

Face Recognition Credentials using Fusion of CDF 5/3 Lift Discrete Wavelet Transform and FFT

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Abstract

Face recognition has emerged as a popular and universally accepted biometrics compared to other biometric traits, since the image can be captured without the knowledge and co-operation of a person. In this paper, we propose Face recognition using fusion of CDF 5/3 Lift DWT and FFT. The face images are preprocessed using Discrete Wavelet Transform (DWT), resize and filtered using edge detection and morphological operation techniques. The features of the preprocessed database images are extracted using Lifting DWT by considering LL band features and FFT by considering magnitude features. Further, these features are fused to obtain database final features. The test image is subjected to same process to generate test image final features and matching is performed by comparing data base image and test image features using Euclidean distance (ED). The performance analysis is carried out by varying number of images with threshold to obtain optimized parameters. It is observed that the performance parameters such as FAR, FRR and TSR are better in comparison with existing techniques for ORL and JAFFE database.

Keywords: Biometrics, Face Recognition, CDF 5/3, FFT, Euclidean Distance, Lift DWT.

1. INTRODUCTION

Biometrics has played a crucial role in both identification and verification of human population. The addition of intelligence to biometric helps to cover wider range of applications. It over comes the disadvantage of traditional methods where authentications were based on passwords, cards etc., which can be easily breached. Biometrics is based on identification or verification of physiological or behavioral traits [1] of a person which are permanence in nature. The feature vectors can be derived from the traits using efficient algorithms which are processed for accurate matching. Over the years application of big data has increased tremendously in various fields. The large data sets comprising of variety of data types are examined. Combining the capabilities of biometrics with big data analytics can be useful for wide range of applications such as access to premises without key, police department for comparing surveillance recording, identify students and their activities in school, to track terrorists, e-Gates, e-Passports and so on. Face recognition has seen a tremendous growth in biometrics over last few decades in areas of automatic face recognition, security and human computer interaction. Face recognition is a challenging task for complex data base with orientation, lighting condition etc. It involves various stages such as preprocessing where resizing, conversion of color to gray, noise removal are performed. Next stage involves feature extraction where counting pixel density, distance between lips and nose and frequency information [2-6] are extracted. The last stage involves comparison of stored feature with the test features using Euclidean distance (ED), Hamming distance (HD), Support Vector Machine (SVM) [7,8] etc.

2. LITERATURE SURVEY

Dong Li et al., [9] proposed a pose-invariant face verification method, which is robust to alignment errors using the HR information based on pore-scale facial features. PPCASIFT adapted from PCA-SIFT is devised for the extraction of a compact set of distinctive pore-scale facial features with a robust-fitting scheme is proposed for the face verification task. Abhijith Punnappurath et al., [10] proposed a methodology for face recognition in the presence of space-varying motion blur comprising of arbitrarily shaped kernels. Blurred face was modeled as a convex combination of geometrically transformed instances of the focused gallery faces, and showed that set of all images obtained by non uniformly blurring a given image forms a convex set. Quanxue Gao et al., [11] proposed a linear approach, called Two-Dimensional Maximum Local variation [2DMLV] for face recognition. In 2DMLV the relationships among pixels in images are encoded using image Euclidean distance, and then incorporate the local variation, which characterizes the diversity of images and discriminating information, in to objective function of dimensionally reduction. Allen Y. Yang et al., [12] studied the speed and scalability of Fast l_1 -Minimization Algorithms, in particular focusing on numerical implementation of a sparsity-based classification frame work in robust face recognition. Haifeng HU [13] proposed an efficient and robust solution, called Locally Grassmannian Discriminant Analysis, for

face recognition based on image set, where each set contains images belonging to the same subject and typically covering large variations. Zhenhua Chai et al., [14] proposed a novel facial feature extraction method named Gabor ordinal measures, which integrates the distinctiveness of Gabor features and the robustness of ordinal measures as a solution to jointly handle inter-person similarity and intra-person variation in face images. Chai-po Wei et al., [15] proposed a novel face recognition algorithm based on low-rank matrix decomposition to address scenario in which training and test image data are corrupted due to occlusion or disguise. Raw training data is decomposed into set of representative bases for better modeling the face images. A constraint of structural incoherence is introduced in to the proposed algorithm. Yang Xu et al., [16] attempted to improve the face recognition accuracy by reducing the uncertainty. Uncertainty of face representation was reduced by synthesizing the virtual training samples. Useful training samples are selected that are similar to test samples from the set of all original and synthesized virtual training samples. A theorem was stated to determine the upper bound of the number of useful training samples. A representation approach based on useful training samples to perform face recognition is devised. Yong Xu et al., [17] proposed a novel representation based classification method for face recognition. This method integrates conventional and the inverse representation-based classification for better recognizing the face. The method exploits the conventional and inverse representation to generate two kinds of scores of the test sample with respect to each class and combines them to recognize the face. Xingjie Wei et al., [18] proposed a novel approach Dynamic Image-to-Class Warping [DICW] to deal with challenges in face recognition. DICW computes the image-to-class distance between a query face and those of an enrolled subject by finding optimal alignment between the query sequence and all sequences of that subject along both the time dimension and with in class dimension. Chuan-Xian Ren et al., [19] proposed a transferrable representation learning model to enhance the recognition performance. To deeply exploit the discriminated information from the source domain and the target domain, the bio inspired face representation is modeled as structured and approximately stable characterization for the communality between different domains. M. Sifuzzaman et al., [20] have listed out the applications of wavelet transform and its advantages compared to Fourier transform. Wavelets allow complex information such as music, speech, images and patterns to be decomposed into elementary forms at different positions and scales and subsequently reconstructed with high precision. Fourier transform is a powerful tool for analyzing the components of a stationary signal but fails when analyzing a non-stationary signal whereas wavelet transform allows the components of a non-stationary signal to be analyzed.

Contribution: In this paper, we propose fusion of 5/3 Lift DWT and FFT for face recognition. The database images and test image are preprocessed using edge detection and morphological operation techniques and features are extracted using fusion of Lift DWT and FFT. The matching is performed using Euclidean distance and performance analysis such as FAR, FRR and TSR are calculated.

3. PROPOSED METHOD

An Efficient face recognition model using Fusion of CDF 5/3 Lifting DWT and FFT is as shown in Figure 1.

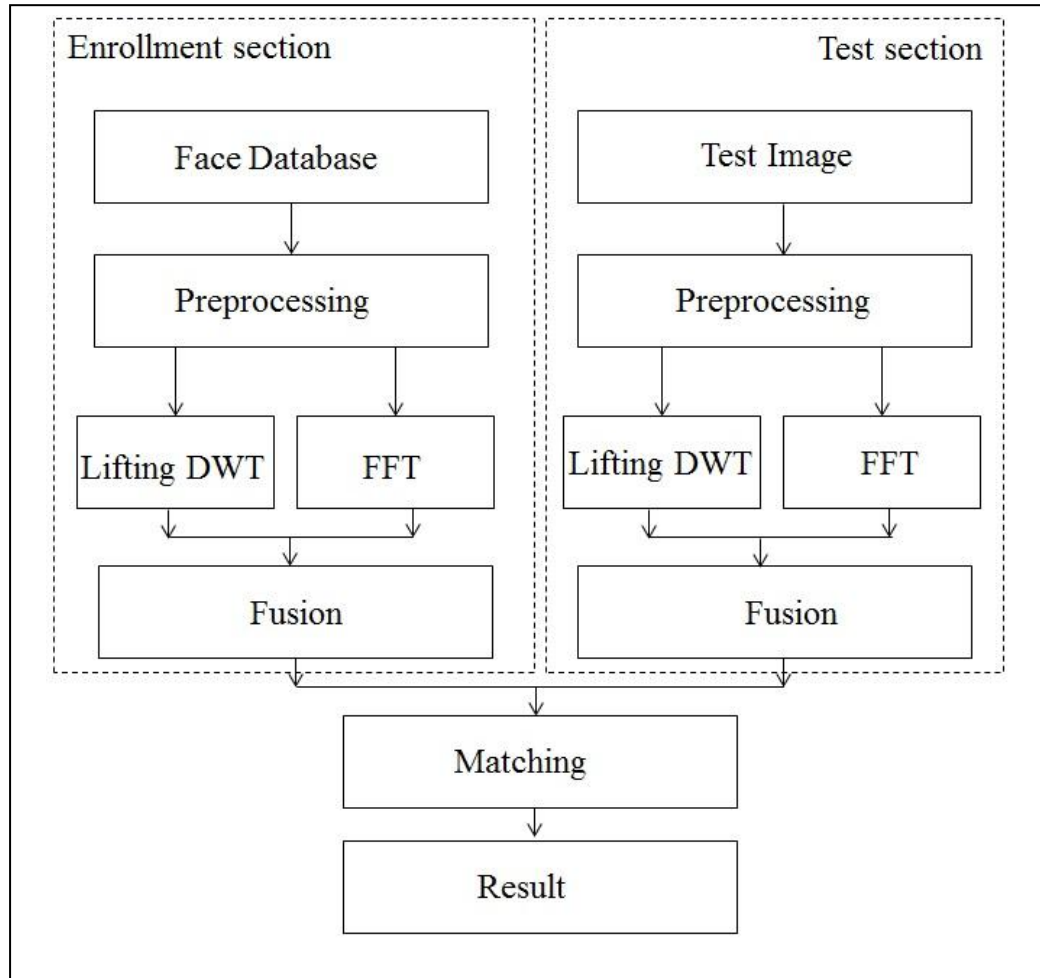


Fig 1: Block Diagram of the proposed model

3.1. Face Image Database

The available face Databases such as ORL and JAFFE are considered for experimental purpose.

3.1.1 Olivetti Research Laboratory (ORL) Database:

ORL contains a set of face images taken between April 1992 and April 1994 at the lab. The database is used in the context of face recognition. There are ten different images of each of 40 distinct subjects. For some subjects, the images were taken at different times, varying the lighting, facial expressions (open / closed eyes, smiling / not smiling) and facial details (glasses / no glasses). The size of each image is 92x112 pixels, with 256 grey levels per pixel.



Fig 2: Samples of ORL face images of a person.

3.1.2 Japanese Female Facial Expression (JAFFE) Database:

The database contains 213 images of 7 facial expressions (6 basic facial expressions + 1 neutral) posed by 10 Japanese female models. Each image has been rated on 6 emotion adjectives by 60 Japanese subjects. All the images were digitized into a resolution of 256×256 pixels. The images were taken from a frontal pose, and the subjects hair was tied back in order to facilitate the exposure of all the expressive zones of the face. In the image scene, an even illumination was created using tungsten lights.

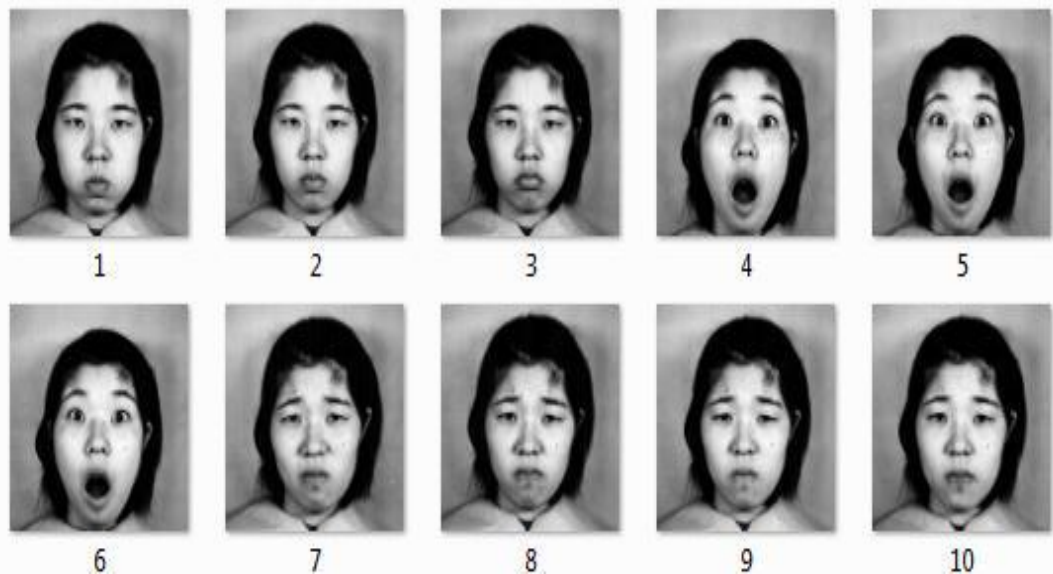


Fig 3: Samples of JAFFE face images of a person.

3.2 PREPROCESSING

There are many chances of face images to get distorted by various noises due to error in acquisition and also the size of face of the same subject may vary due to varying distance between camera and person. These errors can be eliminated by performing many pre-processing techniques before feature extraction. The data captured during

the first step may include noises or has some redundant information which has to be removed before further processing as shown in Figure 4

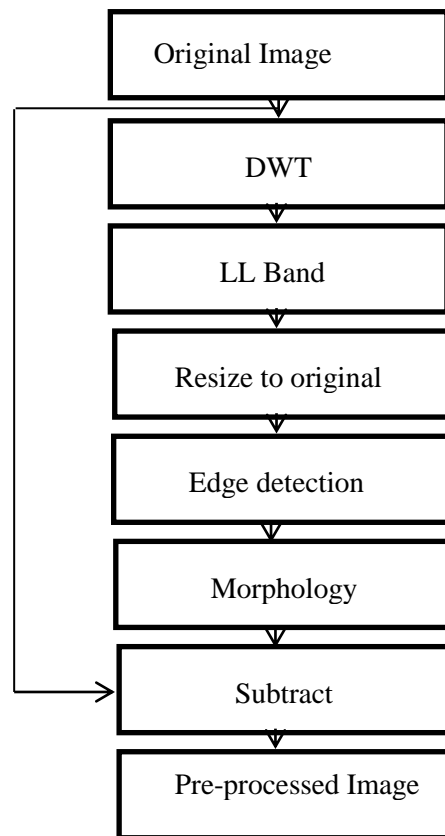


Fig 4: Proposed preprocessing method.



Fig 5: Original and Preprocessed image of standard ORL database

This process involves applying DWT to original image to get approximate coefficients. These coefficients consists maximum information and which is free from noise, Resize the LL Band to original image size, obtain the edges in gray scale using *edge* (*I*, 'Roberts') inbuilt function in MATLAB tool which converts gray scale image to binary image, Apply morphological thin operation on binary image using *bwmorph* (*BW*, 'thin') function and eliminate edges by subtracting morphology image with original image. The subtracted image is noise free, sharpened as shown in Figure 5 which increases the matching accuracy of the system.

3.3 FEATURE EXTRACTION

3.3.1. Cohen-Daubechies-Feauveau (CDF) 5/3 Lifting DWT

Lifting scheme [21] is simplest and efficient algorithm to calculate wavelet transforms. It does not depend on Fourier transforms.

The three stages of Lift 5/3 involves

(i) *Split*: The input samples are split into even data samples and odd data samples as given in equation (1).

Odd data samples: $d_i^0 = x_{2i+1}$

Even data samples: $s_i^0 = x_{2i}$ (1)

Input data samples:

i.e., $x = \{x_1, x_2, \dots, x_{2n}\}$

Split into

$x_e = \{x_2, x_4, \dots, x_{2n}\}$ and $x_o = \{x_1, x_3, \dots, x_{2n-1}\}$

(ii) *Predict*: The odd samples are predicted using the even samples as given in equation (2).

$$d_i^1 = d_i^0 + \left(\frac{1}{2}\right) (s_i^0 + s_{i+1}^0) \quad (2)$$

(iii) *Update*: The original odd and the predicted odd samples are subtracted and is later updated using the even samples, giving the approximated coefficients using equation (3).

$$s_i^1 = s_i^0 - \left(\frac{1}{4}\right) (d_{i-1}^1 + d_i^1) \quad (3)$$

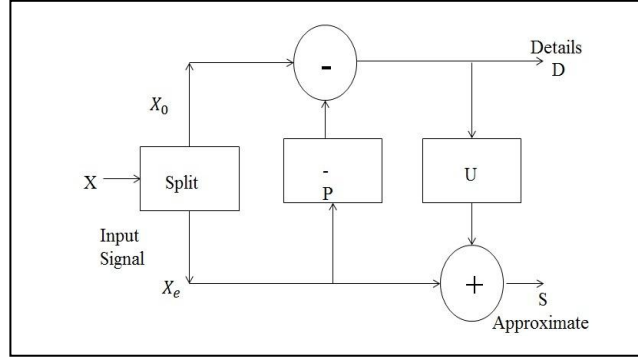


Fig 6: Lifting-based implementation

The Lift based implementation block diagram is shown in Figure 6. The main advantages of computing the DWT using lifting scheme has symmetric forward, inverse transforms, potential for integer wavelet transform and less operation of in-place computation.

3.3.2 Fast Fourier Transform (FFT)

The FFT is applied on spatial domain image to obtain frequency domain coefficients. The features are extracted from FFT [22] 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 complex additions and multiplications required to compute N-point DFT are less. Hence the 2D transform is split as two 1D transforms, one in horizontal direction and the other in the vertical direction. The end result is equivalent to 2D transform in frequency domain. The 1-D DFT and IDFT are given in equations (4) and (5).

$$F(x) = \sum_{n=0}^{N-1} f(n) e^{-j2\pi(x\frac{n}{N})} \quad (4)$$

$$f(n) = \frac{1}{N} \sum_{x=0}^{N-1} F(x) e^{j2\pi(x\frac{n}{N})} \quad (5)$$

3.4 Fusion

The features of Lifting DWT considering only LL band and magnitudes and phase of FFT are fused using the following formula [23] given in equation (6).

$$\text{Final score } F = X * C + (1-X) * D \quad (6)$$

Where,

C=FFT features

D=Lifting DWT features

X is improved factor that ranges from 0 to 1

3.5 Matching Section

The features of test image are compared with features of database images using Euclidian Distance. Threshold value is required in matching process to decide whether the face belongs to an imposter or an authenticated user. The selection of threshold value should be such that the FAR and FRR should be reduced. The decision is made depending on the threshold value. If the distance is less than the Threshold matching is considered as successful else as failure.

The pair-wise distance formula is given by equation (7).

$$d(p, q) = \sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2 + \dots + (p_n - q_n)^2} \quad (7)$$

p=Database features

q=Test image features

4. ALGORITHM

Problem Definition: The proposed algorithm is used to analyze the performance of face recognition using Fusion of Lifting wavelet families and FFT transformation for different Face database is given in the Table 1.

Objectives:

- i) To increase TSR.
- ii) To decrease FRR and FAR.
- iii) To decrease EER.

The algorithm of the proposed method is shown in the Table 1.

Table 1: Proposed Algorithm

Input: Face Database and Test face image
Output: Recognition of a person
<p>Step 1: Read Face Image.</p> <p>Step 2: Resize the original image.</p> <p>Step 3: Remove the noise with Preprocessing.</p> <p>Step 4: Apply Lifting DWT technique and extract LL Band features for preprocessed image.</p> <p>Step 5: Apply FFT for preprocessed image to obtain FFT features.</p>

Step 6: Fuse the FFT and Lifting DWT features.

Step 7: Repeat step 1 to 6 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

Step 8: TSR and FAR vs. FRR graph are tabulated

5. PERFORMANCE ANALYSIS AND RESULTS

In this section, the definitions of performance parameters such as FAR, FRR, TSR and EER and performance analysis are discussed.

5.1. Definitions of Performance Parameters

(i) False Rejection Rate (FRR) is the measure of the number of authorized persons rejected. It is computed using the equation (8).

$$\%FRR = \frac{\text{No. of authorized persons rejected} \times 100}{\text{Total No. of persons in the database}} \quad (8)$$

(ii) False Acceptance Rate (FAR) is the measure of the number of unauthorized persons accepted and is computed using the equation (9).

$$\%FAR = \frac{\text{No. of unauthorized persons rejected} \times 100}{\text{No. of persons outside the database}} \quad (9)$$

(iii) Total Success Rate (TSR) is the numbers of authorized persons successfully matched in the database and is computed using the equation (10).

$$TSR = \frac{\text{No. of authorized persons correctly matched}}{\text{Total No. of persons in the database}} \quad (10)$$

(iv) Equal error rate (EER) is the point of intersection of FRR and FAR values at particular threshold value. The EER is the tradeoff between FRR and FAR. The value of EER must be low for better performance of an algorithm.

5.2. Analysis of performance parameter:

The Performance Parameters such as FRR, FAR, EER and TSR for different face databases viz., ORL and JAFFE are discussed in detail for the proposed model. The performance parameters are computed by running computer simulation using

MATLAB 12.1 version.

5.2.1 Analysis using ORL Database

(i) Lifting DWT:

The data base is created to test the performance of an algorithm by considering thirty Persons Inside Data base (PID) and *ten* Persons Outside Data base (POD) with six samples per person and *ninth* sample is considered as test image sample. The variations of TSR with threshold and FAR versus FRR with threshold are as shown in Fig. 7 and Fig. 8 respectively. It is observed that maximum of 83.33 percentage of TSR and 0.4 EER is obtained using Lift 5/3 DWT technique.

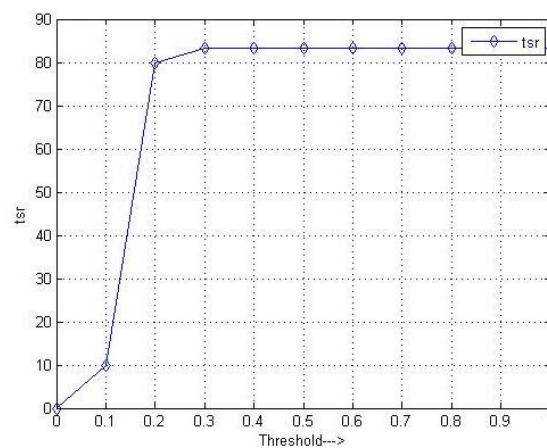


Fig 7: TSR with Threshold for Lifting DWT

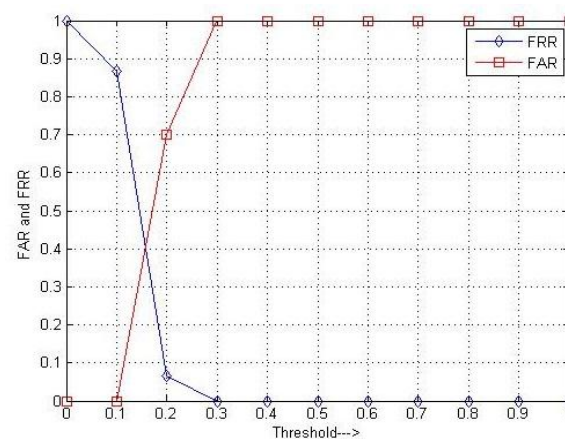


Fig 8: FAR and FRR versus threshold for Lifting DWT

(ii) Fast Fourier Transform:

The data base is created to test the performance of an algorithm by considering *thirty* Persons Inside Data base (PID) and *ten* Persons Outside Data base (POD) with *six*

samples per person and *ninth* sample is considered as test image sample. The variations of TSR with threshold and FAR versus FRR with threshold are as shown in Fig. 9 and Fig. 10 respectively. It is observed that maximum of 91.11 percentage of TSR and 0.35 EER is obtained using FFT technique.

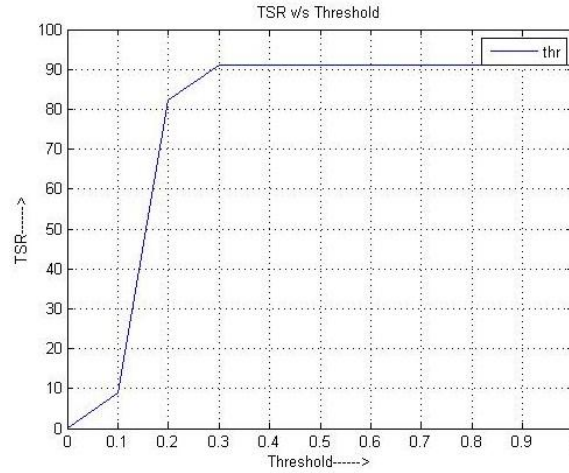


Fig 9: TSR with threshold for FFT

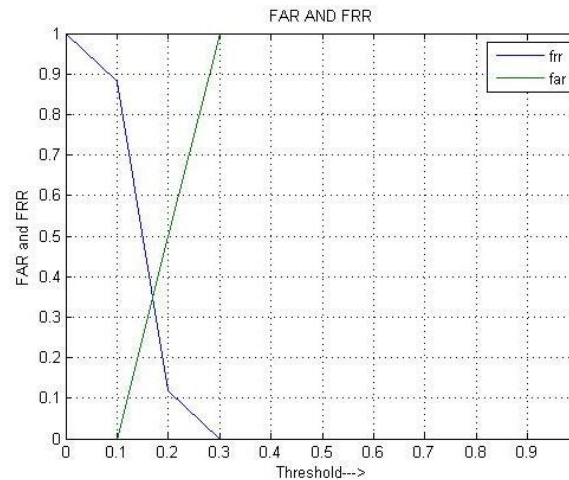


Fig 10: FAR and FRR versus threshold for FFT

(iii) *Proposed Fusion Method:*

The data base is created to test the performance of an algorithm by considering *thirty* Persons Inside Data base (PID) and *ten* Persons Outside Data base (POD) with *six* samples per person and *ninth* sample is considered as test image sample. The variations of TSR with threshold and FAR versus FRR with threshold are as shown in Fig. 11 and Fig. 12 respectively. It is observed that maximum of 96.66 percentage of TSR and 0.18 EER is obtained using proposed fusion technique.

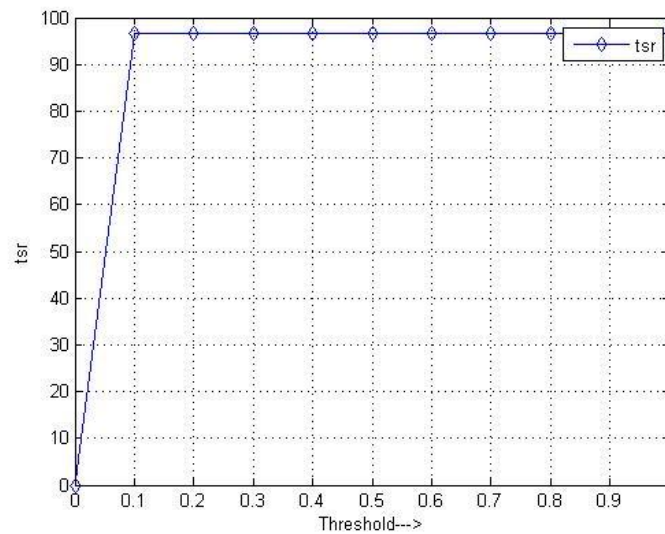


Fig 11: TSR with threshold for Proposed Method

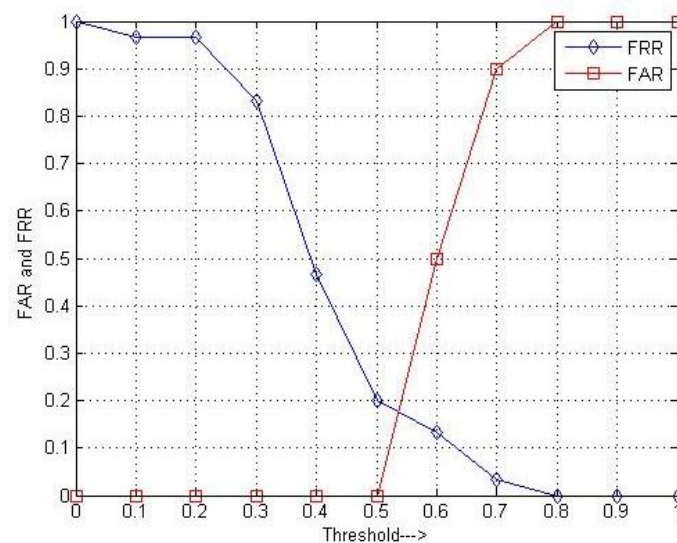


Fig 12: FAR and FRR versus threshold for Proposed Method

(iv) Performance comparison of Lift DWT, FFT and Fusion Technique:

The performance parameters viz., EER Optimum TSR (Opt,TSR) and Maximum TSR (Max.TSR) for Lift DWT, FFT and Fusion domain techniques are tabulated in Table 2. It is observed that the values EER is less in the case proposed Fusion technique compare to Lift DWT and FFT techniques. The values of Opt. and Max. TSR is high in the case of Fusion technique compared to Lift DWT and FFT techniques.

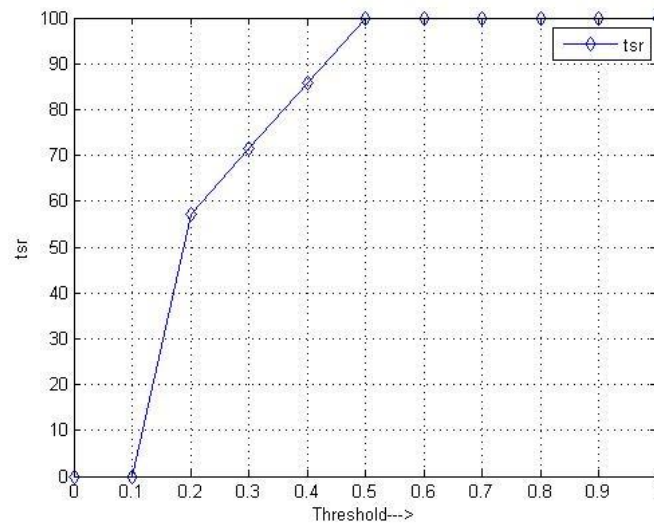
Table 2: EER and TSR values for Different Recognition Methods

Lifting DWT			FFT			Proposed Method		
EER	Opt TSR(%)	Max TSR(%)	EER	Opt TSR(%)	Max TSR(%)	EER	Opt TSR(%)	Max TSR(%)
0.4	50	83.33	0.35	60	91.11	0.18	96.66	96.66

5.2.2 Analysis using JAFFE Database

(i) Lifting DWT:

The data base is created to test the performance of an algorithm by considering *Seven* Persons Inside Data base (PID) and *three* Persons Outside Data base (POD) with *six* samples per person and *ninth* sample is considered as test image sample. The variations of TSR with threshold and FAR versus FRR with threshold are as shown in Fig. 13 and Fig. 14 respectively. It is observed that maximum of 100 percentage of TSR and 0.1 EER is obtained using Lift 5/3 technique.

**Fig 13:** TSR with threshold for Lift DWT Method

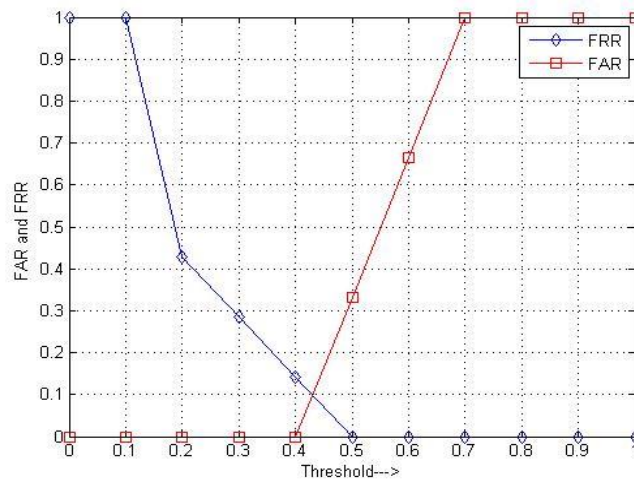


Fig 14: FAR and FRR versus threshold for Lift Method

(ii) *Fast Fourier Transform (FFT):*

The data base is created to test the performance of an algorithm by considering *Seven* Persons Inside Data base (PID) and *three* Persons Outside Data base (POD) with *six* samples per person and *ninth* sample is considered as test image sample. The variations of TSR with threshold and FAR versus FRR with threshold are as shown in Fig. 15 and Fig. 16 respectively. It is observed that maximum of 100 percentage of TSR and 0.22 EER is obtained using FFT technique.

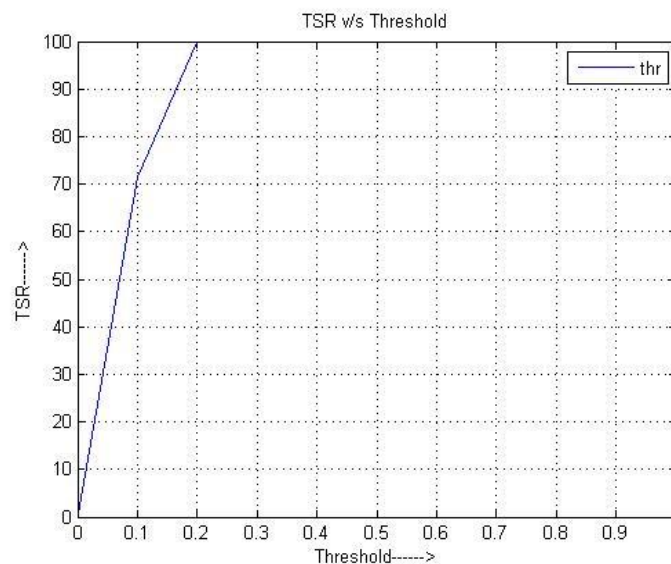


Fig 15: TSR with threshold for FFT Method

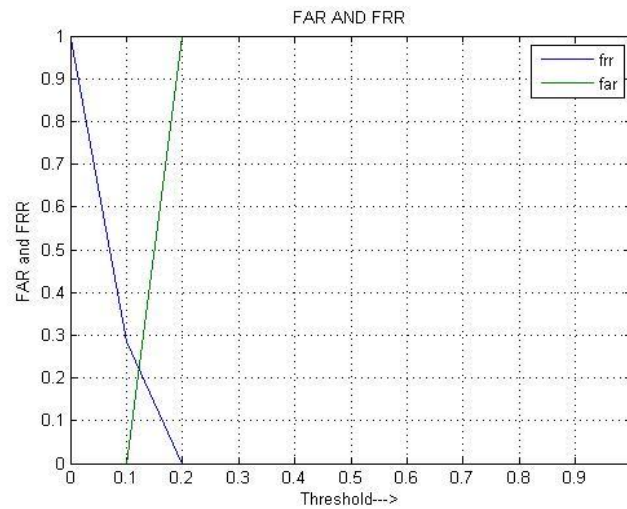


Fig 16: FAR and FRR versus threshold for FFT

(iii) *Proposed Fusion Method:*

The data base is created to test the performance of an algorithm by considering *Seven* Persons Inside Data base (PID) and *three* Persons Outside Data base (POD) with *six* samples per person and *ninth* sample is considered as test image sample. The variations of TSR with threshold and FAR versus FRR with threshold are as shown in Fig. 17 and Fig. 18 respectively. It is observed that maximum of 100 percentage of TSR and 0 EER is obtained using FFT technique.

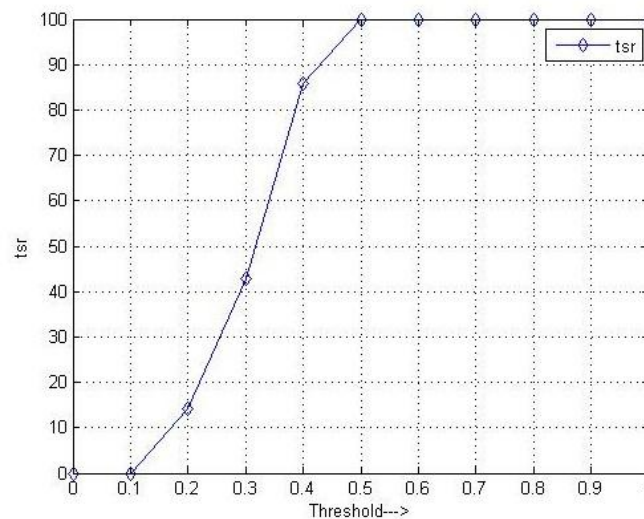


Fig 17: TSR for Proposed Method

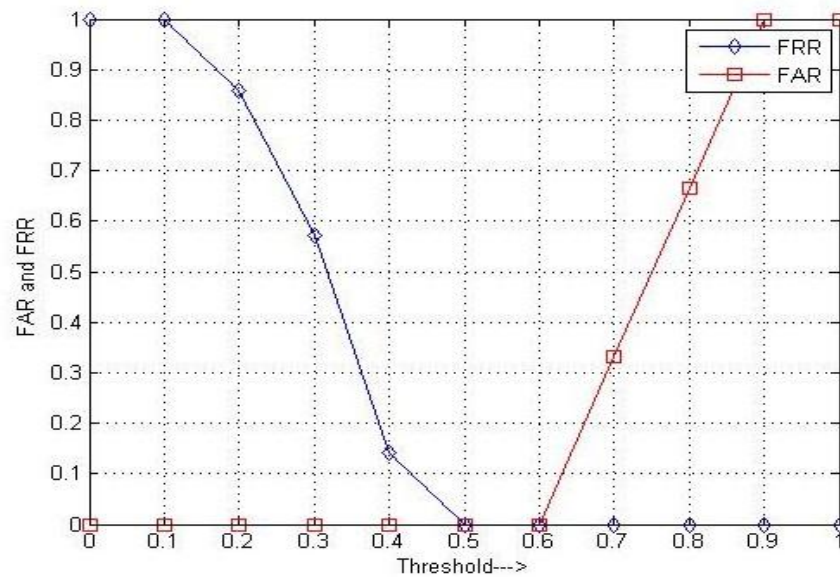


Fig 18: FAR and FRR versus threshold for Proposed Method

(iv) *Performance comparison of Lift DWT, FFT and Fusion Technique:*

The performance parameters viz., EER Optimum TSR (Opt,TSR) and Maximum TSR (Max.TSR) for Lift DWT, FFT and Fusion domain techniques are tabulated in Table 3. It is observed that the values EER is *zero* in the case proposed Fusion technique compare to Lift DWT and FFT techniques. The values of Opt. and Max. TSR is high in the case of Fusion technique compared to Lift DWT and FFT techniques.

Table 3: EER and TSR Values of Different Recognition methods

Lifting DWT			FFT			Proposed Method		
EER	Opt TSR(%)	Max TSR(%)	EER	Opt TSR(%)	Max TSR(%)	EER	Opt TSR(%)	Max TSR(%)
0.1	90	100	0.22	80	100	0	100	100

5.2.3 Comparison of proposed algorithm with existing algorithms with ORL database

The percentage TSR of proposed algorithm for ORL database is compared with existing algorithm presented by Macro Grassi et al., [24], Pallavi D. Wadakar and MeghaWankhade [25] and Swarup Kumar Dandpat and Sukadev Meher [26] and is given in Table 4. It is observed that the percentage TSR is high in the case of

proposed algorithm compared to existing algorithms. The performance of proposed algorithm is better compared to existing algorithm for the following reason. (i) The Lift DWT is applied on face images and only LL band is considered. The Edge Detection and morphological operations are applied on resized LL band and manipulated with original face image to sharpen the face images. (ii).The Lift DWT applied produce feature which represents micro level information. (iii). The FFT magnitudes of filter coefficients are better features in frequency domain. (iv).The features of Lift DWT are fused with FFT features to generate effective final feature set to identify a person accurately.

Table 4: Comparison of proposed method and existing techniques

Author	Technique	TSR (%)
Marco Grassi et al., [24]	DCT & RBF	93.28
Pallavi D. Wadakar and MeghaWankhade [25]	DWT	90
Swarup Kumar Dandpat and SukadevMeher [26]	PCA+2DPCA	90.5
Proposed Method	Lift DWT+FFT	96.66

6. CONCLUSION

In this paper, Face Recognition credentials using fusion of Lift DWT and FFT is proposed. The standard JAFFE and ORL data bases are considered and processed using Resizing, DWT, Edge detection and filtering. The transform domain Lift DWT technique is applied on preprocessed image to generate LL band features. The FFT is applied on preprocessed image to generate FFT magnitude features. The Lift DWT LL band features and FFT magnitude features are fused to generate final features. The Euclidian Distance is used to compare features of test image with features of data base images. The performance parameters are better in the case of proposed algorithm compared to existing algorithms. In future the final features can be compressed and different matching techniques can be used for better results.

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