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ILLUMINATION INVARIANT FACE RECOGNITION SYSTEM

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Abstract: ***Face recognition method is the one of the biometric methods, to identify the face image. It is a computer application for automatically identifying or verifying a person from a digital image. Face recognition system is an important area which is used in many applications such as video surveillance, Security Monitoring, Access control, human computer interface and image database management. Lots of research has been done on face recognition technology. However, there are some challenging problems such as different poses of faces, varied facial expression and variation in illumination in the face images which degrades the performance of face recognition system. This thesis reviews different approaches to overcome the adverse illumination conditions and this thesis also analyzed different pre-processing methods for enhancing image. The proposed approach presents an efficient illumination invariant face recognition system using Discrete Cosine Transform (DCT), Principal Component Analysis (PCA) and Artificial Neural Network (ANN). A discrete cosine transform is modified to improve the performance by truncating the appropriate number of low frequency coefficients and scaling the high frequency coefficients which enhances the detail of image so this is how it improves the performance of the face recognition system. It is employed to compensate for illumination variations in the logarithm domain. The dimensionality of face image will be reduced by the Principal component analysis (PCA) and the recognition will be done by the Artificial Neural Network (ANN). Cropped Yale Face B Database with 65 different illumination conditions is used in this approach.***

Keywords: ***Face Recognition, Discrete Cosine Transform (DCT), Principal Component Analysis (PCA), Logarithm transform, Illumination normalization***

I. INTRODUCTION

The face is our key of attention in social interactions; it plays an important role in conveying identity and emotion. Human beings have ability to recognize lots of faces learned throughout the life span and even they can recognize the faces even after years of parting. This ability of human is quite robust; human can identify a face even if that face has presence of structural components such as beard or mustaches or glasses and also if that face is in different lighting conditions and face with varied facial expressions. Developing face recognition's computational model is fairly hard as it is very difficult to implement a skill that human possess for recognizing the face. Face Recognition became more important and competent with other biometric applications due to rapid advances in technologies such as digital cameras, portable digital computing devices, internet and wireless communication [1]. There is a strong requirement for the system that should be user-friendly system than can secure out material goods, resources or assets and guard our privacy. In recent scenarios there are different security schemes like a password for a computer, password for internet access, one need PIN to withdraw cash from the ATM and so many. There are also exceptionally reliable methods of biometrics exist, such as fingerprint analysis, iris or retinal scans, or speech recognition. These biometric methods depend on the support of test subject or participants to work, like Finger print analysis requires to place participant's hand on the system, in iris scan participant need stand in front of the camera and these methods cannot perform mass identification. It is advantageous than other methods such as it does not rely on cooperation of the participant to work. It also can do mass-identification; it can identify the person from the crowd of the people without people having knowledge of it. Face recognition is an important research problem spanning numerous fields and disciplines. This because face recognition, in additional to having numerous practical applications such as bankcard identification, access control, Mug shots searching, security monitoring, and surveillance system, is a fundamental human behavior that is essential for effective communications and interactions among people[2].

Face recognition is very challenging task. There are some problems which can degrade the performance of face recognition system. Most important problems are changes or variation in illumination, variability in facial expressions, the presence of accessories (glasses, beards, etc), and face may be partially or wholly occluded by some objects and the rotation of a face may change many facial characteristics. Up to now, so many methods have been proposed to deal with the illumination invariant face recognition technique. Some known algorithms are: principal component analysis (PCA)[3,4,5,6,7], KPCA [8], linear discriminate analysis (LDA), independent component analysis (ICA), elastic bunch graph matching (EBGM) [9], artificial neural networks, Local Binary Pattern (LBP), and so on.

II. PROPOSED METHOD

The steps of proposed method are illustrated in fig. 1. An input image is given to logarithm transform. Logarithm transform is often used in image enhancement to expand the values of dark pixels [4]. This logarithmic image is given to discrete cosine transform (DCT) method. DCT converts image from spatial domain to frequency domain; it gives frequency components of image. Here, low frequency coefficients are removed and high frequency coefficients are scaled which will remove the illumination effects and highlight the details of the

image respectively. After pre-processing method image will be given to feature extraction method where PCA method is use to extract the.

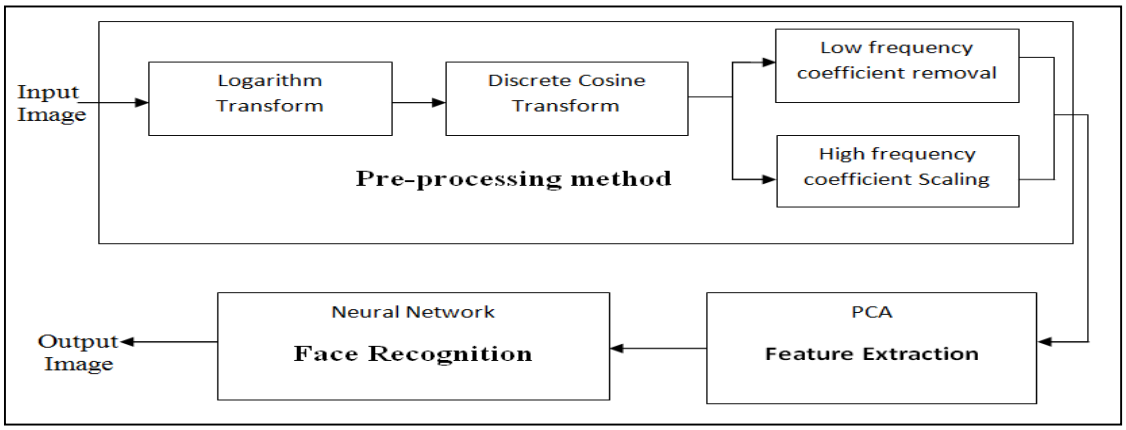

Fig. 1 Block diagram of proposed method

A. Pre-processing or Illumination Normalization Method

Pre-processing methods are filtering techniques that can reduce the effect of lighting conditions and improve image quality.

A.1) Logarithm transform

The facial features in the dark area of the original image are recovered much better by applying DCT on the logarithm image. In fact, only the brightness of the image is adjusted by discarding DCT coefficients of the original image, whereas discarding DCT coefficients of the logarithm image will adjust the illumination and recover the reflectance characteristic of the face. The input image is first given to logarithm transforms then the image will be converted into logarithmic image. Generally, the illuminated face image I(x,y) can be considered as product of reflectance R(x,y) and Illumination L(x,y), i.e.,

$$I(x,y)=R(x,y) \cdot L(x,y) \qquad (1)$$

Since reflectance is stable characteristics of the facial features so our goal is to recover the reflectance in illuminated image. Applying logarithm transform on the illuminated image that is on equation (1), i.e.,

$$\log I(x,y) = \log R(x,y) + \log L(x,y) \qquad (2)$$

Here, addition operation in the logarithm transform is equivalent to the multiplication in original domain. We can recover the reflectance R(x,y) of the image by using

$$\log R(x,y) = \text{Log } I(x,y) - \log L(x,y) \qquad (3)$$

A.2) Modified DCT

DCT coverts image from spatial domain to frequency domain. It is performed on the whole face image to get all frequency components/coefficients of the face image. The output image of logarithm transform is given to discrete cosine transform.

- Low frequency coefficient removal

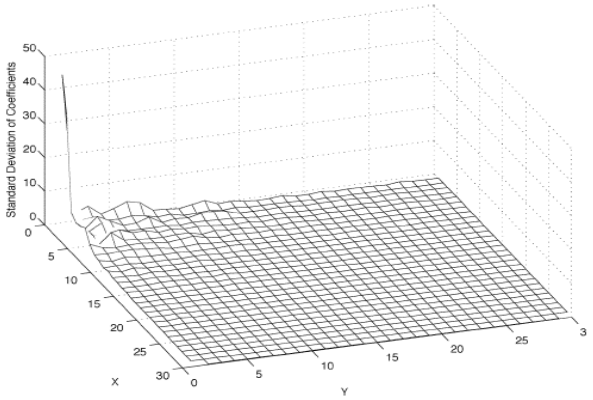

Fig 2: Standard deviations of the logarithm DCT coefficients [3]

The effect of illumination is more at low frequency coefficients. So normalization of illumination is carried out by discarding low frequency coefficient by setting zero value to low frequency coefficients.. The first DCT coefficient (i.e., the DC component) determines the overall illumination of a face image. Therefore, the desired uniform illumination can be obtained by setting the DC coefficient to the same value. i.e.,

$$Dct(1,1) = log(mean) \times D_{col} \times D_{row}$$

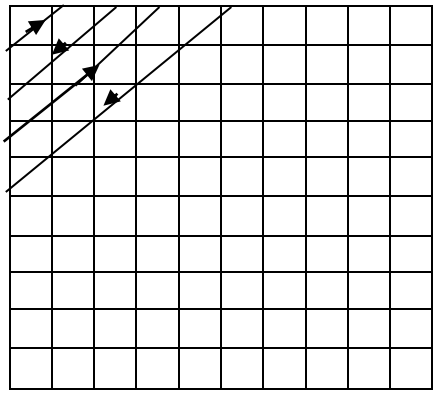

Fig. 3 Manner of discarding DCT coefficients

Fig 3 shows the manner of discarding low frequency coefficients.

- High frequency coefficient scaling

While removing low frequency coefficients, we scale some high frequency coefficients of DCT to make details of the face image clearer. Under poor illuminations, the high-frequency features become more vital in recognition. These high frequency coefficients are multiplied with some scalar value that is how it gives enhanced details of the image. Scaling of high frequency coefficients are also done by following zigzag pattern.

B. Feature Extraction using PCA

This approach attempts to extract facial features which are invariant to illumination variations. Here, Principle Component Analysis (PCA) is employed to extract important facial features.

The PCA algorithm is as follows:

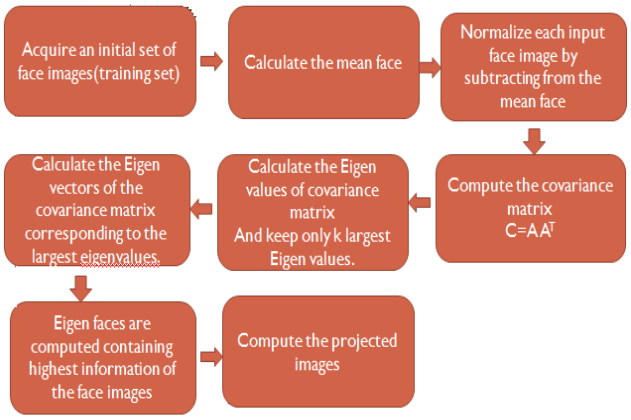

Fig. 4 Features Extraction using PCA

PCA method converts the high dimensional image space to low dimensional space; it computes the maximum variations in data. These extracted projections of face images are given to Artificial Neural Networks for training and testing purposes.

C. Face Recognition using neural network

After the feature extraction using PCA, this generated feature vector is used for recognition process. Artificial neural network is a mathematical or computational model which is based on biological neural networks.

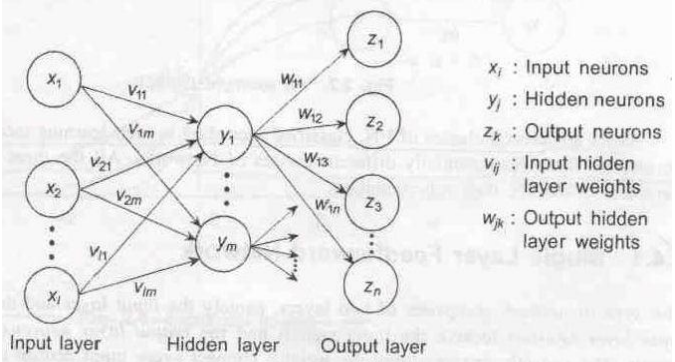

Fig. 5 Back Propagation Neural Network [5]

Back propagation is supervised learning network and a multi-layer feed forward network based on gradient descent learning rule. Here an input signal propagates in forward direction through the network and from left to right and layer by layer basis. This BPNN is computationally efficient method. It takes much time to train the network but once it completes training, testing does not take any more time. It becomes speedy. Being a gradient descent method it minimizes the total squared error of the output computed by the network. The aim is to train the network to achieve a balance between the ability to respond correctly to the input patterns that are used for training and the ability to provide good response to the input that are similar [5].

III. EXPERIMENTAL RESULTS

To evaluate the effectiveness of the proposed method on face recognition, we test it on the Yale Face Database B.

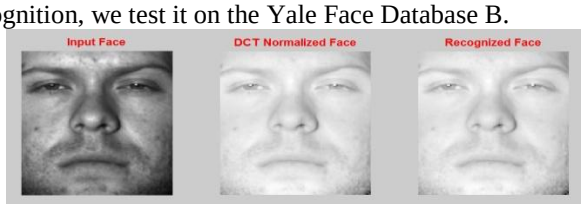

Fig.6 Normal Face

Fig.7 Left side illuminated face

Fig.8 Right side illuminated face.

Fig.9 Highly illuminated face.

Fig.10 A case where face recognition system fails.

Fig 6-9 shows the correctly recognized face and Fig 10 shows the case where face recognition system fails.

Fig.11 shows the comparison between recognition rate of face recognition system with DCT Normalization, without DCT Normalization and with modified DCT normalization. Here, Euclidean distance is used as classifier. We can see that face recognition system with modified DCT Normalization gives higher recognition rate than DCT normalization and DCT normalization gives higher recognition rate than without DCT Normalization system.

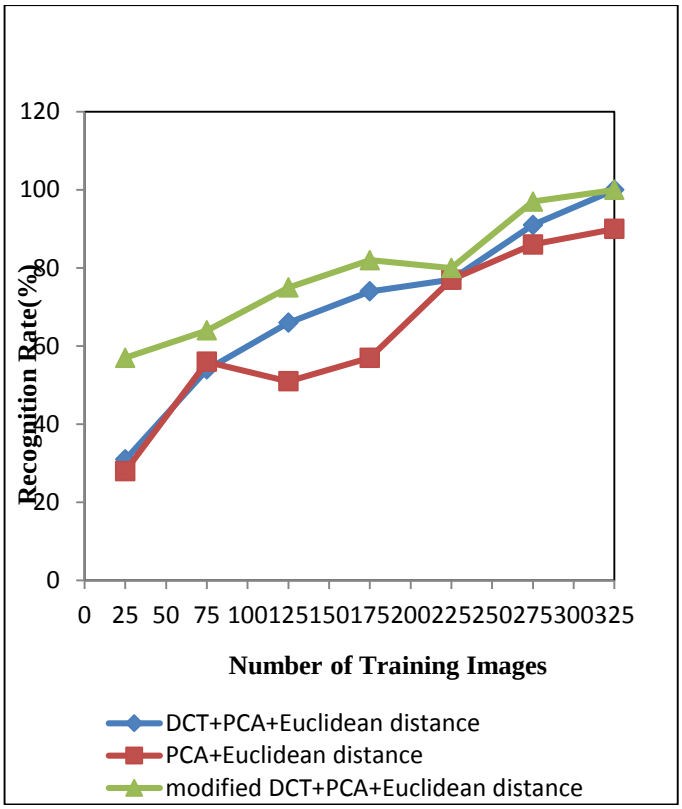

Fig. 11 Comparisons between recognition rate of Approach 1 with, without DCT Normalization and modified DCT normalization

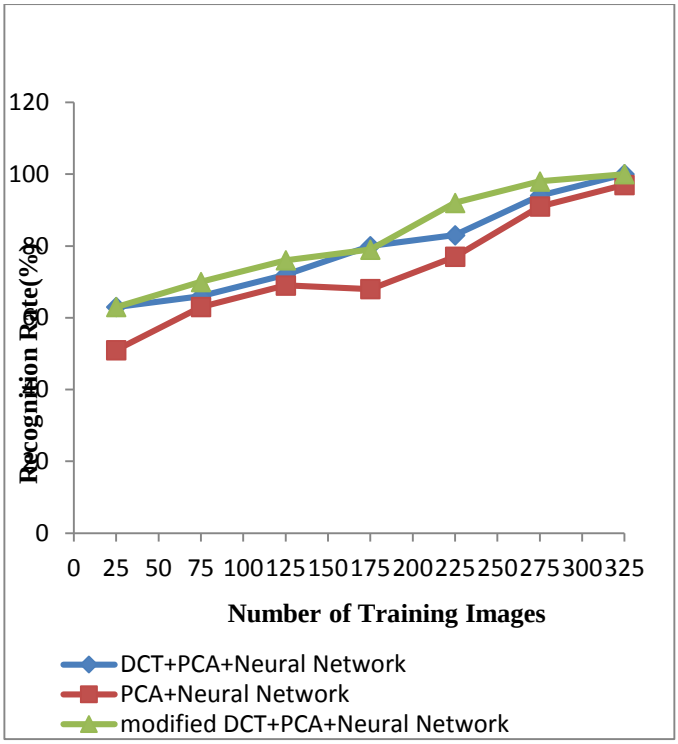

Fig. 12 Comparisons between recognition rate of Approach 2 with, without DCT Normalization and modified DCT normalization

Fig 12 shows the comparison between recognition rate of face recognition system with DCT Normalization and without DCT Normalization and with modified DCT normalization. Here, recognition is done by neural network. We can see that face recognition system with modified DCT Normalization gives higher recognition rate than DCT normalization and DCT normalization gives higher recognition rate than without DCT Normalization system. Fig 13 shows the comparisons between recognition rates of face recognition system with Neural network and face recognition system with Euclidean Distance. We can see that recognition rate of face recognition system with Neural network is higher than face recognition system with Euclidean distance.

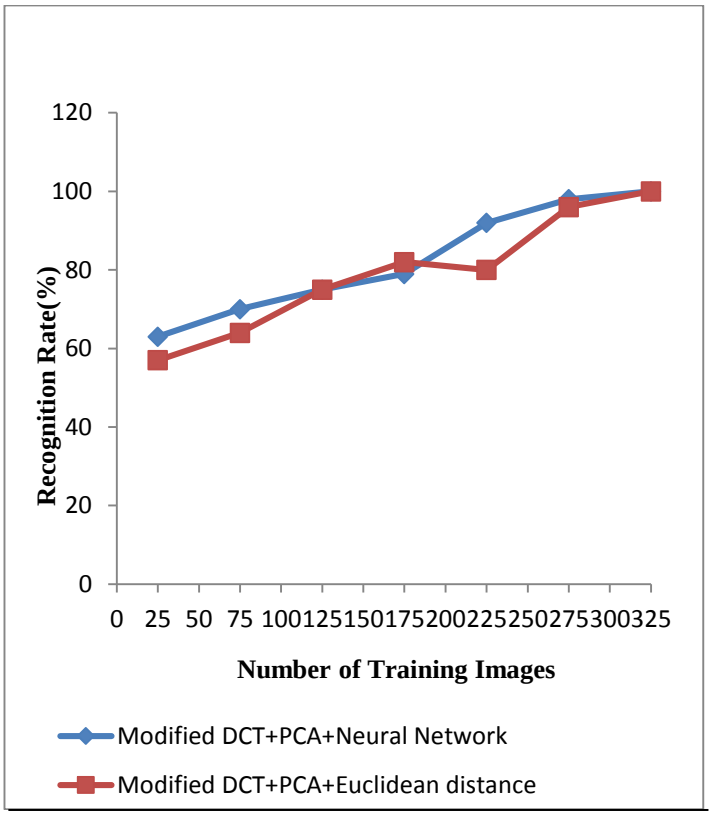

Fig. 13 Comparision between recognition rate of Approach-1 and Approach-2.

Table I is showing the result of 7 different cases where Euclidean distance used as Classifier. Column 2 shows numbers of images which are used in training. Column 3, 4 & 5 are showing number of correctly recognized images with Modified DCT, DCT and without DCT, respectively. Column 6 & 7 shows the recognition rate of the implemented system.

Table II is showing the result of 7 different cases where back propagation neural network is used as Classifier. Column 2 shows numbers of images which are used in training. Column 3, 4 & 5 are showing number of correctly recognized images with Modified DCT, DCT and without DCT, respectively. Column 6 & 7shows the recognition rate of the implemented system.

Table 1
Analysis of the results obtained by approach 1

Case Number	**Number of training images with illumination variation**	**Number of correctly recognized images (with Modified DCT)**	**Number of correctly recognized images (with DCT)**	**Number of correctly recognized images (without DCT)**	**Recognition rate in % (with DCT)**	**Recognition rate in % (with Modified DCT)**
1	325	65	65	58	100%	100%
2	275	63	59	56	91%	97%
3	225	52	50	50	77%	80%
4	175	53	48	37	74%	82%
5	125	49	43	33	66%	75%
6	75	30	35	36	54%	64%
7	25	37	20	18	31%	57%

Table II
Analysis of the results obtained by approach 2

Case Number	**Number of training images with illumination variation**	**Number of correctly recognized images (with Modified DCT)**	**Number of correctly recognized images (with DCT)**	**Number of correctly recognized images (without DCT)**	**Recognition rate in % (with DCT)**	**Recognition rate in % (with Modified DCT)**
1	325	65	65	63	100%	100%
2	275	63	61	59	94%	98%
3	225	60	54	50	83%	92%
4	175	50	52	44	80%	79%
5	125	49	47	45	72%	75%
6	75	46	43	41	66%	70%
7	25	40	41	33	63%	63%

IV. CONCLUSION

Here, Proposed approach, PCA with Back propagation Neural Network (BPNN) gives better result and it is very speedy than PCA with Euclidean Distance. Recognition rate of face recognition system with neural network is higher when numbers of training images are higher. Here, modified DCT is proposed in which appropriate number of low frequency coefficients are truncated and high frequency coefficients are scaled, which gives clear detail of the face and it outperforms the DCT. When, modified DCT applied with Euclidean distance and neural network. Modified DCT with neural network outperforms the Modified DCT with Euclidean distance.

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