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Performance Comparison of Face Recognition using Transform Domain Techniques

Jossy P. George
Department of Computer Science
Christ University
Bangalore, India

Saleem S Tevaramani and K B Raja
Electronics and Communication Engineering Department
University Visvesvaraya College of Engineering
Bangalore, India

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 Performance Comparison of Face Recognition using Transform Domain Techniques (PCFTD). The face databases L – Spacek, JAFFE and NIR are considered. The features of face are generated using wavelet families such as Haar, Symelt and DB1 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). The performance parameters such as FAR, FRR, TSR and EER computed using wavelet families and FFT. It is observed that the performance of FFT is better compared to wavelet families. The success rate of recognition is 100% for L – Spacek and JAFFE face databases as compared to 95% for NIR face databases

Keywords- Face Recognition; DWT; FFT; ED; Biometrics.

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.

The face recognition is a challenging and fast growing area in real time applications of the several Physiological characteristics used in biometrics. Face recognition is one of the sought after areas in automatic face recognition, vision communication and human computer interaction. 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) Preprocessing: 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, PCFTD model is proposed. The features of face images are generated using wavelet families 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 is given in section VI.

II. LITERATURE SURVEY

Jeffery and Masatoshi [8] 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. Kun Ma and Xiaoou Tang [9] proposed an algorithm by using discrete wavelet face graph. This graph is similar to the Gabor face graph. They used the method of elastic bunch graph matching process to locate fiducial points. They used 2340 face images to compare the recognition performance of the two methods. As a result, they conclude that DWT face graph has comparable performance as the Gabor face graph. Duan and Zheng [10] proposed a concept of gray-like image from which generalized Haar like features can be exacted. The process makes use of other forms of images in addition to gray level image in Haar-Adaboost schema. The applications of the gray-like images, the generalized Haar-like features are constructed for fast face detection. The results show that the boosted face detector using the generalized Haar-like features out performs significantly the original using the basic Haar-like features. Paul and Abbes [11] proposed a method to determine the most discriminative coefficients in a DWT/PCA-based face recognition system. This is achieved based on their inter-class and intra-class standard deviations. Also the eigen faces used for recognition are generally chosen based on the value of their associated eigenvalues. Jun Ying Gan and Jun Feng Liu [12] described a novel approach to the fusion and recognition of face and iris image based on wavelet features. They developed Kernel Fisher Discriminant Analysis (KFDA). In the algorithm, after the dimension is reduced, the noise is eliminated and the storage space is saved and then the efficiency is improved by Discrete Wavelet Transform (DWT) to face and iris image. Also the face and iris features are extracted by the fusion of KFDA. After the extraction, nearest neighbor classifier is selected to perform recognition. Experimental results show that not only the small sample problem is overcome by KFDA, but also the correct recognition rate is higher than that of face recognition and iris recognition. Sudha and Mohan [13] proposed a hardware oriented algorithm for eigenface based face detection using FFT. Eigenfaces have long been used for face detection and recognition and are known to give reasonably good results. They have given the FFT-based computation of distance measure which facilitates hardware implementation and fast face detection. Also extended the face detection framework by training with the whole face as well as other facial features like eyes, mouth etc., separately. Satiyan et. al., [14] 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., [15] 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. Hafiz Imtiaz and Shaikh Anowarul Fattah [16] proposed a multi-resolution feature extraction algorithm for face recognition based on 2D-DWT. For feature extraction, an entropy-based local band selection criterion is developed. A very high degree of recognition accuracy is achieved by the proposed method. Ramesh and Raja [17] 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. MODEL

In this section, the definitions of performance analysis parameters and proposed PCFTD model are discussed.

A. Definitions

1) False Accept Rate (FAR): It is the probability that system incorrectly matches with images stored with input image database. The FAR can be calculated using Equation 1

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

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 Equation 2.

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

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 Equation 3.

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

B. Proposed PCFTD Model

In the proposed model Haar, Symlet and DB1 of DWTs 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.

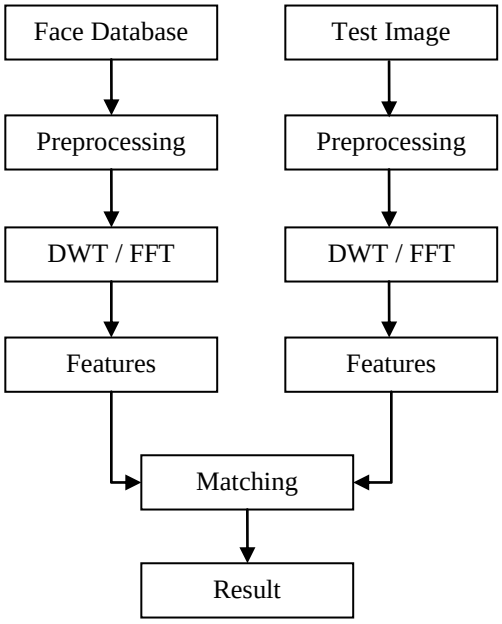

Figure 1. Example of a figure caption

1) Face Databases:

- *Near Infrared (NIR):* The NIR data base is considered due to its variation of pose, expression, illumination, scale, blurring and a combination of them. The database consists of 120 persons with 15 images per person. The data base is created by considering first 60 persons out of 120 persons with first 10 images per person are considered which leads to 600 images in the database and the thirteenth image from first 60 persons is considered as a test image to compute FRR and TSR. The remaining 60 persons out of 120 are considered as out of database to compute FAR. The samples of NIR face images are shown in Figure 2.

Figure 2. Samples of NIR face images of a person

- *L-Spacek*: The total number of persons in the L – Spacek is 120. The first 65 persons are considered for database and reaming 55 persons are considered out of database. Each person has 19 images in that first 10 images per person are considered to create data base which leads to a total of 650 images and thirteenth image of the first 65 persons taken as test image to compute the FRR and TSR. The FAR is computed using 55 persons out of data base images. The samples of L-Spacek face images are shown in Figure 3.

Figure 3. Samples L- Spacek face images of a person

- *JAFFE*: The face database consists of 10 persons with approximately 20 images per person. The database is created by considering first 5 persons out of 10 persons and first 10 images per person are considered to create data base which leads to 50 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 samples of JAFFE face database is shown in Figure 4.

Figure 4. Samples of JAFFE face images of a person

2) Preprocessing:

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 (DWT):

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 wavelet families Haar, Symelt and DB1 are used.

Advantages of Discrete wavelet transform are; It gives information about both time and frequency of the signal, Transform of a non-stationary signal is efficiently obtained, Reduces the size without losing much of resolution, Reduces redundancy and Reduces computational time.

4) Fast Fourier Transform (FFT):

The FFT is applied on spatial domain image to obtain FFT coefficients. The features are extracted from FFT [18] coefficients are real part, imaginary part, magnitude value and phase angle. The FFT 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 4.

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

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 different wavelet families and FFT transformation for different Face database is given in the Table 1.

The objectives are;

- Fingerprint verification to authenticate a person.
- To achieve high TSR
- To have FRR and FAR very low

TABLE I. ALGORITHM OF PCFTD

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, Symlet and DB1 of DWTs and FFT are applied to generate features Step 5: Repeat step 1 to 4 for test image. Step 6: 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

V. PERFORMANCE ANALYSIS

The face databases viz., JAFFE, L-Spacek and NIR are considered to test the algorithm for performance analysis. The frequency domain transformation FFT and transformation domain DWT with different wavelets are used to compute FAR, FRR and TSR.

A) Performance Using FFT

The Table 2 gives the variations of FAR, FRR and TSR with respect to threshold (Th) values for different face database with FFT transformation. FRR decreases whereas FAR increases from 0 value to 100% as threshold value increases from 0 to 5.

TABLE II. Performance on Different Face Databases with FFT

TH	FFT								
	L – Spacek			NIR			JAFFE		
	FAR	FRR	%TSR	FAR	FRR	%TSR	FAR	FRR	%TSR
0	0	1	0	0	1	0	0	1	0
0.25	0	1	0	0	0.85	15.38	0	1	0
0.5	0	0.98	1.54	0	0.63	36.92	0	1	0
0.75	0	0.89	10.77	0	0.49	50.77	0	1	0
1	0	0.80	20	0	0.34	66.15	0	1	0
1.25	0	0.70	29.23	0.02	0.28	72.31	0	1	0
1.5	0	0.55	44.62	0.11	0.25	75.38	0	1	0
1.75	0	0.40	60	0.19	0.22	78.46	1	0.8	20
2	0	0.30	69.23	0.22	0.17	83.08	2	0.6	40
2.25	0	0.16	83.08	0.37	0.15	84.62	2	0.6	40
2.5	0	0.15	84.62	0.44	0.14	86.15	2	0.6	40
2.75	0	0.13	86.15	0.52	0.12	86.15	2	0.6	40
3	0	0.07	92.31	0.69	0.06	90.77	2	0.6	40
3.25	0	0.06	93.85	0.74	0.06	90.77	2	0.6	40
3.5	0	0.04	95.38	0.83	0.03	93.85	2	0.6	40
3.75	0	0.04	95.38	0.91	0.03	93.85	2	0.6	40
4	0	0.04	95.38	0.93	0.03	93.85	3	0.4	60
4.25	0	0.03	96.92	0.93	0.02	93.85	5	0	100
4.5	0	0	100	0.93	0	95.38	5	0	100
4.75	0	0	100	0.94	0	95.38	5	0	100
5	0	0	100	0.94	0	95.38	5	0	100

The success rate of recognition is 100% in the case of L-Spacek and JAFFE face images while success rate is 95% in the case of NIR face database. Hence FFT is better for L-Spacek and JAFFE face databases.

The variations of FAR and FRR with threshold for L-Spacek, JAFFE and NIR face databases with FFT are shown in Figure 5, 6 and 7.

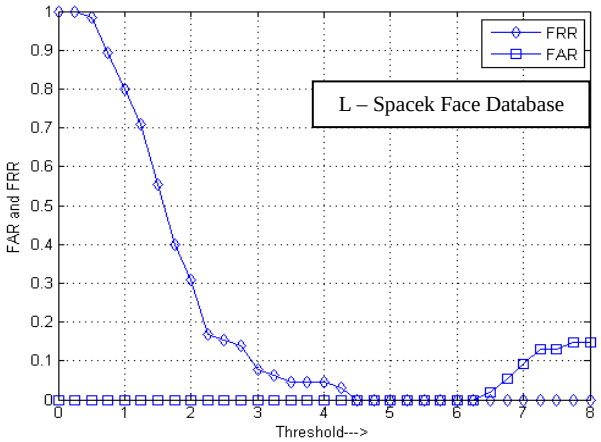

Fig. 5 FAR and FRR with threshold for L-Spacek Database

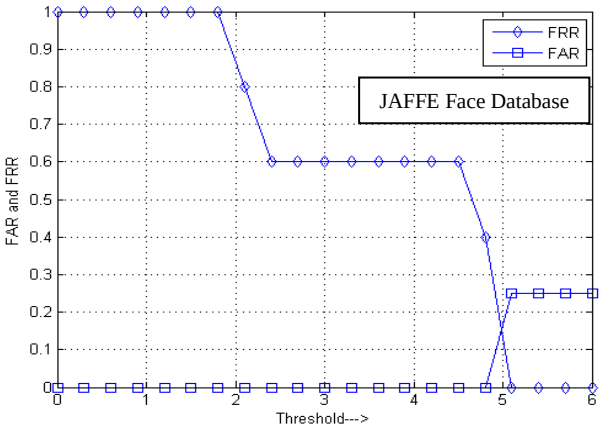

Fig. 6 FAR and FRR with threshold for JAFFE Database

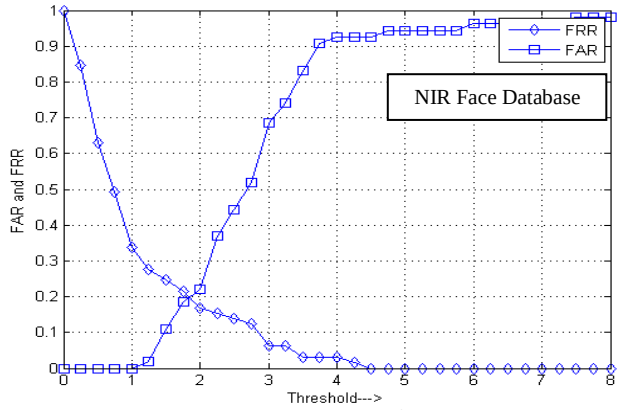

Fig. 7 FAR and FRR with threshold for NIR Database

B) Performance Using FFT

The performance parameters viz., FAR, FRR and TSR values are varying with threshold values for different databases such as L- Speack, NIR and JAFFE with DWT families are given in Tables III, IV and V respectively. The success rate for L- Speack, and JAFFE database is 100% compared to 95% of success rate for NIR database.

TABLE III PERFORMANCE PARAMETERS OF L- SPACEK DATABASES

Th	L – Spacek								
	Haar			Symelet			DB1		
	FAR	FRR	%TSR	FAR	FRR	%TSR	FAR	FRR	%TSR
0	0	1	0	0	1	0	0	1	0
0.25	0	0.98	1.54	0	1	0	0	0.98	1.54
0.5	0	0.88	12.31	0	1	0	0	0.88	12.31
0.75	0	0.71	29.23	0	1	0	0	0.71	29.23
1	0	0.51	49.23	0	1	0	0	0.51	49.23
1.25	0	0.31	69.23	0	0.8	20	0	0.31	69.23
1.5	0	0.25	75.38	0	0.6	40	0	0.25	75.38
1.75	0	0.18	81.54	0	0.6	40	0	0.18	81.54
2	0	0.09	90.77	0	0.6	40	0	0.09	90.77
2.25	0	0.06	93.85	0	0.6	40	0	0.06	93.85
2.5	0	0.05	95.38	0	0.6	40	0	0.05	95.38
2.75	0	0.05	95.38	0	0.6	40	0	0.05	95.38
3	0	0.05	95.38	0.25	0.2	80	0	0.05	95.38
3.25	0	0.03	96.92	0.25	0.2	80	0	0.03	96.92
3.5	0.02	0.03	96.92	0.25	0.2	80	0.02	0.03	96.92
3.75	0.02	0	100	0.25	0.2	80	0.02	0	100
4	0.06	0	100	0.25	0	100	0.06	0	100
4.25	0.15	0	100	0.25	0	100	0.15	0	100
4.5	0.17	0	100	0.25	0	100	0.17	0	100
4.75	0.24	0	100	0.25	0	100	0.24	0	100
5	0.31	0	100	0.25	0	100	0.31	0	100

TABLE IV. PERFORMANCE PARAMETERS OF JAFFE DATABASES

Th	JAFFE								
	Haar			Symlet			DB1		
	FAR	FRR	%TSR	FAR	FRR	%TSR	FAR	FRR	%TSR
0	0	1	0	0	1	0	0	1	0
0.25	0	1	0	0	1	0	0	1	0
0.5	0	1	0	0	1	0	0	1	0
0.75	0	1	0	0	1	0	0	1	0
1	0	1	0	0	1	0	0	1	0
1.25	0	1	0	0	0.8	20	0	0.8	20
1.5	0	0.8	20	0	0.6	40	0	0.6	40
1.75	0	0.8	20	0	0.6	40	0	0.6	40
2	0	0.6	40	0	0.6	40	0	0.6	40
2.25	0	0.6	40	0	0.6	40	0	0.6	40
2.5	0	0.6	40	0	0.6	40	0	0.6	40
2.75	0	0.6	40	0	0.6	40	0	0.4	60
3	0	0.6	40	0.25	0.2	80	0.25	0.2	80
3.25	0	0.6	40	0.25	0.2	80	0.25	0.2	80
3.5	0	0.4	60	0.25	0.2	80	0.25	0.2	80
3.75	0.25	0.2	80	0.25	0.2	80	0.25	0.2	80
4	0.25	0.2	80	0.25	0	100	0.25	0	100
4.25	0.25	0.2	80	0.25	0	100	0.25	0	100
4.5	0.25	0.2	80	0.25	0	100	0.25	0	100
4.75	0.25	0	100	0.25	0	100	0.25	0	100
5	0.25	0	100	0.25	0	100	0.25	0	100

TABLE V PERFORMANCE PARAMETERS OF NIR DATABASES

Th	NIR								
	Haar			Symelet			DB1		
	FAR	FRR	%TSR	FAR	FRR	%TSR	FAR	FRR	%TSR
0	0	1	0	0	1	0	0	1	0
0.25	0	0.69	30.77	0	0.72	27.69	0	0.69	30.77
0.5	0	0.45	55.38	0	0.51	49.23	0	0.45	55.38
0.75	0	0.28	72.31	0	0.29	70.77	0	0.28	72.31
1	0.15	0.22	78.46	0.13	0.22	78.46	0.15	0.22	78.46
1.25	0.35	0.17	83.08	0.33	0.17	83.08	0.35	0.17	83.08
1.5	0.52	0.08	90.77	0.52	0.08	90.77	0.52	0.08	90.77
1.75	0.8	0.03	93.85	0.78	0.03	93.85	0.8	0.03	93.85
2	0.93	0.02	93.85	0.93	0.02	93.85	0.93	0.02	93.85
2.25	0.93	0.02	93.85	0.93	0.02	93.85	0.93	0.02	93.85
2.5	0.94	0	93.85	0.94	0	95.38	0.94	0	93.85
2.75	0.96	0	93.85	0.94	0	95.38	0.96	0	93.85
3	0.96	0	93.85	0.96	0	95.38	0.96	0	93.85
3.25	0.98	0	93.85	0.98	0	95.38	0.98	0	93.85
3.5	0.98	0	93.85	0.98	0	95.38	0.98	0	93.85
3.75	0.98	0	93.85	0.98	0	95.38	0.98	0	93.85
4	0.98	0	93.85	0.98	0	95.38	0.98	0	93.85
4.25	0.98	0	93.85	0.98	0	95.38	0.98	0	93.85
4.5	0.98	0	93.85	0.98	0	95.38	0.98	0	93.85
4.75	0.98	0	93.85	0.98	0	95.38	0.98	0	93.85
5	0.98	0	93.85	0.98	0	95.38	0.98	0	93.85

The variations of FAR and FAR with threshold values for L–Spacek face database using Haar, Symlet and DB1 wavelets are shown in Figure 8, 9 and 10 respectively. The FRR and FAR values are decreasing and increasing as threshold increases. The value of EER is 0.01 for Haar and DB1 wavelets compared to EER value 0.2 in the case of Symlet. Hence Haar and DB1 are better wavelets for L- Spacek face database compared to Symlet.

The variations of FAR and FAR with threshold values for JAFFE face database using Haar, Symlet and DB1 wavelets are shown in Figure 11, 12 and 13 respectively. The FRR and FAR values are decreasing and increasing as threshold increases. The value of EER is 0.2 for Haar, Symlet and DB1 wavelets. Hence Haar, Symelt and DB1 has same performance with JAFFE face database.

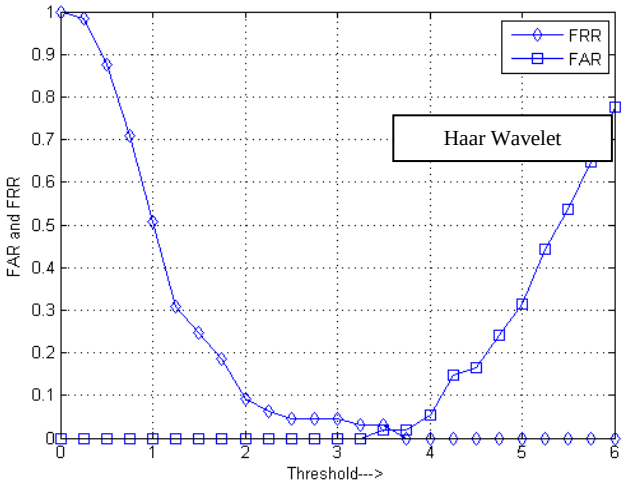

Figure 8. FAR and FRR with threshold for L–Spacek databases

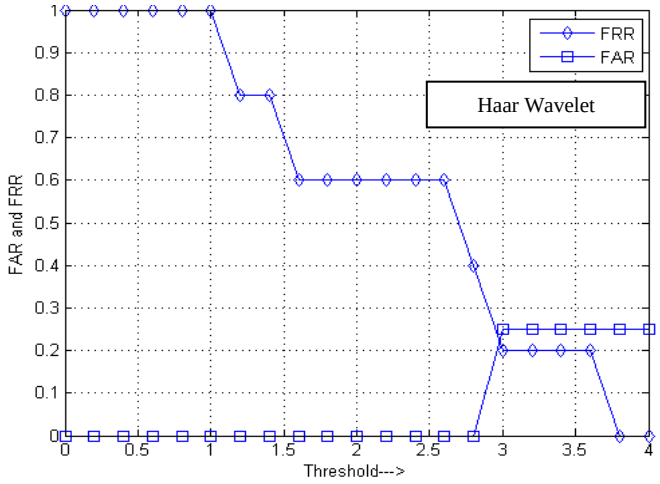

Fig. 11 FAR and FRR with threshold for JAFFE databases

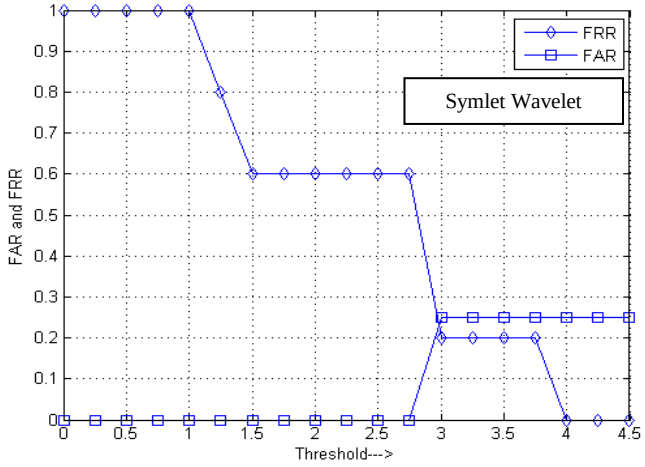

Figure 9. FAR and FRR with threshold for L–Spacek databases

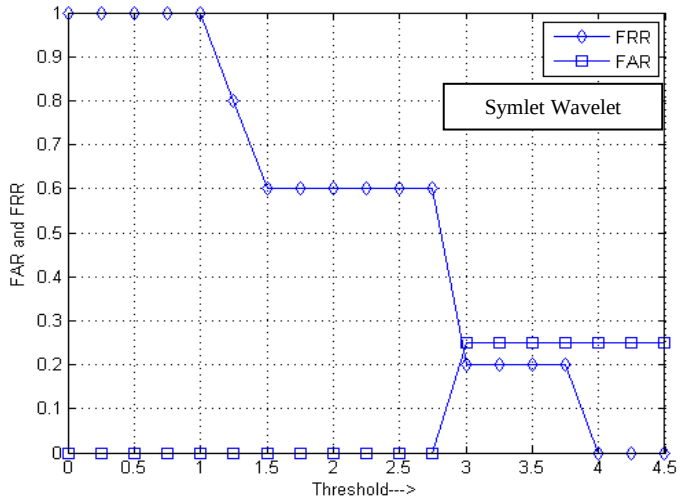

Fig. 12 FAR and FRR with threshold for JAFFE databases

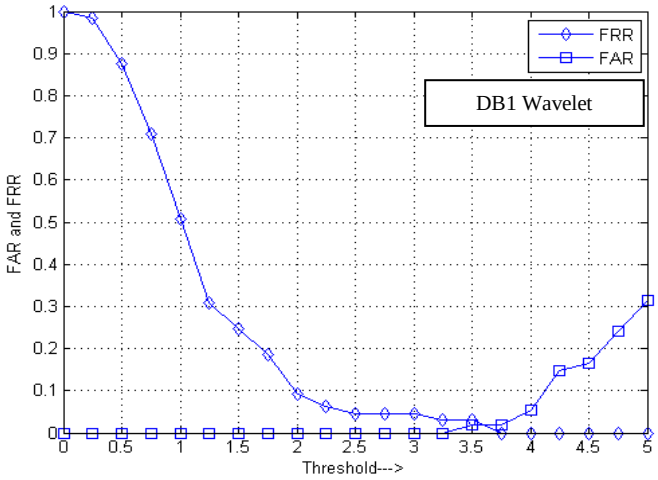

Figure 10. FAR and FRR with threshold for L–Spacek databases

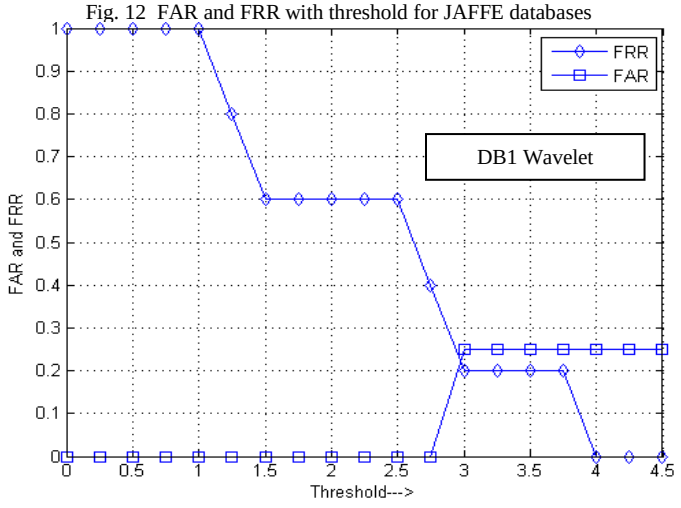

Fig. 13 FAR and FRR with threshold for JAFFE databases

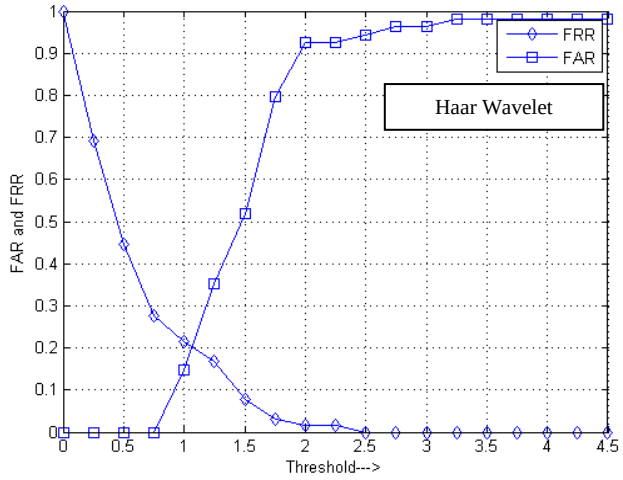

Fig. 14 FAR and FRR with threshold for NIR databases

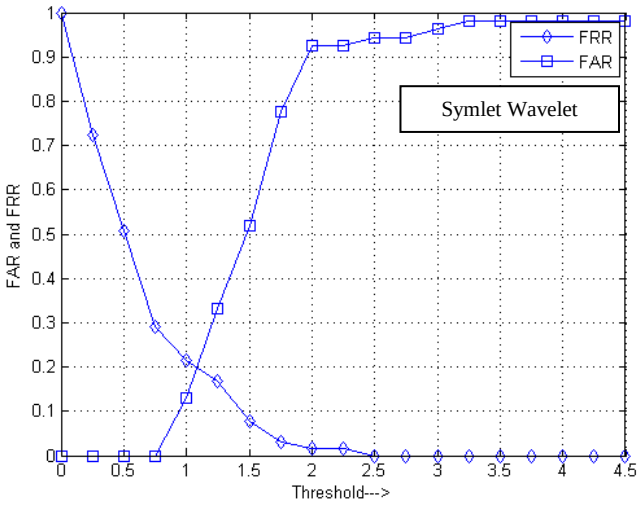

Fig. 15 FAR and FRR with threshold for NIR databases

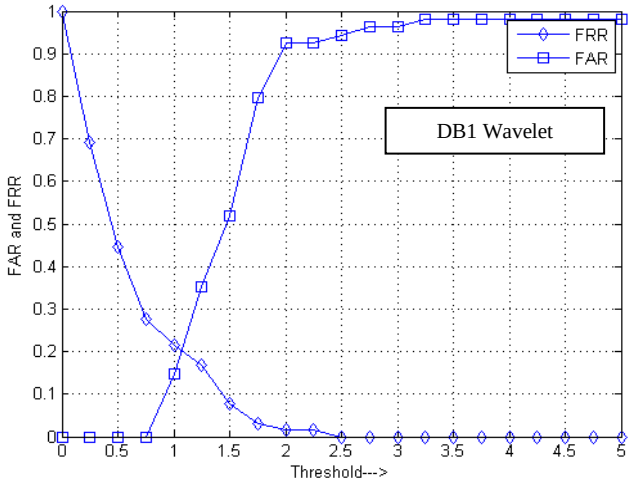

Fig. 16 FAR and FRR with threshold for NIR databases

The variations of FAR and FAR with threshold values for JAFFE face database using Haar, Symlet and DB1 wavelets are shown in Figure 14, 15 and 16 respectively. The FRR and FAR values are decreasing and increasing as threshold increases. The value of EER is 0.2 for Haar, Symlet and DB1 wavelets. Hence Haar, Symelt and DB1 has same effect with NIR face database.

EER values with different transformation and face image database are tabulated in the Table VI. It is observed that the EER values are better in the case of FFT compared to DWTs. The performance with L- Speack database is better compared to JAFFE and NIR with both DWT and FFT transformations

TABLE VI. EER VALUES FOR DIFFERENT TRANSFORMS

Database	EER			
	DWT			FFT
	Haar	Symlet	DB1	
L – Speack	0.01	0.2	0.01	0
JAFFE	0.2	0.2	0.2	0.15
NIR	0.2	0.2	0.2	0.2

VI. CONCLUSIONS

Face recognition is a physiological biometric trait. The different face data bases are considered for performance analysis. The PCFTD model of Face Recognition using Haar, Symlet and Dd1 of DWTs and FFT is proposed. The features of face images are obtained using Haar, Symlet and DB1 wavelets as well as FFT transforms. The features of test image are compared with database images using Euclidian Distance (ED). The performance parameters such as FAR, FRR and TSR are computed using different transform on different face databases. It is observed that the performance of FFT is better compared to DWT. In future, the features of DWT and FFT are fused to get better EER values with 100% recognition rates for all face databases.

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AUTHORS PROFILE

Jossy P. George currently serves as Assistant Professor of the Department of Computer Science at Christ University, Bangalore. He received the B. Sc. In Computer Science, Bachelor of Philosophy (B. Ph), Bachelor of Theology (B. Th) and Master of Computer Application (MCA). He has done his FDPM from IIM, Ahmedabad. He is pursuing his Ph.D. in Computer Science of Christ University under the guidance of Dr. K. B. Raja, Associate Professor, Department of Electronics and Communication Engineering, University Visvesvaraya College of Engineering. His research activities focus on algorithms for improved accuracy in biometrics. He is a member of International Association of Computer Science and Information Technology (IACSIT).

Saleem S Tevaramani obtained his BE in Electronics and Communication Engineering from SJB Institute of Technology, Bangalore and Postgraduate (ME) in Department of Electronics and Communication Engineering, University Visvesvaraya college of Engineering, Bangalore. His research interests include Image processing, Biometrics and Signal processing.

Dr. K B Raja is an Assistant Professor, Department of Electronics and Communication Engineering, University Visvesvaraya college of Engineering, Bangalore University, Bangalore. He obtained his BE and ME in Electronics and Communication Engineering from University Visvesvaraya College of Engineering, Bangalore. He was awarded Ph.D. in Computer Science and Engineering from Bangalore University. He has 85 research publications in refereed International Journals and Conference Proceedings. His research interests include Image Processing, Biometrics, VLSI Signal Processing, computer networks.