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Face Recognition Using Double Dimension Reduction

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***Abstract*—**In this paper a new approach to face recognition is presented that achieves double dimension reduction making the system computationally efficient with better recognition results. In pattern recognition techniques, discriminative information of image increases with increase in resolution to a certain extent, consequently face recognition results improve with increase in face image resolution and levels off when arriving at a certain resolution level. In the proposed model of face recognition, first image decimation algorithm is applied on face image for dimension reduction to a certain resolution level which provides best recognition results. Due to better computational speed and feature extraction potential of Discrete Cosine Transform (DCT) it is applied on face image. A subset of coefficients of DCT from low to mid frequencies that represent the face adequately and provides best recognition results is retained. A trade of between decimation factor, number of DCT coefficients retained and recognition rate with minimum computation is obtained. Preprocessing of the image is carried out to increase its robustness against variations in poses and illumination level. This new model has been tested on different databases which include ORL database, Yale database and a color database. The proposed technique has performed much better compared to other techniques. The significance of the model is two fold: (1) dimension reduction up to an effective and suitable face image resolution (2) appropriate DCT coefficients are retained to achieve best recognition results with varying image poses, intensity and illumination level.

Keywords—Biometrics, DCT, Face Recognition, Feature extraction,.

I. Introduction

Face Recognition has been studied for over 20 years in computer vision [1]. Since the beginning of the 1990s, the subject has become a major issue, mainly due to the important real-world applications of face recognition like smart surveillance, secure access, telecommunications, digital libraries, medicine [2]. Faces are very specific objects whose most common appearance (frontal faces) roughly look alike but subtle changes make the faces different. In this paper, an effort has been made to investigate the double dimension reduction through decimation algorithm and then DCT, whose combination leads to improved recognition results with reduced computation. In this technique of face recognition, preprocessed normalized images are first exposed to decimation algorithm and then DCT is applied on decimated images to extract coefficients of low to high frequencies against each image which is used for training of the system. Later on recognition is performed by projecting a test image to the subspace of dimensionally reduced images. Euclidean distance is criterion used to obtain the best match. Results have been obtained by using ORL, Yale databases and color database. Main parts of the model are shown in Figure 1.

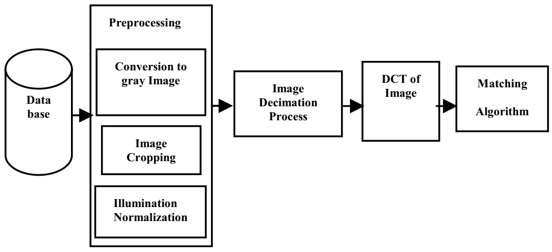

Figure 1. Model of the System

II. Pre-Processing

To avoid computation intensive processing of colored images in three planes of Hue, Saturation and Value, the colored images of database and test images are converted to gray scale images using expression shown below:

$$Y = 0.3R + 0.59G + 0.11B \quad (1)$$

The weights are used to compute gray scale image because for equal amount of color, eye is most sensitive to green, red and then blue [3,4].

Illumination is one of the most important factors that determine success or failure in many imaging and machine vision applications. Physiologically the response of cells in the retina of eye is nonlinear in the intensity of the incoming image, which can be approximated as a log function of the intensity. In this model log transformation is applied on those images which have shadow and non uniformity of poor illumination. Log function can extend low gray level and compress high gray level, which can improve the illumination deficient in essence.

Eyes, nose, lips, chin and surrounding area of face image contribute maximum in face recognition. The images of data sets are cropped to eliminate the unnecessary information and to retain face only. Figure 2 shows the original image and the cropped image.

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Figure 2.Original Image and Cropped Image

III. Decimation Algorithm (DA)

In most pattern recognition systems it is required that all input images have the same dimension and resolution [5]. Decimation algorithm is a novel form to obtain uniform resolution in all images of database. At the same time DA can deal with any changes of image size and resolution by integer factor (L) which can be calculated by:

$$L = M/N \quad (2)$$

Where M=order of original image matrix

N =order of desired decimated image matrix

L = arbitrary down scale decimation factor:

IV. Structure of Decimation Algorithm

In this algorithm the sub sampling under the best circumstances is harmless to image as it scans through lines of pixels, averaging together pair of pixels or group of pixels according to value of L. The resulting image is a reduced size mirror of the original image faithful in tonality to the original image but smaller in size. The sliding mask shown in Figure 3 is applied to achieve the decimation, the mathematical expression of this process is[6]:

$$D_{mxn} = \frac{\sum_{i=0}^{W-1}\sum_{j=0}^{H-1}\left[\sum_{m=i\times\mu_w}^{i\times\mu_w+(\mu_w-1)}\ \sum_{n=j\times\mu_h}^{j\times\mu_h+(\mu_h-1)} O_{ixj}\right]}{L\times L} \quad (3)$$

$$\mu_w = \frac{W}{L} \;\&\; \mu_h = \frac{H}{L}$$

Where W =Width of the original image

H =Height of original image

μ_w =Ratio between actual width of image and desired width

μ_h =Ratio between actual height of image and desired height.

1	1	1
1	1	1
1	1	1

Figure 3. Decimation mask of 3 x 3

The size and movement of window depends upon the value of L. As value of decimation factor is varied, a Gaussian pyramid [7] as shown in Figure 4 is achieved which is used to obtain optimal resolution for best recognition rate with minimum computation.

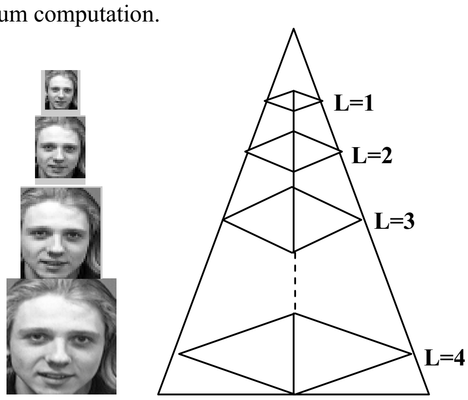

Figure 4. Gaussian pyramid

V. DCT of Image

In pattern recognition techniques to make the model computationally efficient, dimension reduction is as important as the class separation in applications like face recognition. To obtain dimension reduction a transform like DCT is required which exhibits large variance distribution in a small number of coefficients [8].

DCT of the normalized decimated face image is computed and a certain subset of low-to-mid frequency coefficients having the highest variance is retained as a feature vector which describes face

VI. System Training and Recognition Process

Five out of 10 images of database are used for training of model. Images are preprocessed, decimated and their DCT is computed. A feature vector containing 8 x 8 subset of DCT coefficients is retained and stored against each face image.

VII. Recognition

The DCT of preprocessed, decimated test image is obtained and a 8 x 8 subset of coefficients is retained. Feature vector of test image is compared with the images obtained during the training of the system. Euclidian distance is criterion used to get the best match.

VIII. Experiments and Results

Three sets of experiments are presented to evaluate this new approach. First experiments are carried out on ORL and YALE databases containing gray scale images. Model is also tested on a database of color images of different resolutions and constraints.

A. Olivetti Research Laboratory Face Database

The ORL database contains 400 images of 40 individuals, 10 images were taken for each individual and few constraints on facial expression and pose were imposed. Further more number of captured images were subjected to illumination variations. It is expected that this is a more difficult database to work with. There are variations in facial expressions (open / closed eyes, smiling / non- smiling) and facial details (glasses / no glasses). In proposed face recognition model, 200 samples (5 for each individual) of ORL database were selected randomly to train the system. The remaining 200 samples were used randomly as test images. Error rate is computed by varying the value L and results are shown in Figure 5,best recognition success rate of 97% is achieved at L =8.

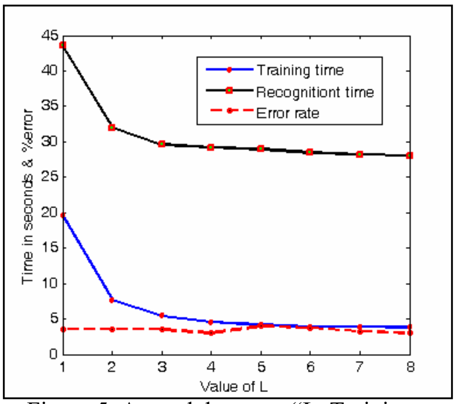

Figure 5. A graph between "L, Training time, Recognition time and Error rate" of ORL Database

B. *Color Face Database*

In the second set of experiments, 15 sets of color images of different individuals with 10 varying poses, sizes and intensity level were taken [9]. These images were obtained with different facial expressions and occlusions. Results with various values of L and its effect on error rate are shown in Figure. 5, best success rate of 94.5% is achieved at L= 8.

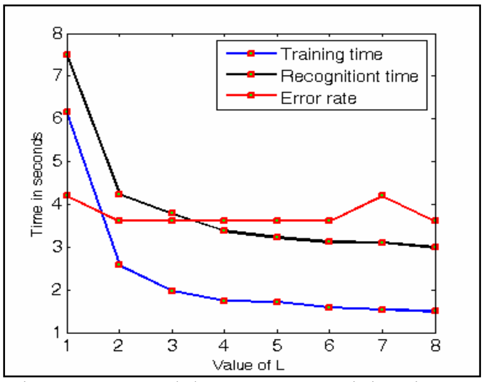

Figure 6. A graph between "L, Training time, Recognition time and Error rate" of Color

C. *Yale dataset*

The Yale database contains 165 gray scale images in GIF format of 15 individuals. There are 11 images per person one per different facial expression or configurations: center-light, with or without glasses, sad, happy, sleepy, surprise and wink. Results with various values of L are shown in Figure 5 which reflects that value of L=8 Provides best recognition rate of 96.5%.

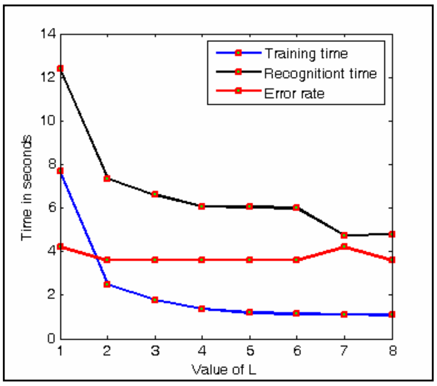

Figure 7 A graph between "L, Training time, Recognition time and Error rate" of YALE database

IX. Discussion

Decimation algorithm is applied to three different databases having images with different constraints. Experiments using Gaussian pyramid of different image resolution values and keeping DCT subset of 8 x 8 coefficients are carried out. Results reflect that a trade of between image resolutions, recognition error rate and computation speed exists in each dataset. Different databases are used to evaluate the proposed model on images acquired under maximum constrained environments. Speed of CPU and recognition rate varies with respect to number of training images because CPU require more time for training as number of images increases. For comparison and standardization five images of each person have been used for training purposes and it is found that results are much better than other techniques. The comparison of results of proposed double dimension model with other dimension reduction techniques like DFT, NMF, PCA and LDA is also carried out and its recognition rate with computational speed were much better.

Figure 8 Few Recognition Results

X. CONCLUSION

Real time security and surveillance due to certain limitations and restrictions (like constrained environment, speed of system and its accuracy) have made this area of research more attractive and challenging for biometric researchers. Proposed system of face recognition using decimation algorithm in conjunction with DCT has been developed to overcome these limitations up to a certain extent and success rate has improved besides enhancing speed. Results have been obtained by using five images as a standard for training purposes. Variations in number of training images affect both the success rate and speed of CPU.

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