed.
- Feature vector for each image is then computed. This feature vector represents the signature of the image. Signature matrix for whole database is then computed.
- Euclidian distance of the image is computed with all the signatures in the database.
- Image is identified as the one which gives least distance with the signature of the image to recognize.

2.2.2.3 Classification: The purpose of the classification sub-module is to map the feature space of a test data to a discrete set of label data that serves as template. The classification techniques used are Neural Network, Normalized correlation, Euclidean Distance.

Neural Network: Neural Network is a machine learning algorithm that has been used for various pattern classification problems such as gender classification, face recognition, and classification of facial expression. Neural Network classifier has advantages for classification such as incredible generalization and good learning ability.

A Neural Network is made up of neurons residing in various layers of network. These neurons of different layers are connected with each other via links and those links have some values called weights. These weights store the information. Basically the neural network is composed of 3 types of layers: first is Input layer, which is responsible for inserting the information to the network. Second is Hidden layer. It may consist of one or more layers as needed but it has been observed that one or two hidden layers are sufficient to solve difficult problems. The hidden layer is responsible for processing the data and training of the network. Last layer is the output layer which is used to give the network's output to a comparator which compares the output with predefined target value neural networks requires training. We give some input patterns for training and some target values and the weights of neural networks get adjusted A Neural network is said to be good and efficient if it requires less training patterns, takes less time for Training and is able to recognize more unseen patterns[10][11][12]

Face neural network consists of 448 input nodes, 12 hidden nodes and 1 output node, and it can be used to train face images. The training images for face neural

network can be categorized into three groups - authorized face images, non-face images and other unauthorized face images. The neural network: is trained to produce an output of either 1 for authorized or 0 for non-face images and other unauthorized face images.

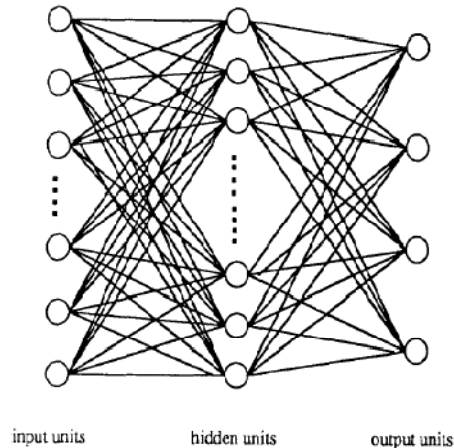


Fig. 2 : Neural Network Architecture

In back propagation method, if we use 20 to 40 hidden neurons, we get 100% recognition accuracy in very less time. When we increase hidden neurons from 40 to 60 the recognition accuracy remains 100% but training time increases. And when we increase the hidden neurons more than 65 the accuracy starts decreasing and after 75, it reaches to zero. The training time shown for feed forward neural network is only for 93.75% accuracy but training time shown for back propagation method. Table 1 shows a comparative analysis of different neural networks over various step size of learning rate. Apparently we can see that back propagation algorithm is more sensitive to variable learning rate. When step size is increased, the back propagation neural network becomes unstable.

Euclidean distance (E.D.): The Euclidean distance is the nearest mean classifier which is commonly used for decision rule is denoted as

$$d_E(x, w_k) = \sqrt{(x - w_k)^T (x - w_k)}$$

Where the claimed client is accepted if $d_E(x, w_k)$ is below the threshold τ_{Ek} and rejected otherwise.

Normalized correlation (N. C.) : The normalized correlation decision rule based on the correlation score denoted as[13]:

$$d'_C(x, w_k) = \frac{|x^T w_k|}{|x| |w_k|}$$

Where the claimed identity is accepted if $d_c(x, w_k)$ exceeds the threshold τ_{cl} .

III. EXPERIMENT & RESULT

The purpose of the experiment is to evaluate the performance of the face recognition system by applying the photometric normalization techniques .i.e. histogram equalization, to the face images. The face images are frontal face images, which are taken from our local face images database. The database consists of face images from twenty (20) individuals, each with ten (10) face images.

For verification, two measures are used, which are the false acceptance rate (FAR) and false rejection rate (FRR).FAR is the case when an impostor, claiming the identity of a client, is accepted, whilst FRR is the case when a client claiming his true identity is rejected. The FAR and FRR are given by:

$$FAR =: IA/I, FRR =: CR/C \quad (15)$$

Where IA is the number of impostor accepted, I is the number of impostor's trials, CR is the number of client rejected and C is the number of client's trials.

Face verification: The first experiment is to evaluate the verification performance of the face recognition system using the original face images. The result is tabulated in TABLE 1, which shows that even though E.D. classifier has the lowest HTER, N.N. classifier gives the best result in PCA feature extractors.

Feature Extractor	Classifier	FAR = FRR (%)		HTER (%)
		FAR	FRR	
PCA	ED	7.250	7.410	7.330
	NC	14.44	15.560	15.00
	NN	5.820	5.560	5.690

Table 1: Verification Results using Original Image

In the second experiment, we initially apply the histogram equalization a to the face images. The result for this experiment is tabulated in TABLE 2, which shows that N.C. classifier has the lowest HTER for both of the feature extractors.

Feature Extractor	Classifier	FAR = FRR (%)		HTER (%)
		FAR	FRR	
PCA	ED	9.320	11.850	10.585
	NC	5.750	6.300	6.025
	NN	7.340	7.780	7.560

Table2: Verification Results using Histogram Equalization

The third experiment is to apply the histogram equalization to the face images. The result tabulated in TABLE 3 shows that N.N. classifier has the lowest HTER.

Feature Extractor	Classifier	FAR = FRR (%)		HTER (%)
		FAR	FRR	
PCA	ED	6.540	12.590	9.565
	NC	5.690	5.560	5.625
	NN	4.140	3.700	3.920

Table 3: Verification Results using Histogram Equalization

Face recognition: For recognition purpose, the performance is evaluated based on the recognition rate or accuracy. The result for experiment using the original image is tabulated in TABLE 4, which shows that E.D. classifier gives the highest recognition rate for PCA A feature extractors

Feature Extractor	Classifier	Recognition (%)
PCA	ED	98.51
	NC	97.04
	NN	87.03

Table 4: Recognition Results using Original Image

IV. CONCLUSION

The paper has presented a face recognition system using PCA with neural networks in the context of face verification and face recognition using photometric normalization for comparison. The experimental results show the N.N. Euclidean distance rules using PCA for overall performance for verification. However, for recognition, E.D.classifier gives the highest accuracy using the original face image. Thus, applying histogram equalization techniques on the face image do not give much impact to the performance of the system if conducted under controlled environment.

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