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# LDA BASED FACE RECOGNITION USING DCT AND HYBRID DWT

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**Abstract** - In this paper we present a hybrid approach for efficient human face recognition. The proposed method is based on linear discriminant analysis of image in DCT domain with a combination of details of DWT. And the similarity measure Minkowshi is used here. This approach reduces the storage requirement and computation time while preserving the data. The approach LDA -DCT-hybrid DWT is evaluated on Matlab using ORL face database. Compared to previous methods the proposed method improves feature extraction and retrieval rate.

**Keywords** - Face recognition; Discrete Cosine Transform; Discrete Wavelet transform; Linear discriminant Analysis.

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## I. INTRODUCTION

During the past two decades, Face recognition [4] bound its importance as the necessity of security levels increasing. This makes the researchers to work for an efficient system of face recognition. The methods of face recognition is mainly divided into two major categories, appearance based (PCA, LDA, IDA etc..) and feature based, in which the former one is more popularized.

In general face images are captured with very high dimensionality, which is above 1000 pixels. As dimensionality increases the complexity also increases which makes difficult to recognize faces based on the original images. This makes the feature extraction as an important step and base to the face recognition.

In appearance based methods, LDA shows most prominent results than PCA because LDA focus on most discriminant features extraction in both inner classes and outer classes, so that it optimizes the low-dimensional representation of face images. Where as in PCA which is also an Eigen face method, projects the image data into a subspace based on the variance between data. And it treats the inner class and outer class as same.

Also, some of the frequency domain methods have been adopted in face recognition such as Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT). Here features are extracted by first transforming images (spatial domain) into frequency domain. Since frequency domain methods are data independent (basis vectors are constant) and also they require only low frequency components which contain the most information to represent the image, these are more efficient than PCA and LDA.

Here we go through a combination of frequency and spatial domains for feature extraction. Frequency domains such as DCT and DWT reduce the redundant data and make the input into an efficient form.

Features are extracted by Linear Discriminant Analysis of image in DCT domain, there by calculating the DWT details of transformed image coefficients. Since the DCT only reduces the correlated data in blocks, using DWT after DCT reduces the redundant data between blocks also.

## II. DISCRETE COSINE TRANSFORM

The Discrete Cosine Transform is the most widely used lossy image compression technique, which forms basis for international standard compression algorithm called "JPEG". Directly using face images having high redundant and correlation data causes heavy burden and complexity in terms of storage and processing speed.

Therefore, a 2D-DCT [1] [6] is applied to an image. It segments the image into a nonoverlapping blocks and DCT is applied to each block separately. This results a transformed image with same dimensions as input image.

For 1D case, DCT is defined as

$$y(k) = \alpha(k) \sum_{n=0}^{N-1} x(n) \cos \left[ \frac{\pi(2n+1)k}{2N} \right],$$

$$k=0,1,\dots,N-1 \quad (1)$$

Where

$$\alpha(k) = \begin{cases} \frac{1}{\sqrt{N}}, & k = 0 \\ \sqrt{\frac{2}{N}}, & k = 1, 2, \dots, N-1 \end{cases}$$

The vector form of equation (1) can be written as  $y = C^T x$ . The elements of matrix C can be derived from equations shown below.

$$c_{n,k} = \frac{1}{\sqrt{N}}, k = 0, n = 0, 1, \dots, N-1$$

$$c_{n,k} = \sqrt{\frac{2}{N}} \cos \left[ \frac{\pi(2n+1)k}{2N} \right],$$

$$K=1, 2 \dots N-1, n=0, 1 \dots N-1$$

Since the transform matrix  $C$  is an orthogonal matrix ( $C^T = C^{-1}$ ), the 2D-DCT can be computed as

$$Y = C_M^T X C_N$$

Where  $X$  is the input image with  $M$  rows and  $N$  columns and  $Y$  is the 2D-DCT coefficients matrix.

#### A. Block DCT

In JPEG standard images are divided into blocks (8x8) where each block is independently applied in DCT. For a given image of size  $p \times q$ , with sub images of size  $n \times n$ , the DCT is applied.

Since the transformation matrix is also an orthogonal matrix, JPEG DCT coefficients are directly used for the LDA approach and the inverse DCT which increases the computation time is skipped.

### III. DISCRETE WAVELET TRANSFORM

Most commonly used frequency domain approach for image analysis is discrete wavelet transform and also become a part of "JPEG2000" standard. A signal is decomposed into a set of basis functions called "wavelets" in DWT [2]. Here decomposition means resolution of signal. In DWT multi resolution analysis is performed with localization in both frequency and time domains.

Mathematically DWT can be expressed as:

$$DWT_{x(n)} = \begin{cases} d_{j,k} = \sum x(n) h_j^*(n - 2^j k) \\ a_{j,k} = \sum x(n) g_j^*(n - 2^j k) \end{cases} \quad (2)$$

The coefficients  $d_{j,k}$  are called detail components of signal  $x(n)$  and coefficients  $a_{j,k}$  are called approximation components. The functions  $g(n)$  and  $h(n)$  refer to the coefficients of low pass and high pass filters with parameters  $j$  and  $k$  as wavelet scale and translation factors.

In case of 2D images, DWT is done as a set of filter banks (combination of low pass and high pass filters). Finally image is decomposed into four non-overlapping, multi-resolution sub bands: LL, LH, HL, HH where, LL corresponds to approximation details (coarse scale) and LH, HL, HH

corresponds to horizontal, vertical and diagonal details (fine scale) respectively. Size of each band is quarter to the original image size. The next level of DWT is obtained by further decomposition of LL sub band. We can repeat the DWT multiple times for multiple level of resolution as shown in Fig.1.

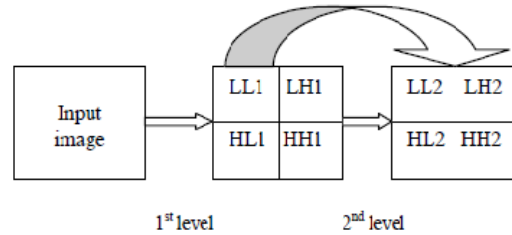


Fig. 1 : Decomposition levels in DWT.

Size of each band in 1<sup>st</sup> level = 1/4<sup>th</sup> of original.

Size of each band in 2<sup>nd</sup> level = 1/4<sup>th</sup> of LL1 (approximation).

### IV. LINEAR DISCRIMINANT ANALYSIS

Linear Discriminant Analysis (LDA) [3] is one of the best dimensionality reduction and feature extraction technique, it proves its importance in image analysis. The main objective of LDA [6] is to find a set of projecting vector that best discriminates the different classes. So that the ratio of between class scatter matrix and within class scatter matrix increases.

In LDA the equations for between class and within class scatter matrix is given as

$$s_b = \sum_{i=1}^c n_i (\bar{X}_i - \bar{X})(\bar{X}_i - \bar{X})^T \quad (3)$$

$$s_w = \sum_{i=1}^c \sum_{X_j \in C_i} (X_j - \bar{X}_i)(X_j - \bar{X}_i)^T \quad (4)$$

Where  $n$  is the number of samples in class  $C_i$ ,  $c$

is the number of classes, and  $\bar{X}_i = \left( \frac{1}{n_i} \right) \sum_{k=1}^{n_i} X_k$  is

the mean of class  $C_i$  and  $\bar{X} = \left( \frac{1}{c} \right) \sum_{k=1}^c X_k$  is the mean of all samples.

The goal of LDA is to maximize the ratio of between-class measure to within class measure so that it best discriminates the classes, and it is determined as:

$$E_{opt} = \arg \max_E \frac{|E^T S_b E|}{|E^T S_w E|} = [e_1, e_2, \dots, e_m] \quad (5)$$

Where  $e_1, e_2, \dots, e_m$  are the  $m$  largest eigenvectors with respect to the  $m$  largest Eigen values  $\lambda_i, i = 1, 2, \dots, m$  i.e.,

$$S_b e_i = \lambda_i S_w e_i, i = 1, 2, \dots, m. \quad (6)$$

And the projection matrix is given as

$$Y = E_{opt}^T X. \quad (7)$$

It has to be proven that, the ratio is maximized even for the projection matrix, which calculated by using the eigenvectors of  $S_w^{-1} S_b$ .

**V. METHODOLOGY**

The block diagram for proposed method of hybrid face recognition is as shown in Fig.2. A combination of DCT, DWT and LDA is used for feature extraction of images. Images are finally retrieved by comparing the features extracted from query and database.

The system performance is evaluated by using database ORL (Olivetti Research Laboratory), Cambridge, U.K. The database contains images of 40 people, with each person having 10 different poses (400 images).

The face recognition model presented in this paper is developed using MATLAB 2009a.

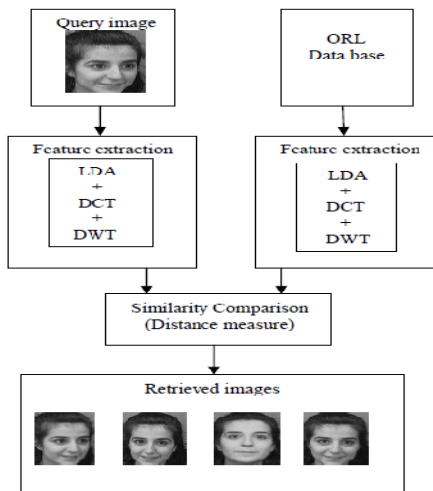


Fig. 2 : Face Recognition system for proposed method.

**A. Feature Extraction**

Before finding the projection result, the within class scatter matrix and between class scatter matrix are transformed in DCT domain using orthogonal matrix Q, i.e.,

$$\overline{S_b} = Q^T S_b Q \quad (8)$$

$$\overline{S_w} = Q^T S_w Q \quad (9)$$

Now these transformed matrices are taken as input to the DWT. A wavelet function called “haar” which is very simple and orthogonal is used in DWT [7]. In DWT, decomposition of matrices makes the output with four details, out of which most of the information in approximation details (smooth information), except the sharp edge information. To maintain the data efficient, instead of using all four sub bands the diagonal details which contain the sharp edge information is merged with approximation details. The new modified/transformed with-in class and between-class scatter matrices are used for further procedure in LDA [6] for feature extraction. Finally a projection matrix with Eigen vectors [5] correspond to highest Eigen values [5] is obtained.

**B. Similarity measure**

Similarity measure is the step done after extracting features. The similarity between the query image and images in database can be obtained by simply measuring the distance. The distance used in this method is Minkowski [8], which is given as

$$\text{Minkowski Distance} = \left( \sum_{i=1}^n |x_i - y_i|^p \right)^{\frac{1}{p}}$$

Where  $n$  is the number of samples and  $p$  is the order.

$p=1$  for Manhattan distance and

$p=2$  for Euclidean distance.

**VI. EXPERIMENTAL RESULTS**

The results shown here are obtained by using the ORL database having 400 images with each image size of 112x92. The results shows that the proposed method performs better when compared to some of the existing methods. The number of features is taken constant throughout all the methods.

The results that obtained by comparing the recognition rates with different methods are as shown in Table 1.

TABLE I : COMPARISON OF RECOGNITION RATES

| Method                                  | Recognition rate(%) per samples |       |      |       |       |
|---|---------------------------------|-------|------|-------|-------|
|   | 1                               | 3     | 5    | 7     | 10    |
| LDA                                     | 100                             | 63.4  | 52.5 | 48.92 | 42.25 |
| LDA in DCT domain                       | 100                             | 86.6  | 81.5 | 71.42 | 65.5  |
| LDA in DWT/DCT domain [7]               | 100                             | 94.16 | 82.5 | 74.64 | 63.5  |
| LDA in DCT/DWT domain (proposed method) | 100                             | 86.6  | 78.5 | 75    | 67.5  |

As from the above table it can be consider that the recognition rate will be increased when DWT is done after DCT.

## VII. CONCLUSION

A new framework for face recognition is presented in this paper. This method uses a combination of DCT and DWT frequency domains with LDA spatial domain for feature extraction. DCT extracts the efficient transformed information for which DWT is applied to extract major features of LDA class matrices. Because of merging the details of smooth and sharp information in DWT the feature size is reduced with increasing efficiency.

Experiment results obtained reveal that the proposed method shows good recognition accuracy compared to previous proposed techniques.

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