Multiple Face Model Recognition of Hybrid Discrete Wavelet Transform and Density Based Score fusion Technique under Uncontrolled Illumination Variation

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Abstract—A facial recognition system is one of the biometric applications for automatically identifying or verifying a person from a digital image or a video frame from a video source. Mostly it is used in security systems and can be compared to other biometrics such as fingerprint or eye iris recognition systems. Now a day's face recognition system is recognize the face using multiple-views of faces, for detecting each view of face such as left, right, front, top, and bottom. This face recognition system for large-scale data sets taken under uncontrolled illumination variations. The proposed face recognition system consists of a novel illumination-insensitive preprocessing method, a hybrid discrete Wavelet Transform (HDWT) for feature extraction and Density based Score Fusion Technique for matching. First, in the preprocessing stage different stages are followed like Gamma Correction, DOG(Difference of Gaussion)filtering and contrast equalization which transforms, a face image into an illumination-insensitive image, Then, for feature extraction of complementary classifiers, multiple face models based upon HDWT are applied. To do the feature extraction this system uses DCT and DCT Wavelet transform to generate the feature vectors of the query and database images. Euclidean distance is used as similarity measure to compare the image. Finally, to combine scores from multiple complementary classifiers, a log likelihood ratio-based score fusion scheme is applied. The proposed system uses the ORL face database which has 10 views of 40 people under various environmental variations such as illumination changes, different poses, and time elapses. Using ORL database the computational time require for the system is 0.3264 msec to 0.9672 msec which is less as compare to FRGC database that is 1.0234 msec to 2.0045 msec.

Keywords- Face Recognition, Preprocessing, Feature extraction, Score Fusion, Biometrics, Multi-view face recognition, DCT Wavelet, Euclidean distance

1 INTRODUCTION

Image processing is widely used in many applications, including medical imaging, industrial manufacturing, and security systems, face recognition, human recognition, figure print recognition in cyber crime, military application, and medical diagnosis. Now days we need to maintain global security Information, in every organization or individual wants to improve their existing security system. Most of the people need better security system which gives complete security solution. From time to time we hear about the crimes of credit card fraud, computer break-in by hackers, or security breaches in company, in shops, in government buildings. In most of these crimes the criminals were taking advantage of that hacking the information from commercial or academic access control system. The systems do not grant access by who we are, but by what we have, such as ID cards, keys, passwords, PIN numbers. These means they are really defining us or they just want to authenticate us. It goes without Permission of owner's, duplicates, or acquires these identity means, he or she will be able to access our data or our personal property any time they want. Recently, technology became available to allow verification of true individual identity. This technology is based in a field called "biometrics". Biometrics is a technique for identifying people by using a unique physiological characteristic, such as a fingerprint, eye, face, etc. or behavioral characteristics, e.g., voice and signature etc. Biometrics is the use of computers to recognize people, considering all of the across-individual similarities and within-individual variations. Among the various biometric ID methods, the physiological methods such as fingerprint, face, DNA are more stable than methods in behavioral category like keystroke, voice print etc.. Face recognition is one of the biometric methods that to have the merits of both high accuracy and low intrusiveness. It has the accuracy of a physiological approach without being intrusive. For this reason, the face recognition has drawn the attention of researchers in fields from security, Psychology, and image processing, to computer vision. Many algorithms have been proposed for face recognition, Face recognition has also proven useful in other multimedia information processing areas. Facial recognition analyzes the characteristics of a person's face images input through a digital video camera or online face capturing.

In this paper, the section II gives Structure and Procedure of Face Recognition System, section III gives Literature Survey of Face Recognition Techniques and section IV gives the proposed work for system. The rest of the paper Describes illumination insensitive representation as a preprocessing

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method is presented in Section V, In Sections VI Feature Extration method hybrid Discrete Wavelet Transform from multiple face models is explained in, In Section VII, log-likelihood-rate based Density based score fusion is presented, in section VIII Experimental results and discussion is discussed and the co clusion is summarized in Section IX.

2 STRUCTURE AND PROCEDURE OF FACE RECOGNITION SYSTEM

The face recognition procedure generally separates into three steps: Face Detection, Feature Extraction, and Face Recogntion [**1**]

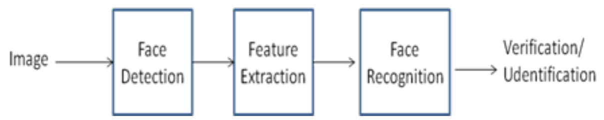

Fig. 1. Fig 1 Architecture of face recognition system [1]

As shown in fig 1 the first task of the face recognition system is capturing image by video or by camera and this image is given to the further step of face recognition system that is:

Face Detection:

The main function of this step is to determine whether the human faces appear in given image or not and where the face is located at. The outputs of this step are patches containing each face in the input image, face alignment are performed to justify the scales and orientations of these patches. These step is working as the preprocessing for face recognition, face detection could be used for region of interest detection, retargeting, video and image classification, etc.

Feature Extraction:

In this step feature extractions are performed to do information packing, dimension reduction, salience extraction, and noise cleaning. After this step, a face patch is usually transformed into a vector with fixed dimension or a set of fiducial points and their corresponding locations

Face Recognition:

Feature extraction step analyzes the representation of each face; this last step is used to recognize the identities of these faces. In order to achieve automatic recognition, a face database is required to build. For each person, several images are taken and their features are extracted and stored in the database. Then when an input face image comes in, then perform face detection and feature extraction, and compare its feature to each face class stored in the database. There have been many researches and algorithms proposed to deal with this classification problem. There are two general applications of face recognition, one is called identification and another one is called verification. Face identification means given a face image, can be used to determine a person's identity even without his knowledge or consent. While in face verification, given a face image and a guess of the identification, the system must to tell about the true or false about the guess.

3 SURVEY OF FACE RECOGNITION TECHNIQUES

Face recognition can be largely classified into two different classes of approaches, the local feature-based method and the global feature-based method. The Human faces can be characterized both on the basis of local as well as of global features global features are easier to capture they are generally less discriminative than localized features local features on the face can be highly discriminative, but may suffer for local changes in the facial appearance or partial face occlusion. Now a day's face recognition system is recognize the face using multiple-views of faces, these Multi-view face recognition techniques has proposed by some authors for detecting each view of face such as left, right, front, top, and bottom using some methods which is discussed below .

The method proposed by Ramamoorthi and Pat Hanrahan[2] and Amnon Shashua and Tammy Riklin-Raviv[3] color based; image based re-rendering recognition which is proposed by Ravi. This method is has problem of pose variation and that is solve by Hybrid PCA method, But this method does not work well when large number of database is used for face recognition. Hybrid-PCA method is suggested by M. Savvides, B. Kumar, and P. Khosla[5], which works better when large database is consider for face recognition, this method is also work on partial faces, as well as illumination condition but the accuracy of recognizing faces is somewhat poor. This accuracy problem is slightly resolved in Kernel based face recognition method which has been suggested by Xiaoyang Tan and Bill Triggs[8],these method have the problem of additional feature set which is resolve in likelihood ratio based score fusion technique which is proposed by Karthik Nandakumar[19], which increase the recognition rate without need of additional parameters. Some of these methods works only on local features of face image, but in the Fisher Linear Discremenant method which is suggested by Yu Su, Shiguang Shan, X. Chen, and W. Gao[12], it works on both the features like local and global features of face image, but the problem of illumination condition is not solve using this method. This problem is solve by Hybrid Fourier feature method suggested by Wonjun Hwang, Haitao Wang, Hyunwoo Kim[13], This method works well on different illumination condition, also works only in frequency domain. Because of this reason the computation time is increase for extracting the features from face. And also this affects on efficient face recognition performance. This problem is discussed in following proposed work method.

4 PROPOSED WORK

The above discussed methods have some limitations which have solved by many researchers, but there are still some other issues in face recognition like computational time and efficiency of recognizing the faces from large databases. **A**utomatic face recognition is an important vision task with many practical applications such as biometrics, video surveillance, image retrieval, and human computer interaction. One major issue for face recognition is how to ensure recognition accuracy for a

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large data set captured in various conditions. Several face data sets are collected to compare with this system, like face recognition technology (FERET) [20], face recognition vendor test (FRVT) [21], [22], and face authentication test [23]. Most recently, face recognition grand challenge (FRGC) [24] has been designed to improve the accuracy of recognition systems in a large-scale data set, particularly focused on verification of the person rather than identification. In FRGC, The main issue is how to match two face images of the same person under different conditions, but in Olivetti Research Ltd (ORL) database of faces. The database consists of 400 images, 10 each of 40 different subjects. The subjects are either Olivetti employees or Cambridge University students. Five images of each subject were used for training and Five for testing, giving a total of 200 training and 200 test images. One is taken in a controlled studio setting while the other is captured in uncontrolled illumination conditions such as hallways, atria, or outdoors. To overcome the problem of uncontrolled environmental problem using preprocessing method which is discussed in section V , a hybrid DWT (Discrete Wavelet Transform) will be used for feature extraction which reduces the computational complexity, because work in both frequency and time domain, DWTs also have higher flexibility, better compression ratio and performance, This approach combines multiple classifiers with complementary features instead of improving the accuracy of a single classifier. Illumination insensitive preprocessing and density based score fusion technique is combine into the proposed face recognition system which will give efficient face recognition performance. The following figure shows the block diagram of the proposed system.

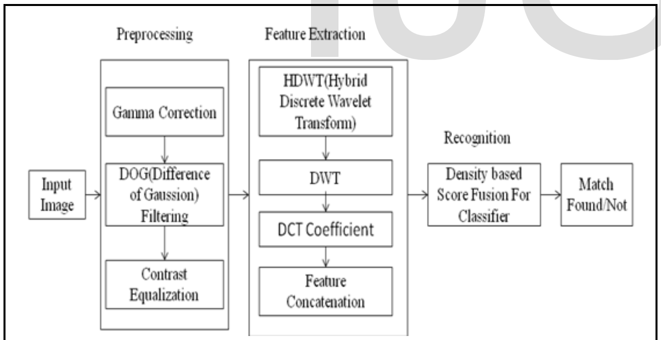

Fig 4.Block Diagram of Proposed System

Above block diagram shows the structure of proposed system which includes three steps preprocessing, feature extraction and recognition. First step of proposed multiple face model recognition is preprocessing which includes Gamma Correction, Difference of Gaussion(DOG) and Contrast Equalization. The preprocessing method is used here to solve one of the common problems in face images, due to a real capture system i.e. lighting variations. The different stages include gamma correction, Difference of Gaussian (DOG) filtering and contrast equalization. Gamma correction enhances the local dynamic range of the image in dark or shadowed regions while compressing it in bright regions and is determined by the value of γ. DOG filtering is a grey scale image enhancement algorithm that eliminates the shadowing effects. Contrast equalization rescales the image intensities to standardize a robust measure of overall intensity variations [16]. In feature Extraction Hybrid Discrete Wavelet transform is used which is used for person classification and any invariance in the face images against environmental changes. The advantage of Wavelet Transform (WT) is that its ability to analyze the signal in both time and spatial domains. DWTs also have higher flexibility, better compression ratio and performance. The Hybrid wavelet transforms are generated by combination of two orthogonal transforms. The concept of Hybrid transforms gives better performance than wavelet transforms. In proposed multiple face models focus on compensatory face models in imitation of human perception, which uses both internal features for e.g., mutual spatial configuration of facial components and external facial features e.g., hair and jaw-line for face recognition. With multiple complementary features and classifiers [15]. In recognition step as we having the set of complementary classifiers, then build a unified classifier combining these complementary classifiers. The purpose of this classifier is to construct a strong classifier by suitably combining a set of classifiers. To this end, to keep as much information each classifier extracts as possible, and at the same time the combination should be easy to implement. The information each classifier extracts is well summarized in the score each classifier produces. Hence, combining the classifiers can be achieved by processing the set of scores produced by component classifiers and generating a new single score value. This process is called "Density Based score fusion." a Density Based score fusion method based upon a probabilistic approach, namely, log likelihood ratio (LLR) for face recognition [9].

5 PREPROCESSING METHOD UNDER VRYING ILLUMINATION CONDITION

This preprocessing method combines the features of gamma correction, DOG filtering and contrast equalization techniques. Over all stages of proposed preprocessing method is shown in Fig.3 [21].

Fig 5.The Stages of Preprocessing method [16]

5.1 Gamma Correction

Gamma Correction matters when you have any interest in displaying an image accurately on computer screen. It controls overall brightness of image. Image which is not properly corrected can look either light or too dark. Trying to reproduce colors accurately also requires some knowledge of gamma. Varying the amount of gamma correction changes not only the brightness, but also the ratios of red to green to blue. If gamma correction is done properly for the computer system, then the output should accurately reflect in image input. Gamma correction, gamma nonlinearity, gamma encoding, or often simply gamma, is the name of a nonlinear operation used to code and decode luminance or tristimulus values in video or still image systems. Gamma correction is defined by the following power-law expression [16]:

$$V_{out} = AV_{in}^{\gamma}$$

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Where A is a constant and the input and output values are non negative real values, in the common case if A=1 input and output are in the range of 0-1.A gamma values $\gamma<1$ is sometime called as encoding gamma and the process of encoding with this compressive power-law nonlinearity is called gamma compression; conversely a gamma value $\gamma > 1$ is called a decoding gamma and the application of the expansive power-law nonlinearity is called gamma expansion. Gamma Correction is a nonlinear gray-level transformation that re laces gray-level I with the gray level $I^{1/\gamma}$ and is given by,

$$I = I^{1/\gamma} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

(for > 0) or log(I) (for = 0), where ∈ [0, 1] is a user-defined parameter. This enhances the local dynamic range of the image in dark or shadowed regions while compressing it in bright regions [21].

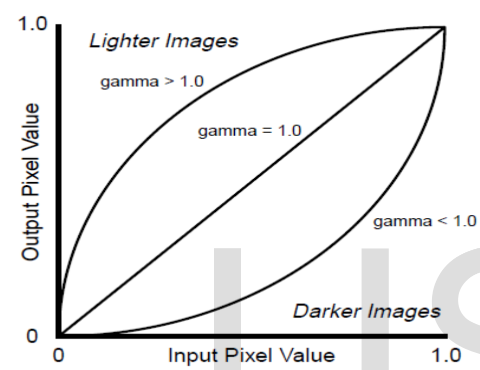

Fig 5. (A) Gamma Curve [21].

This curve is valuable in keeping the pure black parts of the image black and the white parts white, while adjusting the values in-between in a smooth manner. Thus, the overall tone of an image can be lightened or darkened depending on the gamma value used, while maintaining the dynamic range of the image. In Figure 5.a, the pixel values range from 0.0 represents pure black, to 1.0, which represents pure white. As the figure shows, gamma values of less than 1.0 darken an image. Gamma values greater than 1.0 lighten an image and a gamma value equal to 1.0 produces no effect on an image. Here Gamma= 0.4 is used as the default setting [21].

5.2 Difference Of Gaussian(DOG) Filtering

Gamma correction does not remove the influence of overall intensity gradients such as shading effects. Difference of Gaussians is a feature enhancement algorithm that involves the subtraction of one blurred version of an original image from another, less blurred version of the original. In the simple case of grayscale images, the blurred images are obtained by convolving the original grayscale images with Gaussian kernels having differing standard deviations. Blurring an image using a Gaussian kernel suppresses only high-frequency spatial information. Subtracting one image from the other preserves spatial information that lies between the ranges of frequencies that are preserved in the two blurred images. Thus, the difference of Gaussians is a band-pass filter that discards all but a handful of spatial frequencies that are present in the original grayscale image. As an image enhancement algorithm, the Difference of Gaussian (DOG) can be utilized to increase the visibility of edges and other detail present in a digital image. The Difference of Gaussians algorithm removes high frequency detail that often includes random noise and this approach could be found well suitable for processing images with a high degree of noise [21].

The DOG Filter is defined as follows:

$$DOG(x,y) = \frac{1}{2\pi\sigma_1^{\,2}} e^{\frac{x^2+y^2}{2\sigma_1^{\,2}}} - \frac{1}{2\pi\sigma_2^{\,2}} e^{\frac{x^2+y^2}{2\sigma_2^{\,2}}} \ldots\ldots (2)$$

Where the default values of σ_1 and σ_2 are chosen as 1.0 and 2.0 respectively. Since this effect leads to the reduction in the overall contrast produced by the operation and hence the contrast has to be enhanced in the subsequent stages.

5.3 Contrast Equalization

The final stage of the preprocessing method which rescales the image intensities. Contrast equalization is contrast enhancement technique which increases the global contrast of many images. Especially when the usable data of the image is represented by close contrast gvalues. This allows for areas of lower local contrast to gain a higher contrast. The method is useful in images with backgrounds and foregrounds that are both bright or both dark. This stage includes Top-hat and Bottom-hat filtering can be used together to enhance contrast in an image. Top-hat filtering can be used to uneven illumination when the background is dark. It is used to extracting the light object. Bottom hat is used to extract dark object from light background. The procedure is to add the original image to the Top-Hat filtering image and then subtract the bottom-hat filtered image.

$$T_{hat}=X-(X\circ K)$$

$$B_{hat}=(X\bullet K)-X$$

where X is an image and K is a structuring element ,structuring element in a is a shape, used to probe or interact with a given image, with the purpose of drawing conclusions on how this shape fits or misses the shapes in the image.

The figure 5.1 shows the structure of preprocess stages after applying on image.

Fig 5.1Structure of preprocess image

The above diagram represents the overall structure of input image after performing all preprocesses stages. First, it will select an image form database then perform the smoothing filter operation on image, then it generates the smooth image but this smooth image cannot reduce the dark and light part of image accurately for that reason next we will apply Gamma Correction step on it. After generating result for gamma correction it will further apply Difference of Gaussion (DOG) Filter which reduces the all showing effect from image and it will increase the visibility of edges and other details present in image, but using this stage it will generate the contrast in mage and hence the contrast has to be enhance in contrast equalization stage. This stage increases the global contrast of image. The method is useful in images with backgrounds and foregrounds that are both bright or both dark which is shown in Contrast equalization image, Further this image will given as a input for performing feature extraction operation that describes in below section.

6 HYBRID DISCRETE WAVELET TRANSFORM FOR FEATURE EXTRACTION

Wavelets became popular in few past years in mathematics and digital signal processing area because of their ability to effectively represent and analyse data. There are many generalisations of original orthogonal wavelet systems. In addition to construct more general wavelet system, The ways how to construct discrete hybrid wavelet transforms (HWT), i.e. generalisation of discrete wavelet transforms (DWT) where basis is created by mixing 2 or more bases of existing DWT. Such approach is call hybridisation and to the resulting transform we refer as discrete hybrid wavelet transforms (HWT) [15]. The discrete wavelet transform (DWT) uses filter banks for the construction of the multiresolution time-frequency plane. A filter bank consists of filters which separate a signal into frequency bands. An example of a two channel filter bank is shown in Fig.6 discrete time signal x(k) enters the analysis bank and is filtered by the filters L(z) and H(z) which separate the frequency content of the input signal in frequency bands of equal width. The filters L(z) and H(z) are therefore respectively a low-pass and a high-pass filter. The output of the filters each contains half the frequency content, but an equal amount of samples as the input signal. The two outputs together contain the same frequency content as the input signal; however the amount of data is doubled. Therefore down sampling by a factor two, denoted by ↓2, is applied to the outputs of the filters in the analysis bank. Reconstruction of the original signal is possible using the synthesis filter bank. In the synthesis bank the signals are upsampled (↑ 2) and passed through the filters L'(z) and H'(z).The filters in the synthesis bank are based on the filters in the analysis bank. The outputs of the filters in the synthesis bank are summed, leading to the reconstructed signal y(k). The different output signals of the analysis filter bank are called subbands, the filter-bank technique is also called subband coding [17].

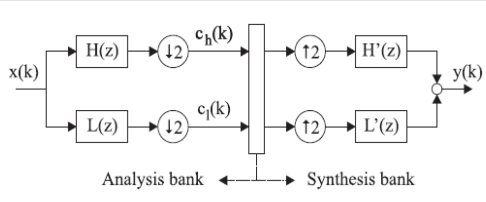

Fig 6. Two channel filter bank [17]

The low-pass and high-pass filters L(z) and H(z) split the frequency content of the signal in half. It therefore seems logical to perform a down sampling with a factor two to avoid redundancy. If half of the samples of the filtered signals cl(k) and ch(k) are reduced, it is still possible to reconstruct the signal x(k). The down-sampling operation (↓ 2) saves only the even numbered components of the filter output, hence it is not invertible. In the frequency domain, the effect of discarding information is called aliasing. In the synthesis bank the signals are first up-sampled before filtering. The up-sampling by a factor two (↑ 2) is performed by adding zeros in between the samples of the original signal. The wavelet transforms give better performance than other transforms are proved in many applications. The Hybrid wavelet transforms are generated by combination of two orthogonal transforms. The concept of Hybrid transforms gives better performance than wavelet transforms [18].

In this paper to do the feature extraction this system uses DCT Wavelet transform to generate the feature vectors of the query and database images. DCT wavelet is applied over row mean vector of each block separately and 4 sets of DCT wavelet coefficients are obtained respectively [19]. Out of these few coefficients are selected from each block and arranged in consecutive order to form the feature vector of the image. Variable size feature vectors are formed by changing the number of coefficients selected from each row vector. These two different feature databases obtained using DCT wavelet is then tested using different query images. Euclidean distance is used for similarity measurement to compare the image features. Euclidean distance calculated is sorted into ascending order to count the images which are relevant to the query image. First separate the image into Approximate, Horizontal, vertical and diagonal planes and then decomposing the image plane into 4 blocks and applying DCT transform over row mean vectors of each block of it to obtain the information of the image. Same process is repeated with DCT wavelet transform over row mean vectors of each block of each plane. Discrete cosine transform is made up of cosine functions taken over half the interval and dividing this interval into N equal parts and sampling each function at the center of these parts, the DCT matrix is formed by arranging these sequences row wise [19]. This paper uses DCT transform to generate the feature vectors. Wavelets are mathematical functions that cut up the data or signal into different frequency components by providing a way to do a time frequency analysis. Analysis of the signals containing the discontinuities and sharp spikes is possible with help of wavelet transforms. This paper has proposed a new algorithm to represent the feature vectors in the form of discrete cosine wavelet transform coefficients for image database. The DCT definition of 2D sequence of Length N is given in equation (5) using which the DCT matrix is generated [19]. The generalized algorithm which can generate wavelet transform of size N^2xN^2 from any orthogonal transform of size NxN is applied to DCT matrix and DCT Wavelet is developed which satisfies the condition of orthogonal transforms given in equation (6) [19]. Once the Discrete Cosine Transform Wavelet is generated following steps are followed to form the feature vectors of the images.

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$$F[k,l] = \sum_{m=0}^{M-1}\sum_{n=0}^{N-1} f[m,n]\alpha(k)\alpha(l)\cos\left[\frac{(2m+1)k\pi}{2M}\right]\cos\left[\frac{(2n+1)l\pi}{2N}\right] \quad \text{.............. (5)}$$

$$\alpha(k) = \begin{cases} \sqrt{\frac{1}{N}}, for\ k = 0 \\ \sqrt{\frac{2}{N}}, for\ k = 1,2,..N-1 \end{cases} \quad \text{.........(6)}$$

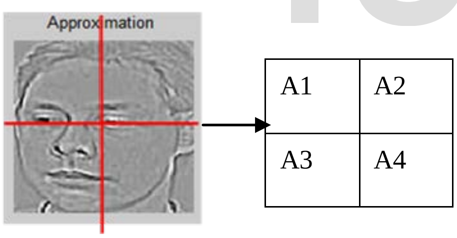
Orthogonal: DCT Wavelet transform is said to be orthogonal if the following condition is satisfied [19].

$$[DCTW][DCTW]^T = [D] \text{............(7)}$$

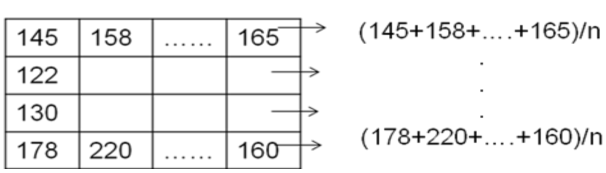
6.1 ALGORITHM for DCT WAVELET [19]:

1. Separate image into approximate, Horizontal, and vertical plane.

2. Divide each plane of image into four blocks A1, A2, A3 and A4 of all equal sizes



3. For each block calculate the row mean vectors.



4. Applying a DCT wavelet over all row mean vectors of all four blocks of each plane of all database images and new DCT Wavelet feature database is prepared.
5. Representation of feature vectors is explained as follows:

Select a few DCT wavelet coefficients from each row vector of all four blocks of each plane and arrange them in single vector in consecutive order. It gives the feature vector of that particular plane. Similar procedure is followed to get the feature vector for all three planes Approximate, Horizontal, Vertical and diagonal. Feature vectors for planes Approximate, Horizontal, Vertical and diagonal plane are obtained using above procedure and two feature vector databases are created for all the database images using DCT wavelet.

6. Once the feature databases are prepared system is tested with query image. Feature extraction of query image will be done in same manner as it does for the database images.

Similarity measure Euclidean distance given in equation (8) is applied to compare the query image with the database images for similarity [19].

$$D_{QI} = \sqrt{\sum_{i=1}^{n}(FQ_i - FI_i)^2} \quad \text{............ (8)}$$

7. Retrieval results are based on the criterion of sorting the Euclidean distances in ascending order and selecting images with respect to minimum distances from nearest distances sorted in ascending order for all database images [19].

So that applies DWT for the DCT co-efficient. The image it's converted as signal while extracting features. DCWT requires only N (2N-1) multiplications which saves considerable computational time of the system and gives better performance as well.

7 RECOGNITION USING DESITY BASED SCORE FUSION

Once we have a set of complementary classifiers, then we build a unified classifier combining these complementary classifiers. The purpose of this classifier here is to construct a strong classifier by suitably combining a set of classifiers. To keep as much information each classifier extracts as possible, and at the same time the combination should be easy to implement. The information of each classifier extracts is well summarized in the score each classifier produces. Hence, combining the classifiers can be achieved by processing the set of scores produced by component classifiers and generating a new single score value. This process is call as “score fusion.” Previous methods for score fusion include sum rule, product rule, weighted sum, Bayesian method, and voting [13]. A multiple face model that consists of different face models with different eye distances in the same image size. Here the different face models with the same image sizes, 256×256, are constructed with different eye distances and the Gamma Correction, DOG (Difference of Gaussion) Filtering, Contrast Equalization these stages are applied to each normalized face image. Then we have Approximate, Horizontal, and Vertical face models after applying HDWT on preprocess image. The Approximate face model is formed to analyze the internal components of a face, such as the eyes, nose, and mouth, while the Horizontal face model includes the general structures of a face and the external components such as hair, ear, and jaw-line. The last one, the Vertical face model, is a compromise between

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the approximate model and the Horizontal model. Each face model can play an inherent role for the others in the face recognition system. For example, the approximate face model is robust to background and hair style changes but sensitive to pose changes. On the other hand, the Horizontal face model shows the opposite tendency. In the end, we can have different classifiers, and each similarity score is calculated by a normalized correlation. The equation of the normalized score between two features Y_i^a and Y_i^b in the i^{th} classifier is defined as [13].

$$S(Y_i^a, Y_i^b) = \frac{\sum_{k=1}^{d} Y_{i,k}^{a} Y_{i,k}^{b}}{\|Y_i^a\| \|Y_i^b\|} \text{……….. (9)}$$

Here in this paper we considering the score fusion method based on weighted sum method, this method is based on Equal Error Rate (EER). The EER-based score fusion computes a weighted sum of scores, where the weight is a measure of the discriminating power of the component classifier. To combine the scores is to compute a weighted sum as follows [13]:

$$S = \sum s_i w_i \text{………….. (10)}$$

Where the weight w_i is the amount of confidence we have in the i^{th} classifier and its score s_i. One drawback of the weighed sum method is that the scores generated by component classifiers may have different physical or statistical meaning and different ranges. Hence, we should make sure that the range of each score is normalized appropriately [13]. The LLR-based fusion method is more principled than the weighted sum method in that the LLR-based fusion method is derived from the optimal likelihood ratio test. The method's decision boundary is nonlinear, there by being able to perform more complex classification. The set of scores as a feature vector from which we perform the classification task. Suppose we have a set of scores $s_1 \ldots s_n$ computed by n classifiers. Now the problem is to decide whether the query-target pair is from the same person or not based upon these scores. We can cast this problem as the following [13]:

$$P(s_1, \ldots \ldots, s_n | diff)$$

$$P(s_1, \ldots \ldots, s_n | same) \text{……. (11)}$$

Where $P(s_1, \ldots \ldots, s_n | diff)$ is the distribution of the scores when the query and target are from different persons, and $P(s_1, \ldots \ldots, s_n | same)$same is the distribution of the scores when the query and target are from the same person. If we know the two densities $P(s_1, \ldots \ldots, s_n | diff)$and $(s_1, \ldots \ldots, s_n | same)$, the log-likelihood ratio test achieves the highest verification rate for a given false accept rate. However, the true densities $P(s_1, \ldots \ldots, s_n | diff)$ and $P(s_1, \ldots \ldots, s_n | same)$are unknown, so we need to estimate these densities observing scores computed from query-target pairs in the training data. Then, we model the distribution of s_i as a Gaussian random variable with mean $m_{diff.i}$ and vriance $\sigma^2_{diff.i}$, and model $\{S_i\}_{i=1}^{n}$ as independent Gaussian radom variables with density

$$P(s_1, \ldots \ldots, s_n | diff) = \pi N(s_i; m_{diff.i}; \sigma^2_{diff.i}) \text{… (12)}$$

Where,

$N(s_i; m; \sigma^2) = \left(1/\sqrt{2\pi\sigma^2}\right) exp\{-((x-m)^2/2\sigma$ is the Gaussian density function, The parameters$(m_{diff.i}; \sigma^2_{diff.i})$ are estimated from the scores of the i^{th} classifier corresponding to non-match query-target pairs in the training database. Similarly, approximate density of $\{S_i\}_{i=1}^{n}$by $\pi N(s_i; m_{same.i}; \sigma^2_{same.i})$ and the parameters$(m_{diff.i}; \sigma^2_{diff.i})$ and $(m_{same.i}; \sigma^2_{same.i})$ are computed from the scores of the i^{th} classifier corresponding to match query-target pairs in the training database. The score fusion in (26.4955) depends upon the parameters that we estimate from the training data. Thus, this method is more sensitive to compare between the statistics of the training data and the test data than the weighted sum method. For instance, the score fusion in (26.4955) is affected by the shift of the mean parameters $m_{diff.i}$ and $m_{same.i}$.

8 Experimental Result with Different Database and Discussion

8.1 FRGC Database

FRGC provides three components as evaluation framework image data sets, experimental protocols, and the infrastructure. The FRGC data corpus contains high-resolution 2-D still images taken under controlled lighting conditions and with unstructured illumination as well. The data corpus is divided into training and validation partitions. The training set consists of 200 images from 20 subjects, with 100 controlled still images and 100 uncontrolled still images. The FRGC database is tested with proposed system with different face models. The accuracy of FRGC database with this system is 95% and it recognizes 41.86% images accurately form training image database and also the computational time require for recognize image from database is approximately 1.0234 msec to 2.0045 msec. The FRGC has provided high-resolution images together with four ground locations of the four fiducial points, namely two eyes, nose, and mouth points, to improve the recognition performance we have work with other database that is ORL database.

8.2 ORL Database

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Olivetti Research Ltd (ORL) database of faces. The database consists of 400 images, 10 views of each 40 different subjects. The subjects are either Olivetti employees or Cambridge University students. The age of the subjects ranges from 18 to 81, with the majority of the subjects being aged between 20 and 35. There are 4 female and 36 male subjects. Subjects were asked to face the camera and no restrictions were imposed on expression; For most subjects the images were shot at different times and with different lighting conditions, but always against a dark back- ground. Some subjects are captured with and without glasses. The images were manually cropped and rescaled to a resolution of 92x112, 8-bit grey levels. Here we are considering the size of image is 256×256. Five images of each subject were used for training and Five for testing, giving a total of 200 training and 200 test images. One is taken in a

TABLE I

COMPRESSION OF ACCURACY AND COMPUTATIONAL TIME MEASUREMENT OF FRGC AND ORL DATABASE WITH PROPOSED METHOD

Name of database	Accuracy	Computation time Per image
FRGC	95%	1.0234 msec to 2.0045 msec
ORL	98.55%	0.3264 msec to 0.9672 msec

controlled studio setting while the other is captured in uncontrolled illumination conditions such as hallways, atria, or outdoors. Using ORL database proposed system gives 98.55% accuracy for face recognition. Here we are using 100 train database images and 50 test image database .It recognizes 45% images accurately from test database images which have more effective as compare to FRGC database. And also the time require for recognize the image from database is approximately 0.3264 msec to 0.9672 msec which is less as compare to FRGC database. Proposed system is tested using ORL database which gives effective performance and reduced face recognition time. The proposed method will be useful for the scenarios where the input images have high resolution and it has the benefits of lower computational complexity.

9 END SECTIONS

9.1 ACKNOWLEDGMENT

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9.2 CONCLUSION

A The Multi Model face recognition system based on HDWT(Hybrid Discrete Wavelet Transform) and Density based Score fusion technique has been discussed in this paper It mainly focuses on application and Score Fusion technique under uncontrolled illumination, their performance analysis and comparative study with FRGC and ORL databases. First, we proposed a preprocessing method based upon the analysis of the face imaging model with different stages Gamma correction, DOG (Difference of Gaussion) Filtering and Contrast Equalization an illumination insensitive representation for face recognition. We also proposed HDWT with Multiple face models which basically Hybridization of DCT (Discrete Cosine Transform) +DWT (Discrete Wavelet Transform). In this stage each image is divided into 3 planes Approximate, Horizontal and Vertical. This information is handled separately to form the feature vectors. As each plane is divided into 4 blocks and transforms are applied to row mean vectors of each block which tells that the appearance of the image is taken into consideration while forming the feature vectors. By changing the size of the feature vectors using different sets of images computational time complexity is analyzed and it can be defined that computational time can be saved with smaller size feature vectors which are performing better as compared to the larger ones. Multiple face models always perform better than the dominant face model. Moreover, to effectively utilize the several classifiers, we proposed the score fusion method based upon the LLR at the final stage of the face recognition system. With the proposed method, we achieved an average 98.55% verification accuracy using ORL database as compare with FRGC database which achieves 95% accuracy. The proposed system achieves successful accuracy in face recognition under uncontrolled illumination situations. But as there is scope for further improvement so that these approaches can be used for variable image sizes and along with color and texture shape feature can also be considered for the comparisons and also the overall average precision and also these system can be used to develop the real time application such as for home application, Commercial application and security purpose etc.

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