Hybrid Domain based Face Recognition using DWT, FFT and Compressed CLBP

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Abstract

The characteristics of human body parts and behaviour are measured with biometrics, which are used to authenticate a person. In this paper, we propose Hybrid Domain based Face Recognition using DWT, FFT and Compressed CLBP. The face images are preprocessed to enhance sharpness of images using Discrete Wavelet Transform (DWT) and Laplacian filter. The Compound Local Binary Pattern (CLBP) is applied on sharpened preprocessed face image to compute magnitude and sign components. The histogram is applied on CLBP components to compress number of features. The Fast Fourier Transformation (FFT) is applied on preprocessed image and compute magnitudes. The histogram features and FFT magnitude features are fused to generate final feature. The Euclidian Distance (ED) is used to compare final features of test face images with data base face images to compute performance parameters. It is observed that the percentage recognition rate is high in the case of proposed algorithm compared to existing algorithms.

Keywords: Biometrics, CLBP, DWT, Face Recognition, FFT, Histogram.

1. INTRODUCTION

The biometrics stands for life measurements i.e., the measurement and analysis of biological characteristics such as fingerprints, iris patterns, retina etc. or the behavioural characteristics such voice, gait, signature etc. of an individual. The identification of a person is based on biological factors and behavioural characteristics. Some of the different types of biological biometrics are: (i) *Fingerprint Recognition*: The ridges and valleys in the fingertips to identify an individual. The drawback with this approach is that most often it is possible for an individual to lose the fingerprints due to injury or due to working in hazardous work environments. (ii) *Face Recognition*: The facial characteristics of an individual are analysed. (iii) *Finger/Hand Geometry Recognition*: The special and transform domain features are analysed for recognition. (iv) *Iris Recognition*: An individual is identified based on the unique patterns of the iris. (v) *Retina Recognition*: Analysing the features of the capillary vessels present at the back of the eye. (vi) *Vein Detection*: The vein patterns in the back of the hand and the wrist is used to identify an individual. The analysis of various behavioural characteristics to identify an individual are: (i) *Voice Recognition*: Analysing the tone, frequency and pitch of an individual's voice. (ii) *Signature Recognition:* Analysis of the style in which a person does the signature. (iii*) Keystroke Recognition:* Studying the pattern in which an individual types on the keyboard.

Face recognition is the biometric technique of identifying through the analysis of facial features. The key advantage of face recognition is that it does not require any cooperation from the subject under test. Most face recognition systems implemented in surveillance applications captures and analyses the individuals even without their knowledge. Face recognition has extensive application in both one-to-one mapping for verification of a person and one-to-many mapping for identification of an individual. One of the ways to achieve this is by first acquiring the facial features and then comparing it with the facial databases. The advantages and applications of face recognition is a hot field of research and challenging task for efficient identification under illuminations pose variations etc.

Contribution: In this paper Hybrid Domain based Face Recognition using DWT, FFT and Compressed CLBP is proposed. The Face images are preprocessed to sharpen the images. The CLBP is applied on face images to generate CLBP features. The histogram is applied to compress CLBP features. The FFT is applied on preprocessed image to generate magnitude features, which are fused with Histogram features to generate final features. The final test features and data base features are compared using ED.

Organisation: section 1 gives brief introduction of biometrics. The related work of existing techniques described in section 2. The proposed model is described in section 3. In section 4 algorithm is given. The performance analysis is discussed in section 5. The conclusion is given in section 6.

2. RELATED WORK

Faisal R.AI-Osaimi et al., [1] proposed a spatially optimised data/pixel-level fusion of 3D shape and texture. Here in order to make the expression and illumination variations reside better in PCA subspace, the fusion is spatially optimised with respect to multimodal pixel values. Also they proved that identification performance was further improved by using higher order fusion functions and multiple fusion functions systematically. Raghuraman Gopalan et al., [2] created a subspace resulting from convolution of an image with a set of orthogonal basis functions and showed that subspace created by clear image and its blurred versions are equal under ideal conditions of zero noise. Ping-Han Lee et al., [3] explored the orientations of edges and proposed Oriented Local Histogram Equalization (OLHE) which compensates illumination. The OLHE feature combinations schemes are used for viz, encoded most edge orientations, compactness with good edge-preserving capabilities and performs better in extreme lighting conditions. Discriminant nonlinear with Generalise Discriminant Analysis (GDA) was applied to LBP, Gabor and Local TernityPatterns (LTP) are used for feature extraction. Cosine distance based nearest neighbour is used for classification.

Timo Ahonen et al.,[4] proposed face recognition using Local Binary Pattern (LBP).The LBP features are extracted by dividing face into several regions and enhanced feature vectors are used for face recognition. In the field of 3D face recognition system. Parama Bagchi et al., [5] have given a robust system which can handle pose as well as occlusions. The system takes in 3D image, registers facial surfaces to common model minimizing distance between a probe model and gallery model using ICP (Iterative Closest Point) algorithm. Later the occlusions are extracted by thresholding depth map values of 3D image. The Principal Component Analysis (PCA) is used for feature extraction. Classification on the extracted features was performed using Artificial Neural Networks. Michel F.Valstar and Maja Pantic [6] have proposed a method for detecting larger facial behaviour by recognizing facial muscle actions that have expressions .The geometric features are used for recognition. The Support Vector Machine (SVMs) and Hidden Morkove Model (HMMs) are used for feature classification.

Wilman W.W.Zou and Pong C. Yuen [7] proposed a method to learn relation between the high resolution image spaces, very low resolution image (VRL) space and face super resolution (SR). Based on this new data and discriminative constraints were designed for good visuality. SVM and INN methods are used for classification. Hu Han et al., [8] have presented a generic frame work for automatic demographic (age, gender and race) estimation for a face image. Demographic informative features are extracted from biologically inspired features and they have predicted the demographic attributes of a face image using a hierarchical classifier to predict the age, gender and race. Changxing Ding et al., [9] proposed face identification for handling the full range of pose. First the original pose-invariant face recognition problem is transformed into a partial frontal face recognition problem. To represent the synthesised partial frontal faces, a robust patch based face representation scheme is developed.

Faisal Ahmed et al., [10] introduced a face recognition method using Compound Local Binary Pattern (CLBP).This method uses encoding scheme which combines magnitude information of the difference between two grey values along with original LBP pattern. The performance of CLBP features are classified using Support Vector Machines (SVM) classifier. Gae Yong Choi et al., [11] proposed colour texture features based on Colour Local Gabor Wavelets (CLGWs) and Colour Local Binary Pattern (CLBP) for face recognition. To perform classification multiple colour local textures are combined at the feature level with uniform weights.

3. PROPOSED MODEL

The block diagram of proposed model is shown in Figure1. The face images are pre-processed using DWT, Laplacian filtering and subtraction for better performance.

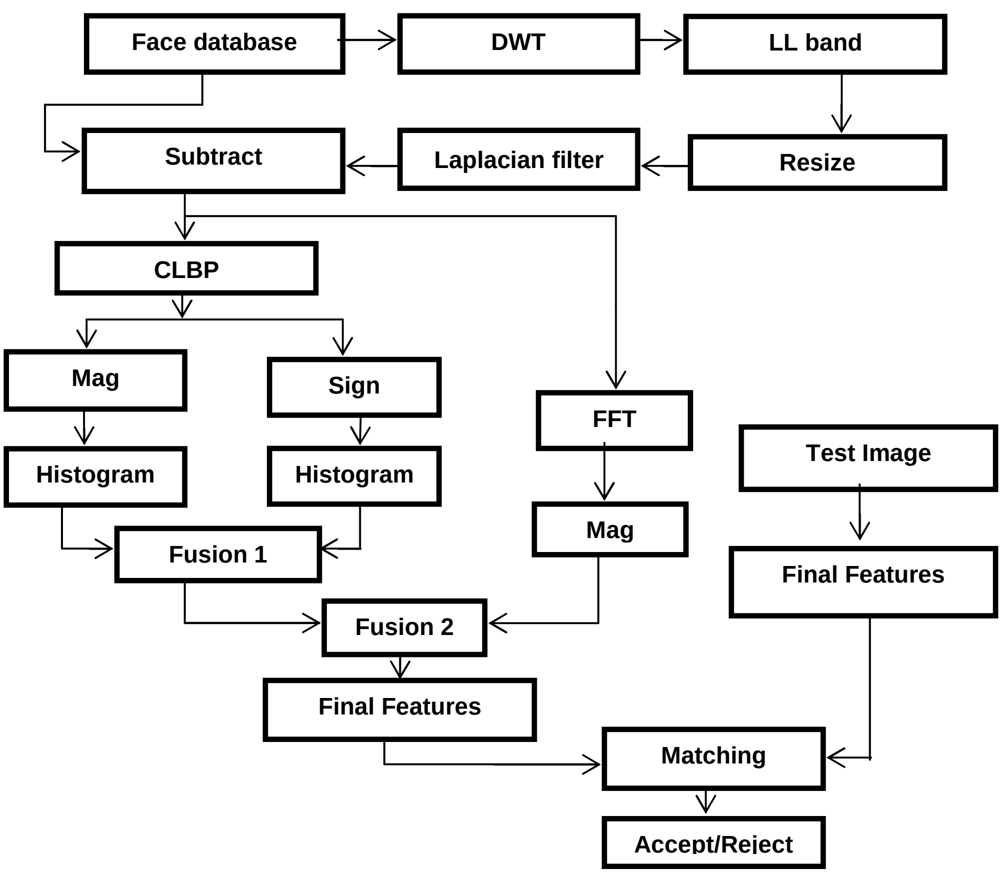


FIGURE 1: Block diagram of proposed model.

3.1 **Face Database**

The standard face databases such as JAFFE, ORL, Indian male and Indian female are considered to test the proposed model.

3.1.1 JAFFE Database

The JAFEE face data base [12] has 10 persons with approximately twenty face images per person. The different images captured for single person are based on facial expressions, such as emotional, happy, angry, disgust, surprise and neutral movements. The original size of image is 256×256 and ten image samples of a person are shown in Figure 2. For experimental results the data base is created by considering eight persons with seven images per person that is fifty six images to compute performance parameters FRR and TSR. The remaining two persons with one image per person are considered to compute FAR.

FIGURE 2: Samples of JAFFE face images of person.

3.1.2 ORL Database

The ORL database [13] shown in Figure 3 has forty persons with ten images per person. The ten different images of a same person are taken at different times by varying lightning, facial expression (which includes opening/closing of eyes and smiling/not smiling), facial details (glass\no glass).The database is created by considering first thirty persons out of forty persons and first six images per person are considered to create database which leads to one eighty images in the database and ninth image from first thirty persons are taken as test image to compute FRR and TSR. The remaining ten persons out of forty are considered as out of database to compute FAR.

FIGURE 3: Samples of ORL face images of person.

3.1.3 Indian Male

The Indian male face database [14] shown in Figure 4 has twenty persons with approximately eleven images per person. The images were taken in homogeneous background with an upright and frontal position. The eleven different images include facial orientations such as looking front, looking left, looking right, looking up, looking up towards left, looking up towards right, looking down, with emotions neutral, smile, laughter, sad/disgust. The database is created by considering first twelve persons out of twenty persons with first six images per persons are considered to create database which leads to seventy two images in the database and ninth image from first twelve persons are taken as test image to compute FRR and TSR. The remaining eight persons out of twenty persons are considered as out of database to compute FAR.

FIGURE 4: Samples of Indian male data base face images

3.1.4 Indian Female

The Indian females face database [14] shown in Figure 5 consists of twenty two persons with approximately eleven images per person. The variations in pose and expressions are same as Indian male face database. The database is created by considering first fifteen persons out of twenty two persons with first seven images per persons are considered to create database which leads to hundred five images in the database and ninth image from first fifteen persons are taken as test image to compute FRR and TSR. The remaining seven persons out of twenty two persons are considered as out of database to compute FAR.

FIGURE 5: Samples of Indian female database face images

3.2 Discrete Wavelet Transform

It serves as one of the important tools for image compression due to their data reduction capability. It analyses the signal at different frequency bands with different resolution by decomposition using high and low pass filters.

The Two Dimensional-Discrete Wavelet Transform (2D-DWT) is a multilevel decomposition technique that converts the images from spatial to frequency domain [15]. One-level of wavelet decomposition produces four filtered and sub sampled images referred to as sub bands. 2D-DWT is implemented as a convolution of selected wavelet function with the original image or it can be viewed as a set of two matrices of filters with row and columns. The mathematical representation of decomposition is given in equation (1).

$C_f = X \times I \times Y$ -- (1)

Where,
C_f is the final matrix of wavelet coefficients

I is the original image

X is the matrix of row filters

Y is the matrix of column filters.

Figure 6 shows two levels of 2D filter tree [16]. The input image in each level is split into four bands using the low pass and high pass wavelet filters on the rows and columns. The row filters in each level are used to convert an image into low and high frequency components. The column filters in each level are used to convert low frequency components of row filters into low and high frequency components. Similarly high frequency components of row filters are converted into low and high frequency components. In each level four sub bands are generated. The low frequency sub bands of level 1 act as input to the level 2.

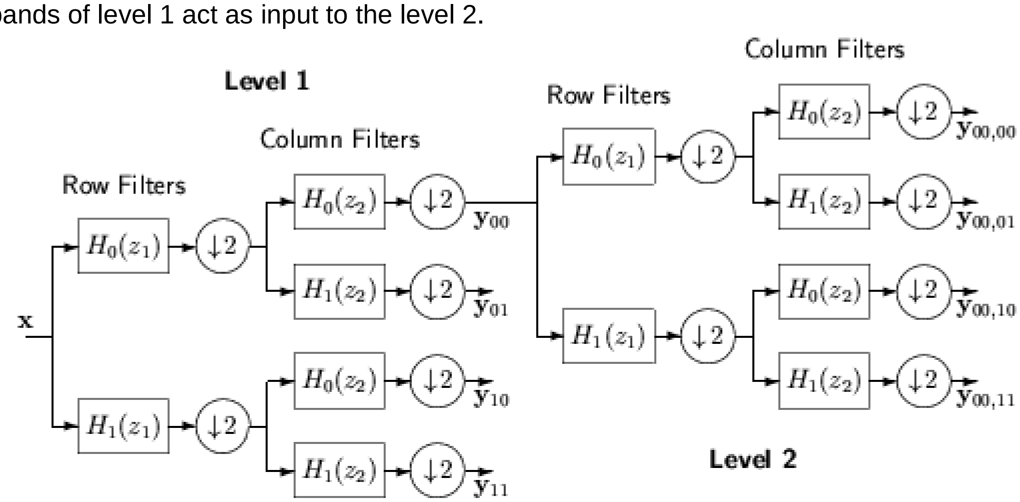


FIGURE 6: 2D DWT decomposition into two levels.

3.3 Laplacian Filter

It is used for image edge detection. The laplacian filter is applied on resized LL band coefficients of DWT. The original image coefficients are subtracted from laplacian filter coefficients to generate sharpened image.

3.4 Compound Local Binary Pattern (CLBP)

It is an extension of the Local Binary Pattern (LBP) texture operator. The image is converted into number of cells of dimension 3*3. The centre pixel in the 3*3 cell is considered as reference to generate CLBP texture operator with LSB for magnitude component and MSB for sign component. An example of CLBP texture operator for 3*3 image is shown in Figure 7. The intensity value of centre pixel is say Ic and intensity values of surrounded pixels are represented by Ip.

The sign component of CLBP is generated using equation (2)

$$CLBP\_Sign = \begin{cases} 0: & Ip - Ic \leq 0 \\ 1: & Ip - Ic > 0 \end{cases} \quad \text{------} (2)$$

The magnitude components of CLBP are generated using equation (3)

$$CLBP\_Mag = \begin{cases} 0: & Ip - Ic \leq M_{avg} \\ 1: & Ip - Ic > M_{avg} \end{cases} \quad \text{------} (3)$$

Where,

M_{avg}= (|m1|+|m2|...........+|m8|)/8

m1 to m8 are the magnitude values of difference between respective *Ip*and *Ic*.

Example: Fig (a) is the original image, the intensity value difference between centre pixel and neighbouring pixels are given in fig (b). The sign component and magnitude components with CLBP are given in figures (c), (d) and (e) respectively. The binary 8 bits of sign and magnitude of each pixel are converted into decimal values to generate sign and magnitude features. The binary 8 bits of sign and magnitude of each pixel are converted into decimal values for feature extraction. The numbers of magnitude and sign components of CLBP for an image size of 256*256 are 64512.

$$\text{Mavg} = \frac{16+13+9+3+11+39+74+15}{8} = \frac{200}{8} = 25$$

9	12	34
10	25	28
99	64	56

(a) Original Image

-16	-13	9
-15		3
74	39	31

(b) Difference

0	0	1
0		1
1	1	1

(c) sign Components

0	0	0
0		0
1	1	1

(d) Magnitude Components

00	00	10
00		10
11	11	11

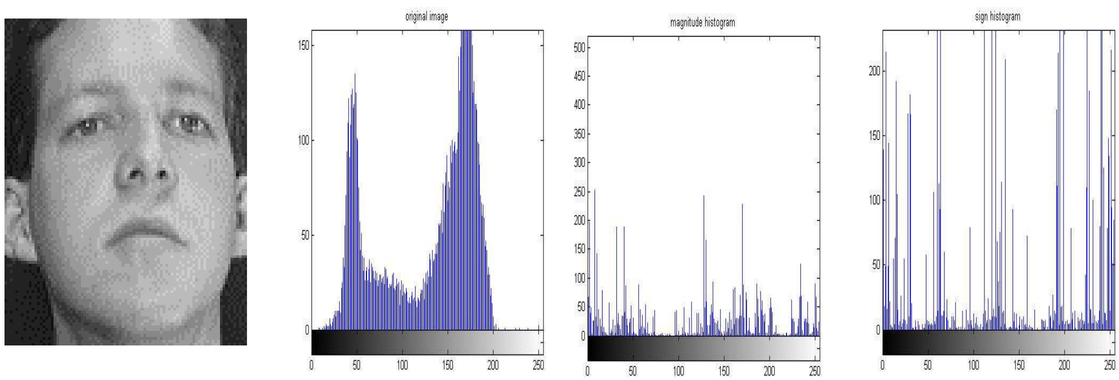
(e) CLBP Matrix

FIGURE 7: CLBP Operator.

3.5 Histogram

Histogram or specifically image histogram is the representation of an image in terms of a bar graph of pixel intensities. Histogram is a powerful tool used to view the image contrast and intensity distribution [17]. The histogram for image consists of pixel intensities plotted along the x-axis and the frequency of these pixel intensities along the y-axis. The histogram reduces number of features, which is advantage in real time application.

Example: - Consider an image of size 256 × 256 as shown in Figure 8. The total number of pixels in the image is 65536 with intensity levels varying from 0 to 255. The histogram of an image is shown in Figure 8. The histogram is applied on magnitude and sign components of CLBP to generate histogram features. The number of CLBP features are reduced from 64512 to 256, which increases the processing speed in real time applications. The histogram features of magnitude and sign components of CLBP are fused by concatenation to form CLBP – histogram features which are represented by C.



(a) Image (b) Histogram (c) Magnitude (d) Sign

FIGURE 8: Histogram of original face image and CLBP.

3.6 Fast Fourier Transform (FFT)

The tool used to decompose an image into cosine (real) and sine (imaginary) components [18]. The transformation is the representation of input image into frequency domain. FFT algorithm is based on either divide and conquers method or linear filtering. The divide and conquer method includes FFT algorithms like Radix-2 and Radix-4 uses Decimation in Time (DIT) and Decimation in Frequency (DIF). FFT is facilitates computation of Discrete Fourier Transform (DFT) in real time which reduces the complexity and reduces the computational time. The FFT and its inverse of 2D image can be computed using the equations (4) and (5).

DFT: $F(x, y) = \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} f(m,n) e^{-j2\pi(x\frac{m}{M}+y\frac{n}{N})}$ ------------------------ --------------------------------- --- (4)

IDFT: $f(m, n) = \frac{1}{MN} \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} F(x,y) e^{j2\pi(x\frac{m}{M}+y\frac{n}{N})}$ --- (5)

Where,
M is the number of rows
N is the number of columns

It is observed from the equations (4) and (5) that the implementation is complex and expensive. 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 (6) and (7).

$$F(x) = \sum_{n=0}^{N-1} f(n) e^{-j2\pi(x\frac{n}{N})} \quad (6)$$

$$f(n) = \frac{1}{N} \sum_{n=0}^{N-1} F(x) e^{j2\pi\left(x\frac{n}{N}\right)} \quad (7)$$

The magnitude values of F(X) are very high compared to pixel intensity values in the spatial domain and features are represented by D.

3.7 Fusion

The texture features are fused with transform domain features to generate final features. The final fusion features differentiate different and similar images efficiently compared to individual features. The CLBP-Histogram features and FFT magnitudes are fused using equation (8) to generate final features of an image.

$$Final\ Score\ F = P * D + (1 - P) * C \quad (8)$$

Where *P* is improved factor varies from 0 to 1
D is transform domain features
C is CLBP-histogram features.

3.8 Euclidian Distance

The final features of test images are compared with final features of images in the data base using Euclidian Distance (ED) to identify a person using equation (9).

$$E\ D = \sqrt{\sum_{i=1}^{M} (\mathrm{Pi} - \mathrm{qi}\ )^2} \quad (9)$$

Where, M = No of coefficients in a vector.
Pi= Coefficients values of vectors in database.
qi = Coefficient values of vectors in test image

4. ALGORITHM

Problem Definition: The hybrid domain technique is used for face recognition with DWT in the Preprocessing.

The objectives are
i) To increase TSR
ii) To decrease FRR, FAR and EER

The proposed face recognition algorithm using DWT, Filtering, CLBP, Histogram and FFT is given in Table 1.

TABLE 1: Proposed Algorithm.

Input: Face Images
Output: Performance parameters

1. The Face Images are pre-processed using DWT, resize, filtering and subtract.
2. The CLBP is applied on preprocessed face images to generate magnitude and sign components.
3. The Histogram is applied on magnitude and sign components of CLBP and concatenate the Histograms of magnitude and sign.
4. The FFT is applied on preprocessed image to generate FFT magnitude features.
5. The FFT magnitude features are fused with concatenated histogram features to generate final features.
6. The final features of test and data base images are compared using Euclidian Distance.
7. Compute performance parameters such as TSR, FRR, FAR and EER.

5. PERFORMANCE ANALYSIS

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

5.1 Definitions of Performance Parameters

(i) **False Acceptance Rate**: The number of unauthorized persons accepted as authorized persons. It is the ratio of the number of unauthorized persons accepted to the total number of persons in the outside database and given in equation (10)

$$FAR=\frac{Number\ of\ unauthorised\ persons\ accepted}{Total\ number\ of\ persons\ in\ the\ out\ of\ data\ base} \quad (10)$$

(ii) **False Rejectio Rate:** The number of authorized persons rejected as unauthorized persons. It is the ratio of number of authorized persons rejected to the total no of persons in the database as given in equation (11)

$$FRR=\frac{Number\ of\ authorised\ persons\ rejected}{Total\ number\ of\ persons\ in\ the\ data\ base} \quad (11)$$

(iii) **Total Success Rate:** The number of authorized persons recognized correctly in the database. It is the ratio of number of persons correctly matched to the total no of persons in the database and is given in equation (12)

$$TSR=\frac{Number\ of\ persons\ correctly\ matched}{Total\ number\ of\ persons\ in\ the\ data\ base} \quad (12)$$

(iv) **Equal Error Rate**:It is the measure of trade-off between FAR and FRR and is given in equation (13).

$$EER=FAR=FRR \quad (13)$$

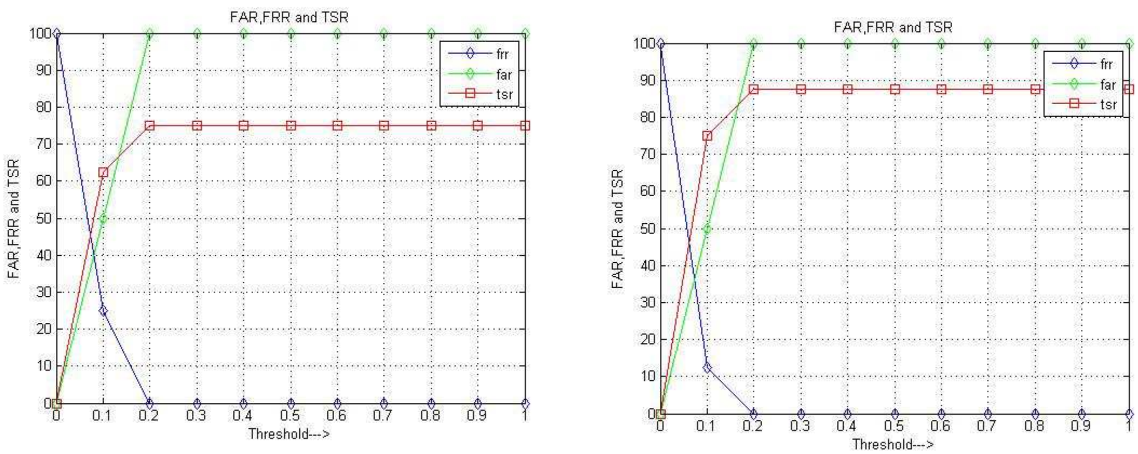
5.2 Analysis of Performance Parameter

The Performance Parameters such as FRR, FAR, EER and TSR for different face databases viz., JAFFE, ORL, Indian male and Indian female are discussed in detail for the proposed model.

5.2.1 Analysis using JAFFE Database

(i) CLBP Technique

The database is created to test the performance of an algorithm by considering eight persons inside data base and two persons outside data base. The variations of FAR, FRR and TSR with threshold using CLBP technique with/without Preprocessing are shown in Figure 9. The values of FRR decrease from 100 % to 0 % as threshold increases. The values of FAR and TSR increases with threshold. The values of Maximum TSR (Max.TSR) are 75 % to 87.5 % without and with preprocessing respectively. The EER values are less with preprocessing compared to without preprocessing.

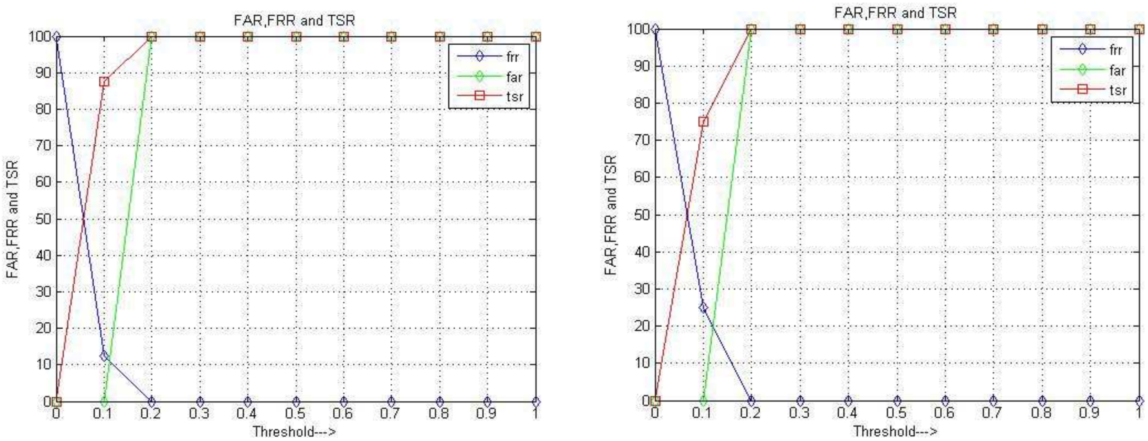


(a) Without Preprocessing (b) With Preprocessing

FIGURE 9: The variations of FAR, FRR and TSR with threshold for CLBP technique.

(ii) FFT Technique

The data base is created to test the performance of an algorithm by considering eight persons inside data base and two persons outside data base. The variations of FAR, FRR and TSR with threshold using CLBP technique with/without Preprocessing are shown in Figure 10. The values of FRR decrease for 100% to 0% as threshold increases. The values of FAR and TSR increases with threshold. The values of Max.TSR without and with Preprocessing are 100%. The EER values are less with preprocessing compared to without preprocessing.

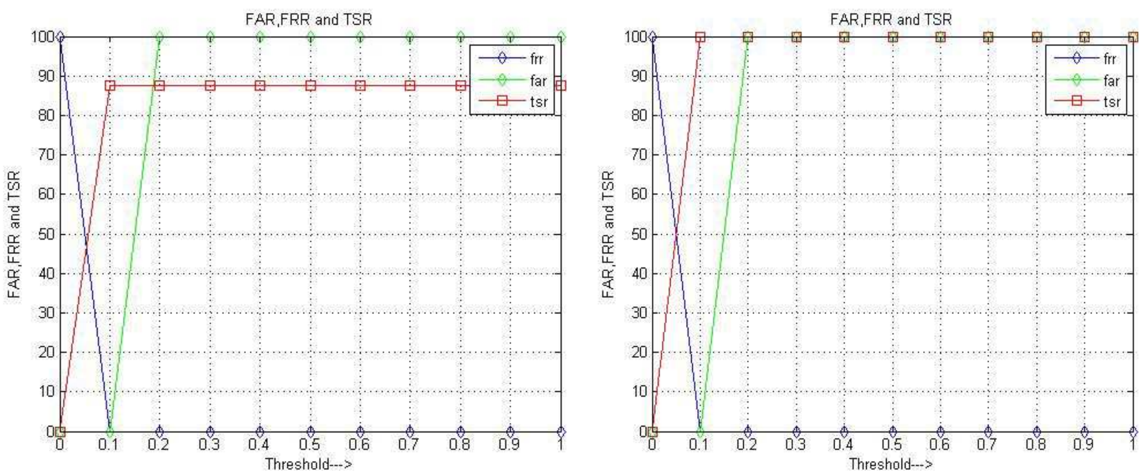


(a) Without Preprocessing (b) With Preprocessing

FIGURE 10: The variations of FAR, FRR and TSR with threshold for FFT technique.

(iii) Proposed Hybrid Technique

The data base is created to test the performance of an algorithm by considering eight persons inside data base and two persons outside data base. The variations of FAR, FRR and TSR with threshold using CLBP technique with/without Preprocessing are shown in Figure 11. The Values of FRR decrease for 100 % to 0 % as threshold increases. The values of FAR and TSR increases with threshold. The values of Max. TSR are 88.33% to 100% without and with preprocessing respectively. The EER values are less with Preprocessing compared to without Preprocessing.



(a) Without Preprocessing (b) With Preprocessing

FIGURE 11: The variations of FAR, FRR and TSR with threshold for Hybrid technique.

(iv) Performance Comparison of CLBP, FFT and Hybrid Techniques

The performance parameters viz., EER, Optimum TSR (Opt.TSR) and Maximum TSR (Max.TSR) for CLBP, FFT and Hybrid domain techniques are tabulated in Table 2. The values of EER with Preprocessing are lower compared to without preprocessing. In all the three techniques the values of Max.TSR and Opt.TSR values are higher in the case of with preprocessing compared to without preprocessing It is observed that the values EER are zero in the case proposed hybrid technique compared to CLBP and FFT techniques. The values Opt. and Max. TSR with and without preprocessing are high in the case of hybrid technique compared to CLBP and FFT techniques.

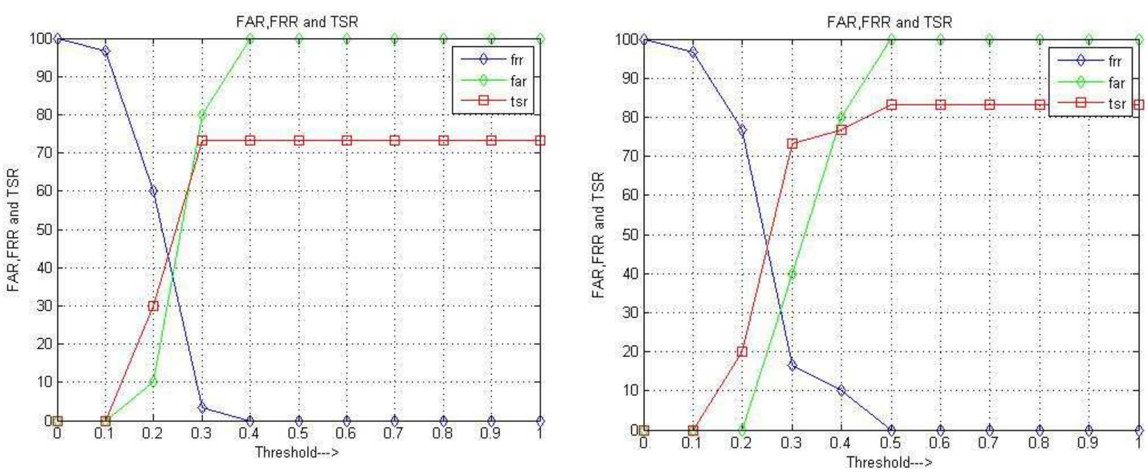
TABLE 2: Percentage variations of FAR, FRR and TSR without and with preprocessing.

Techniques	CLBP			FFT			Hybrid Technique		
	EER (%)	Opt. TSR (%)	Max. TSR (%)	EER (%)	Opt. TSR (%)	Max TSR (%)	EER (%)	Opt. TSR (%)	Max TSR (%)
Without preprocessing	40	50	75	20	80	100	0	88.33	88.33
With preprocessing	36	55	87.5	12	90	100	0	100	100

5.2.2 Analysis using ORL Database

(i) CLBP Technique

The data base is created to test the performance of an algorithm by considering thirty persons inside data base and ten persons outside data base. The variations of FAR, FRR and TSR with threshold using CLBP technique with/without Preprocessing are shown in figure 12. The values of FRR decrease for 100 % to 0 % as threshold increases. The values of FAR and TSR increases with threshold. The values of Max. TSR are 73.33 % to 83.33 % without and with Preprocessing respectively. The EER values are less with Preprocessing compared to without Preprocessing.

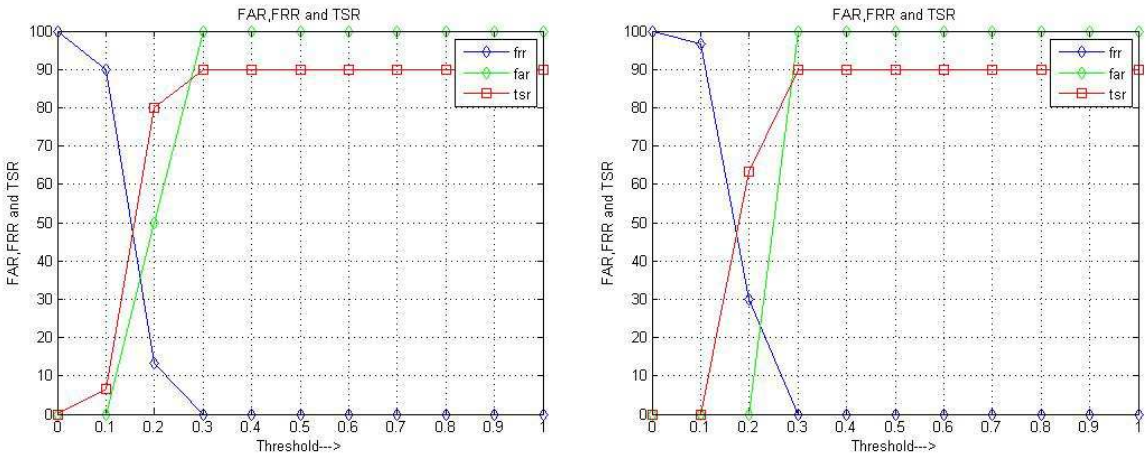


(a) Without Preprocessing (b) With Preprocessing

FIGURE 12: The variations of FAR, FRR and TSR with threshold for CLBP technique.

(ii) FFT Technique

The data base is created to test the performance of an algorithm by considering thirty persons inside data base and ten persons outside data base. The variation of FAR, FRR and TSR with threshold using CLBP technique with/without Preprocessing is shown in Figure 13. The values of FRR decrease for 100% to 0% as threshold increases. The values of FAR and TSR increases with threshold. The values of Max. TSR is 90% without and with Preprocessing. The EER values are less with preprocessing compared to without preprocessing



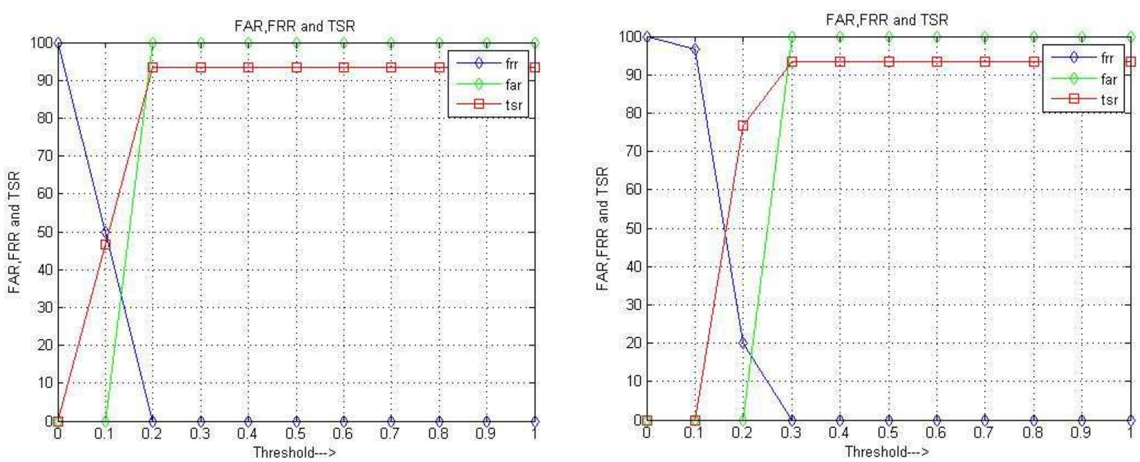
(a) Without Preprocessing

(b) With Preprocessing

FIGURE 13: The variations of FAR, FRR and TSR with threshold for FFT technique.

(iii) Proposed Hybrid Technique

The data base is created to test the performance of an algorithm by considering thirty Persons Inside Data base and ten Persons Outside Data base. The variations of FAR, FRR and TSR with threshold using CLBP technique with/without Preprocessing are shown in Figure 14. The values of FRR decrease for 100 % to 0 % as threshold increases. The values of FAR and TSR increases with threshold. The values of Max. TSR are 93.33% without and with Preprocessing. The EER values are less with preprocessing compared to without preprocessing.



(a)Without Preprocessing

(b) With Preprocessing

FIGURE 14: The variations of FAR, FRR and TSR with threshold for Hybrid technique.

(iv) Performance Comparison of CLBP, FFT and Hybrid Techniques

The performance parameters viz., EER, Optimum TSR and Maximum TSR for CLBP, FFT and Hybrid domain techniques are tabulated in Table 3. The values of EER with preprocessing are lower compare to without preprocessing. In all the three techniques the values of Max.TSR and opt. TSR values are higher in the case of with preprocessing compared to without preprocessing. It is observed that the values EER are zero in the case proposed hybrid technique compare to CLBP and FFT techniques. The values opt. and Max.TSR with and without preprocessing are high in the case of hybrid technique compared to CLBP and FFT techniques.

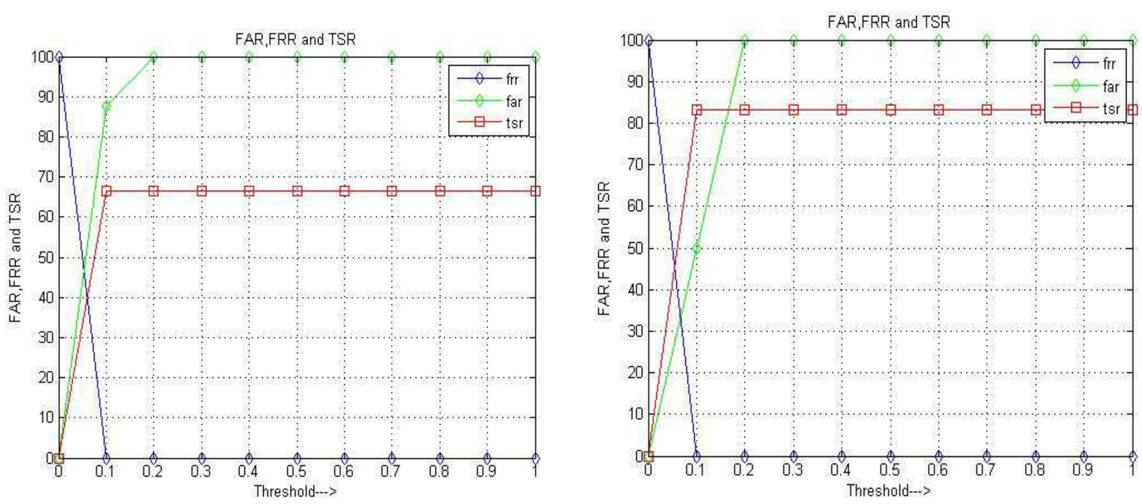
TABLE 3: Percentage variations of FAR, FRR and TSR without and with preprocessing.

Techniques	CLBP			FFT			Hybrid Technique		
	EER (%)	Opt. TSR (%)	Max. TSR (%)	EER (%)	Opt. TSR(%)	Max. TSR (%)	EER (%)	Opt. TSR (%)	Max. TSR (%)
Without preprocessing	40	45	73.33	20	60	90	32	60	93.33
With preprocessing	30	60	83.33	12	68	90	18	80	93.33

5.2.3 Analysis using Indian Male Database

(i) CLBP Technique

The data base is created to test the performance of an algorithm by considering twelve Persons inside Data base and eight Persons Outside Data base. The variation of FAR, FRR and TSR with threshold using CLBP technique with/without Preprocessing is shown in Figure 15. The values of FRR decrease for 100 % to 0 % as threshold increases. The values of FAR and TSR increases with threshold. The values of Max. TSR are 66.66 % to 83.33 % without and with Preprocessing respectively. The EER values are less with preprocessing compared to without preprocessing.

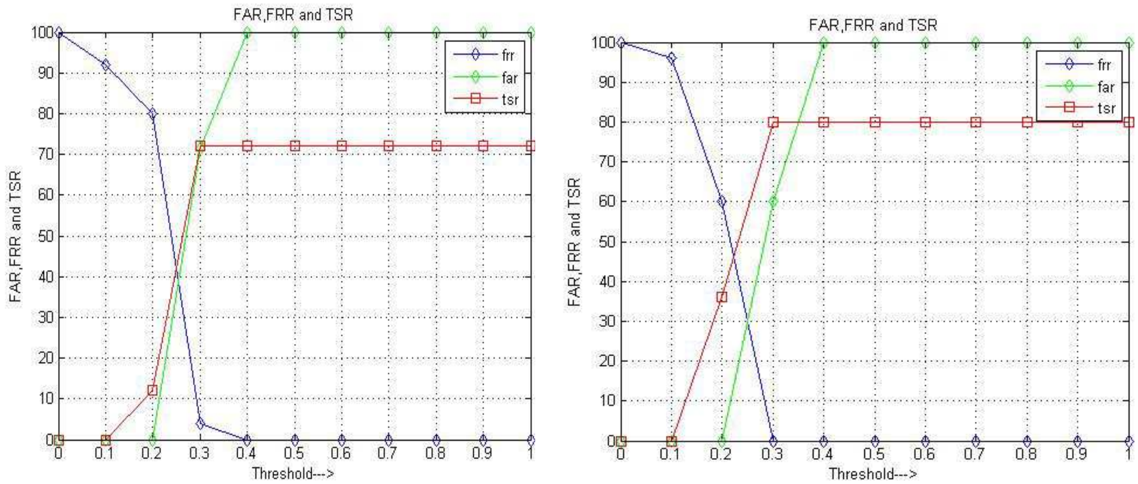


a) Without Preprocessing (b) With Preprocessing

FIGURE 15: The variations of FAR, FRR and TSR with threshold for CLBP technique.

(ii) FFT Technique

The data base is created to test the performance of an algorithm by considering twelve Persons inside Data base and eight Persons outside Data base. The variations of FAR, FRR and TSR with threshold using CLBP technique with/without Preprocessing are shown in Figure 16. The values of FRR decrease for 100% to 0% as threshold increases. The values of FAR and TSR increases with threshold. The values of Max. TSR are 72% to 80% without and with Preprocessing respectively. The EER values are less with preprocessing compared to without preprocessing

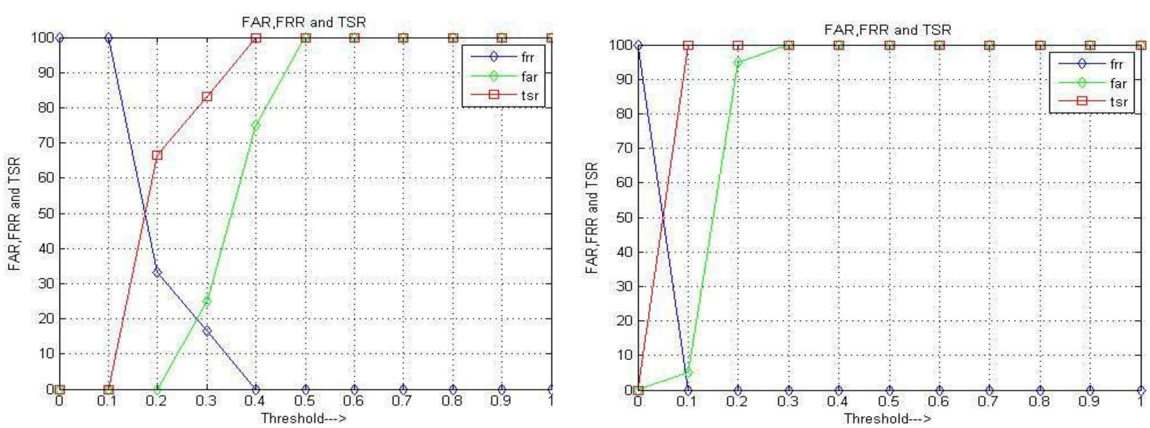


(a) Without Preprocessing (b) With Preprocessing

FIGURE 16: The variations of FAR, FRR and TSR with threshold for FFT technique.

(iii) Proposed Hybrid Technique

The data base is created to test the performance of an algorithm by considering eight Persons Inside Data base and two Persons Outside Data base. The variations of FAR, FRR and TSR with threshold using CLBP technique with / without Preprocessing are shown in Figure 17. The values of FRR decrease for 100 % to 0 % as threshold increases. The values of FAR and TSR increases with threshold. The values of Max.TSR without and with Preprocessing are 100%. The EER values are less with preprocessing compared to without preprocessing.



(a) Without Preprocessing (b) With Preprocessing

FIGURE 17: The variations of FAR, FRR and TSR with threshold for Hybrid technique.

(iv) Performance Comparison of CLBP, FFT and Hybrid Techniques

The performance parameters viz., EER, optimum TSR and maximum TSR for CLBP, FFT and Hybrid domain techniques are tabulated in Table 4. The values of EER with preprocessing are lower compared to without preprocessing. In all the three techniques the values of Max. TSR and opt. TSR values are higher in the case of with preprocessing compared to without preprocessing. It is observed that the values EER are zero in the case proposed hybrid technique compared to CLBP and FFT techniques. The values opt. and Max.TSR with and without preprocessing are high in the case of hybrid technique compared to CLBP and FFT techniques.

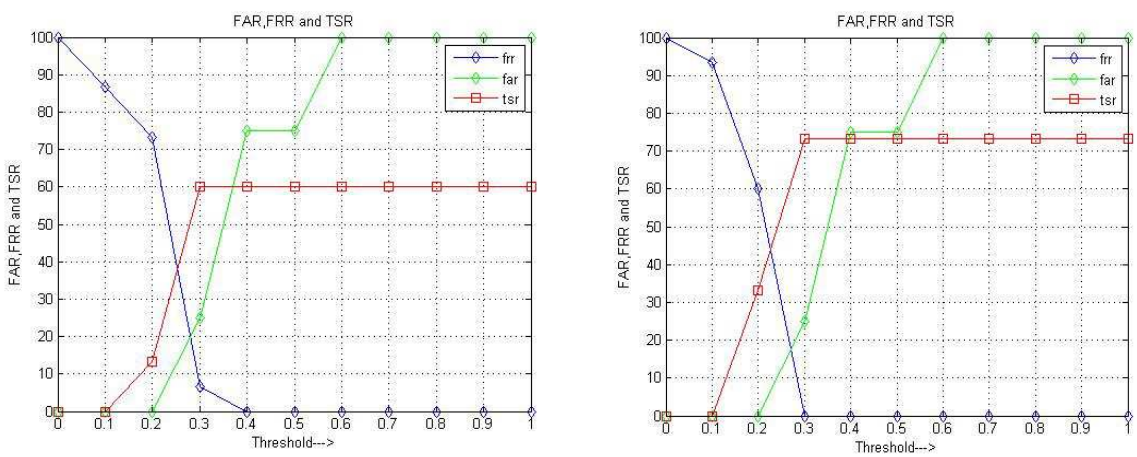
TABLE 4: Percentage variations of FAR, FRR and TSR without and with preprocessing.

Techniques	CLBP			FFT			Hybrid Technique		
	EER (%)	Opt. TSR (%)	Max. TSR (%)	EER (%)	Opt. TSR (%)	Max TSR (%)	EER (%)	Opt TSR (%)	Max TSR (%)
Without preprocessing	48	50	66.66	40	43	72	20	80	100
With preprocessing	32	56	83.33	30	60	80	4	100	100

5.2.4 Analysis using Indian Female Database

(i) CLBP Technique

The data base is created to test the performance of an algorithm by considering fifteen persons inside data base and seven persons outside data base. The variation of FAR, FRR and TSR with threshold using CLBP technique with / without Preprocessing is shown in Figure 18. The values of FRR decrease for 100 % to 0 % as threshold increases. The values of FAR and TSR increases with threshold. The values of Max.TSR are 60 % to 72.11 % without and with Preprocessing respectively. The EER values are less with preprocessing compared to without preprocessing.

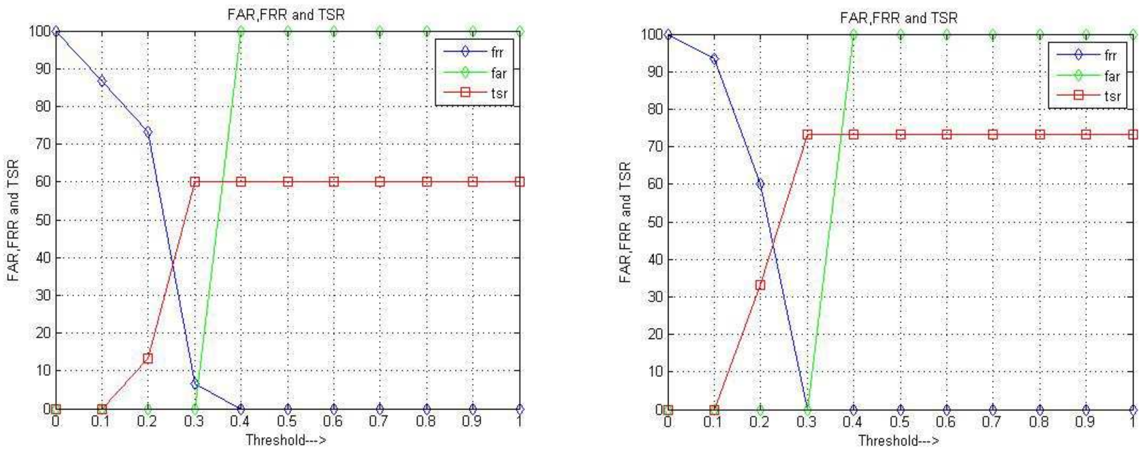


(a) Without Preprocessing (b) With Preprocessing

FIGURE 18: The variations of FAR, FRR and TSR with threshold for CLBP technique.

(ii) FFT Technique

The data base is created to test the performance of an algorithm by considering fifteen persons inside data base and seven persons outside data base. The variations of FAR, FRR and TSR with threshold using CLBP technique with / without Preprocessing are shown in Figure 19. The values of FRR decrease for 100% to 0% as threshold increases. The values of FAR and TSR increases with threshold. The values of Max. TSR are 60% to 72.11 without and with Preprocessing. The EER values are less with preprocessing compared to without preprocessing

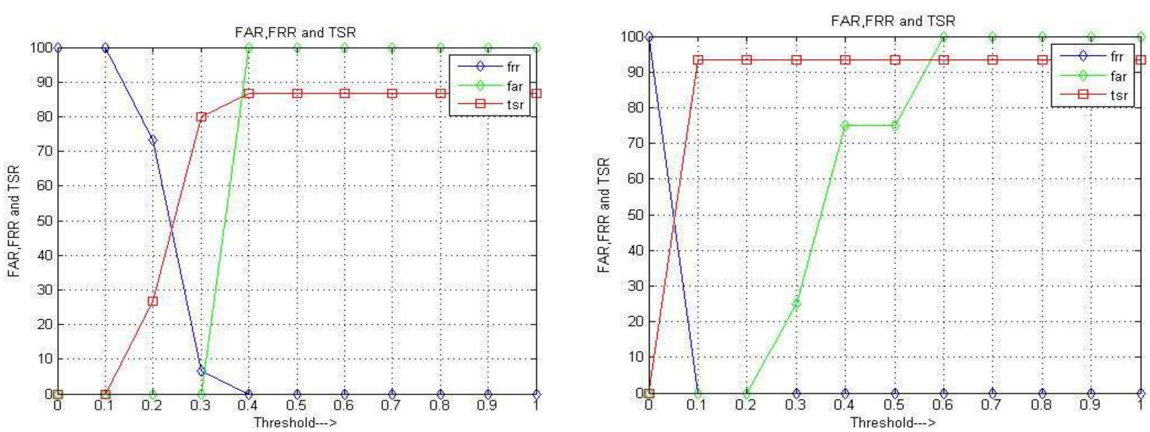


(a) Without Preprocessing (b) With Preprocessing

FIGURE 19: The variations of FAR, FRR and TSR with threshold for FFT technique.

(iii) Proposed Hybrid Technique

The data base is created to test the performance of an algorithm by considering fifteen persons inside data base and seven persons outside data base. The variations of FAR, FRR and TSR with threshold using CLBP technique with / without Preprocessing are shown in figure 20. The values of FRR decrease for 100 % to 0 % as threshold increases. The values of FAR and TSR increases with threshold. The values of Max.TSR are 86.46% to 93.33% without and with Preprocessing respectively. The EER values are less with preprocessing compared to without preprocessing.



(a) Without Preprocessing (b) With Preprocessing

FIGURE 20: The variations of FAR, FRR and TSR with threshold for Hybrid technique.

(iv) Performance comparison of CLBP, FFT and Hybrid Techniques

The performance parameters viz., EER, optimum TSR and maximum TSR for CLBP, FFT and Hybrid domain techniques are tabulated in Table 5. The values of EER with preprocessing are lower compare to without preprocessing. In all the three techniques the values of Max. TSR and opt. TSR values are higher in the case of with preprocessing compared to without preprocessing. It is observed that the values EER are zero in the case proposed hybrid technique compare to CLBP and FFT techniques. The values opt. and Max.TSR with and without preprocessing are high in the case of hybrid technique compared to CLBP and FFT techniques.

TABLE 5: Percentage variations of FAR, FRR and TSR without and with preprocessing.

Techniques	CLBP			FFT			Hybrid Technique		
	EER (%)	Opt. TSR (%)	Max. TSR (%)	EER (%)	Opt. TSR (%)	Max TSR (%)	EER (%)	Opt TSR (%)	Max TSR (%)
Without preprocessing	20	50	60	5	60	60	5	80	86.46
With preprocessing	18	60	72.11	0	72.11	72.11	0	93.33	93.33

5.2.5 Comparison of Proposed Algorithm with Existing Algorithms for ORL Database

The percentage TSR of proposed algorithm for ORL database is compared with existing algorithm presented by Pallavi D. Wadakar and Megha Wankhade [19], Swarup Kumar Dandpat and Sukadev Meher [20] and D Murugan et al.,[21] and is given in Table 6. It is observed that the percentage TSR is high in the case of proposed algorithm since the combination of DWT, CLBP and FFT techniques are used compared to DWT, PCA+2DPCA and DWT+PCA techniques used in the existing algorithms. The performance parameter values are computed to demonstrate the proposed algorithm is better for the following reasons. (i) The face images are preprocessed using DWT and Laplacian filter to generate sharpened face images.(ii)The CLBP magnitude and sign component produce texture feature which represents micro level information and also produce high dimensional features which results in better performance parameters.(iii)The histogram on CLBP features reduces high dimensional features to low dimensional features.(iv)The FFT magnitude features are able to produce highly discriminant features for images of different persons.(v)The proposed algorithm is able to produce highly similar features for images of same persons and highly discriminant features for images of different persons. This is proved through Euclidian Distance and experimental results.

TABLE 6: Comparison of TSR with proposed and existing algorithms.

Sl No	Authors	Techniques	Max.TSR (%)
1	Pallavi D. Wadakar and Megha Wankhade[19]	DWT	90
2	Swarup Kumar Dandpat and Sukadev Meher [20]	PCA+2DPCA	90.5
3	D Murugan et al.,[21]	Gabor filter + DWT + PCA	92
4	**Proposed Method**	DWT + CLBP+FFT	93.33

6. CONCLUSION

The biometrics are used to create human data base of nation for authentication and national security. In this paper Hybrid Domain based Face Recognition using DWT, FFT and Compressed CLBP is proposed. The face data bases are preprocessed using LL band of DWT and Laplacian filter to generate sharpened face images. The CLBP is applied on sharpened face images to generate high dimensional magnitude and sign features. The histogram is applied on magnitude and sign features to convert high dimensional features to low dimensional features. The FFT is applied on sharpened face images to generate FFT magnitude features. The low dimensional histogram features are fused with high dimensional FFT magnitude features using strengthening equation to generate final features. The data base image features and test image features are compared using ED to compute performance parameters. The performance parameter values are better in the case of proposed algorithm compared to existing algorithms. In future the algorithm can be tested using FPGA which suits real time applications.

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