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Efficient Face Recognition Algorithm by Using DWT and FFT

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Abstract— The biometrics is a powerful tool to authenticate a person for multiple applications. The face recognition is better biometrics compared to other biometric traits as the image can be captured without the knowledge and cooperation of a person. In this paper, we propose Discrete Wavelet Transform and FFT based feature extraction for Face recognition system. The face databases ORL and JAFFE are considered. The face images of JAFFE database are resized to 112*92 uniform dimensions. The features of face are generated using Haar wavelet family by considering approximation band only. The face features are also generated using magnitudes of FFTs. The test image features are compared with database features using Euclidian Distance (ED). It is observed that the values of False Rejection Rate (FRR), False Acceptance Rate (FAR) and Total Success Rate (TSR) are better in the proposed model compared to existing method.

Keywords— Face recognition, DWT, FFT, Euclidian distance

I. INTRODUCTION

The reliable identification systems are required to verify and confirm the identity of an individual requesting their service. Secure access to the buildings, laptops, cellular phones, ATM etc., are an example of some of the applications. In the absence of robust verification systems, these systems are vulnerable to the wiles of an impostor. The traditional methods of authentications are passwords (knowledge – based security) and the ID Cards (token – based security). These methods can be easily breached due to the chance of stolen, lost or forget. The development and progress of biometrics technology, the fear of stolen, lost or forget can be eliminated. Biometrics refers to the automatic identification (or verification) of an individual (or a claimed identity) by using certain physiological or behavioral traits associated with the person [1].The biometrics identifies the person based on features vector derived from physiological or behavioral characteristics such as uniqueness, permanence, accessibility, collectability and the minimum cost. The physiological biometrics are Fingerprint, Hand Scan, Iris Scan, Facial Scan and Retina Scan etc. and behavioral bio-metric are Voice, Keystroke, Gait, Signature etc. The physiological biometrics measures the specific part of the structure or shape of a portion of a subject's body. But the behavioral biometric are more concerned with mood and environment. Face Recognition by a robot or machine is one of the challenging research topics in the recent years. It has become an active research area which crosscuts several disciplines such as image processing, pattern recognition, computer vision, neural networks and robotics. For many applications, the performances of face recognition systems in controlled environments have achieved a satisfactory level. However, there are still some challenging issues to address in face recognition under uncontrolled conditions. The variation in illumination is one of the main challenging problems that a practical face recognition system needs to deal with. It has been proven that in face recognition, differences caused by illumination variations are more significant than differences between individuals.

Every face recognition system generally consists of (i) Face image acquisition and storage: The face database consisting of face images of different persons with certain degree of orientation and large variations in the facial expressions. (ii) Pre-processing: The images of different size are computed in to uniform scale by resizing, color image is converted to gray scale, gray image is converted to binary image and filters may be used to remove unwanted noise.(iii) Features extractions: The image features are extracted in the spatial domain itself or transform domain of an image. The extracted features in spatial domain are counting the pixel density, distance between lips and nose, distance between lips and line joining two eyes, width of the lips, pixel mean, variance and standard deviation etc. The features in transformation domain are Fast Fourier Transformation (FFT) [2], Discrete Cosine Transform (DCT) [3], Short-Time Fourier Transform (STFT) [4], Discrete Wavelet Transform (DWT) [5] and Dual-Tree Complex Wavelet Transform (DT-CWT) [6] transformation domain coefficients. (iv) The matching features of a test image with the data base image: In this the features of the test image is compared with stored data base image features using Euclidean Distance (ED), Hamming Distance (HD) Chi-square, Support Vector Machine (SVM)[7] etc.

Contribution: In this paper, Face recognition model is proposed. The features of face images are generated using Haar wavelet family and FFT. The features of test image are compared with database images using ED.

Organization: The Introduction is given in section I, the existing research papers are discussed in section II, the proposed model is explained in section III, the algorithm is described in section IV, the performance analysis is discussed in section V and finally, conclusion and future work is given in section VI.

II. LITERATURE SURVEY

Ravi J et al.,[8] proposed a method of face recognition technique using DT-CWT and LBP features in which five level DT-CWT is applied on face image to obtain real and Imaginary bands to generate DT-CWT coefficients. The LBP algorithm is applied on each 3x3 matrix of DT-CWT coefficients to obtain final features. Jagadeesh H S et al.,[9] proposed a technique for face recognition, The image is pre-processed and DWT is applied. The DBC(Directional Binary Code) technique is used to extract features from LL sub band only. Tahia Fahrin Karim et al., [10] implemented a reliable PCA based face recognition system and evaluated the performance using standard face databases such as Indian database and the Face recognition data, University of Essex, UK**.** The different techniques such as sum of absolute difference, sum of squared difference and normalized cross correlation are used for matching unknown images with known images. Satiyan et. al., [11] investigated the performance of a Daubechies Wavelet family in recognizing facial expressions. A set of luminance stickers were fixed on subject's face and the subject is instructed to perform required facial expressions. Also the subject's expressions are recorded in video. A set of 2D coordinate values are obtained by tracking the movements of the stickers in video using tracking software. Standard deviation is derived from wavelet approximation coefficients for each daubechies wavelet orders. Hengliang Tang et al., [12] proposed a novel face representation approach known as Haar Local Binary Pattern histogram (HLBPH). The face image is decomposed into four-channel sub images in frequency domain by Haar wavelet transform, and then the LBP operator is applied on each sub image to extract the face features. Jeffery and Masatoshi [13] proposed a new data structure known as Haar Spectral Diagram (HSD) which is useful for representing the Haar spectrum of boolean functions. To represent the Haar transform matrix in terms of a Kro-necker product yielding a natural decision diagram based representation is an alternative ordering of Haar coefficients. The resulting graph is a point- decomposition of the Haar spectrum using O-element edge values.

Ramesh and Raja [14] proposed a performance evaluation of face recognition based on DWT and DT-CWT using Multi-matching Classifiers. The face images are resized to required size for DT-CWT. The two level DWT is applied on face images to generate four sub bands. Euclidian Distance, Random Forest and Support Vector Machine matching algorithms are used for matching.

III. PROPOSED MODEL

In this section the definitions of performance analysis and the block diagram of the proposed model are discussed.

A. Definitions

1. False Acceptance Rate(FAR):

It is the probability that system incorrectly matches with images stored with input image database. The FAR can calculated using following equation.

$$FAR = \frac{No.of\ persons\ accepted\ out\ of\ database}{Total\ no.of\ persons\ in\ database} \quad (1)$$

2. False Rejection Rate(FRR):

It is the ratio of number of correct persons rejected in the database to the total number of persons in database and can be calculated using the following equation.

$$FRR = \frac{No.of\ correct\ persons\ rejected}{Total\ no.of\ persons\ in\ database} \quad (2)$$

3. *Equal Error Rate(EER):*

It is the value where both the FRR and FAR rates are equal.

4. True Success Rate(TSR):

It is the ratio of total number of persons correctly matched in the database to the total number of persons in the database and is given by the following equation.

$$TSR = \frac{No.of\ persons\ correctly\ matched\ in\ the\ database}{Total\ no.of\ persons\ in\ database} \quad (3)$$

B. Proposed Face Recognition Module

In the proposed model Haar wavelet and FFT transformations are applied to generate features of face images to identify a person effectively. The block diagram of proposed model is shown in the Figure 1.

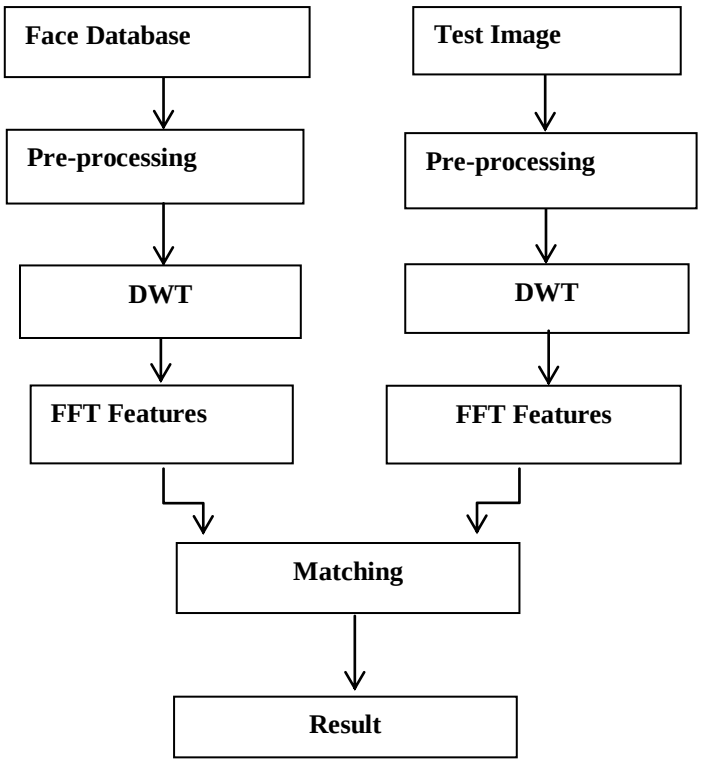

Figure 1. Block diagram of the proposed model.

1) Face Databases:

ORL: The ORL data base is considered due to its variation of pose, expression, illumination, scale, blurring and a combination of them. The database consists of 40 persons with 10 images per person. The database is created by considering first 20 persons out of 40 persons with first 8 images per person are considered which leads to 160 images in the database and the ninth image from first 20 persons is considered as a test image to compute FRR and TSR. The remaining 20 persons out of 40 are considered as out of database to compute FAR. The samples of NIR face images are shown in Figure 2.

Figure 2. Samples of ORL face images of a person

JAFFE: The face database consists of 10 persons with 23 images per person. The database is created by considering first 5 persons out of 10 persons and first 8 images per person are considered to create data base which leads to 40 images in the database and fourteenth image from first 5 persons are taken as test image to compute FRR and TSR. The remaining 5 persons out of 10 are considered as out of database to compute FAR. The JAFFE database of twenty three images of single person is shown in Figure.3.

2) Pre-processing:

The color image is converted into gray scale images. The original size of Face images are re-sized to the required sizes.

3) Discrete Wavelet Transformation:

The wavelet transform represents a signal in terms of mother wavelets using dilation and translation. The wavelets are oscillatory functions having finite duration both in time and in frequency, hence represents in both spatial and frequency domains. The features extracted by wavelet transform gives better results in recognition as well as in bifurcating low frequency and high frequency components as approximation band and detailed bands respectively. The Haar wavelet family is used.

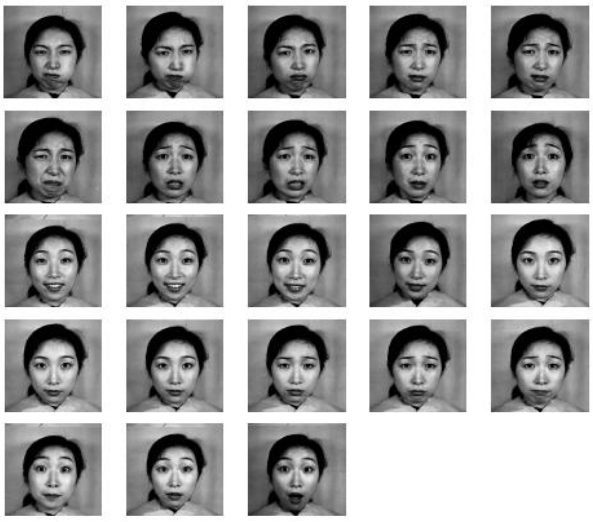

Figure 3. JAFFE Database

4) Fast Fourier Transform(FFT):

The FFT is applied on spatial domain image to obtain FFT coefficients. The features are extracted from FFT coefficients are real part, imaginary part, magnitude value and phase angle. The FFT [15] computation is fast compared to Discrete Fourier Transform (DFT), since the number of multiplications required to compute N-point DFT are less i.e., only $\frac{N}{2}[\log_2 N]$ in FFT as against N^2 in DFT.

5) Features:

The features of DWT are obtained from approximation band only. The features of FFT are computed using the magnitude values.

6) Matching:

The features of test image are compared with features of database images using Euclidian Distance with the Equation 1.

$$d1(p,q) = \sqrt{1/M \sum_{i=1}^{M} (p_i - q_i)^2} \quad (4)$$

Where,
M = the dimension of feature vector.
Pi = is the database feature vector.
qi = is the test feature vector.

IV. ALGORITHM

A. *Problem definition:*

The proposed algorithm is used to analyse the performance of face recognition using Haar wavelet family and FFT transformation for different Face database is given in the Table 1.
The objectives are;

- To authenticate a person
- To achieve high TSR
- To have FAR and FRR very low

TABLE 1. Proposed algorithm

Input: Face Database, Test Face Image Output: Recognition of a person Step 1: Face image is read from data base. Step 2: Colored image is converted in to gray scale. Step 3: Image is resized Step4: Haar wavelet of DWT and FFT are applied to generate features Step 5: Repeat step 1 to 4 for test image. Step6: Test features are compared with database features using Euclidean distance. Step 7: Image with Euclidean distance less than threshold value is considered as matched image otherwise mismatch.

V. RESULT ANALYSIS

The face databases such as ORL and JAFFE are considered to test the algorithm for performance analysis. The frequency domain transformation FFT and transformation domain DWT with Haar wavelet are used to compute FAR, FRR and TSR.

The values of FRR, FAR and TSR variations with threshold for ORL face database is tabulated in Table 2.

TABLE 2: FRR, FAR and TSR variation with Threshold for ORL Database

Threshold	FAR	FRR	Match	TSR (%)
0	0	20	0	0
0.1	0	20	0	0
0.2	0	19	1	5
0.3	0	13	7	35
0.4	0	6	13	65
0.5	1	2	17	85
0.6	10	1	18	90
0.7	19	0	19	95
0.8	20	0	19	95
0.9	20	0	19	95
1	20	0	19	95

The Table 2 shows the variations of performance parameters such as RR, FAR and FRR for different values of threshold. As the value of threshold increases, the values of FRR and FAR decreases and increases respectively.

The variations of FAR and FRR with threshold and variations of TSR with threshold for ORL face databases are shown in Figure 4 and 5.

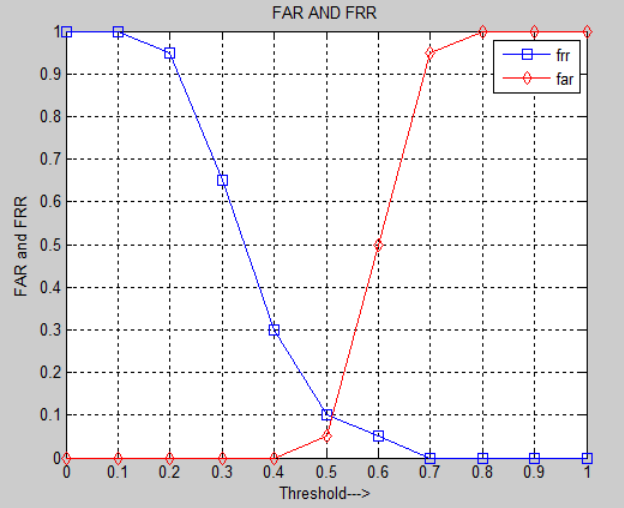

Figure 4. Graph of FAR and FRR with threshold value for ORL database

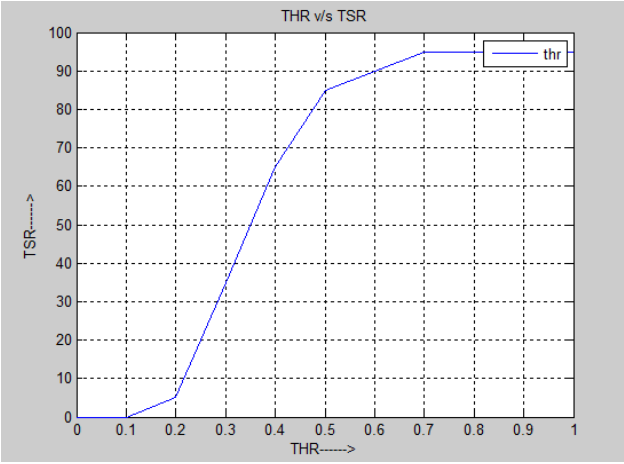

Figure 5.Graph of TSR with threshold value for ORL database

The values of FRR, FAR and TSR variations with threshold for JAFFE face database is tabulated in Table 3.

TABLE 3: FRR, FAR and TSR variation with Threshold for JAFFE Database

Threshold	FAR	FRR	Match	TSR (%)
0	0	5	0	0
0.1	0	5	0	0
0.2	0	3	2	40
0.3	0	0	5	100
0.4	0	0	5	100
0.5	0	0	5	100
0.6	3	0	5	100
0.7	3	0	5	100
0.8	3	0	5	100
0.9	4	0	5	100
1	5	0	5	100

The table 3 shows that the TSR is reaching 100% for JAFFE database.
The variations of FAR and FRR with threshold and variations of TSR with threshold for JAFFE face database are shown in Figure 6 and 7.

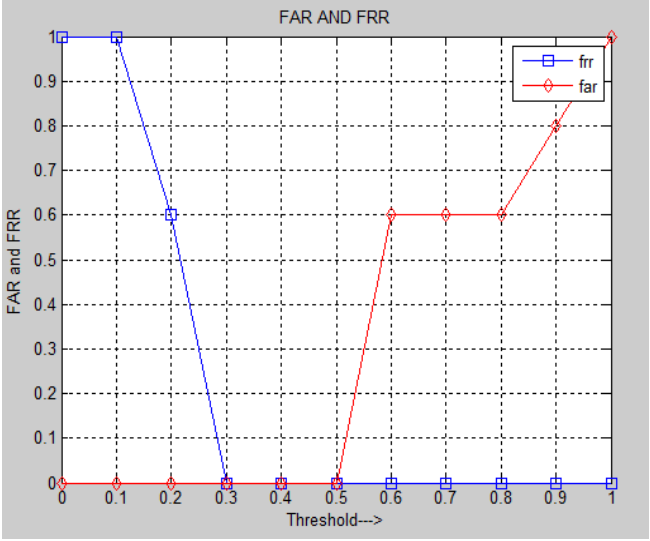

Figure 6. Graph of FAR and FRR with threshold value for JAFFE database

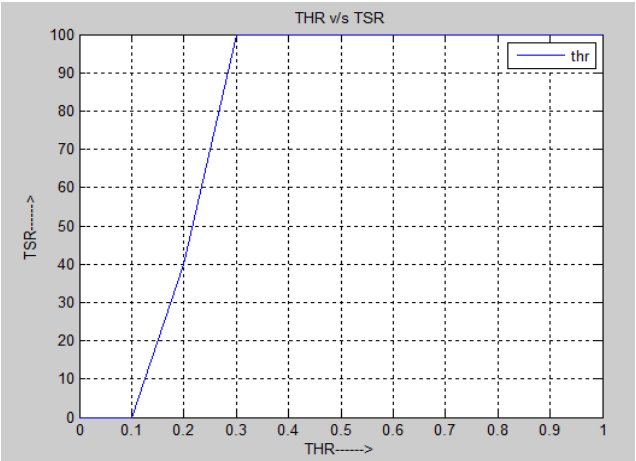

Figure 7.Graph of TSR with threshold value for JAFFE database

VI. CONCLUSION

The face image is physiological trait and is a better biometric data as the samples can be obtained without the co-operation of a person as well as can also be captured with reasonable distance. The Face images are pre-processed to get only face part and resized to 112*92 dimensions. The DWT is applied and only LL sub band is considered. The final

features are obtained after applying FFT. The values of TSR, FAR and FRR are computed. It is observed that the value of TSR is improved in the proposed algorithm compared to the existing algorithm. The True success rate of recognition for ORL and JAFFE face databases are 95% and 100% respectively.

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