MSB based Face Recognition Using Compression and Dual Matching Techniques

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Abstract

Biometrics are used in almost all communication technology applications for secure recognition. In this paper, we propose MSB based face recognition using compression and dual matching techniques. The standard available face images are considered to test the proposed method. The novel concept of considering only four Most Significant Bits (MSB) of each pixel on image is introduced to reduce the total number of bits to half of an image for high speed computation and less architectural complexity. The Discrete Wavelet Transform (DWT) is applied to an image with only MSB's, and consider only LL band coefficients as final features. The features of the database and test images are compared using Euclidian Distance (ED) an Artificial Neural Network (ANN) to test the performance of the pot method. It is observed that, the performance of the proposed method is better than the existing methods.

Keywords: Biometrics, Face Recognition, DWT, MSB, Compression.

1. INTRODUCTION

The face recognition machinery has been extensively used in every phase of social life such as forensic applications, human-computer interaction, bank transactions, land records verification, password serviced etc. The main challenging task in face recognition system is to identify human beings with variations in face images due to illumination changes, angle variations in face images, shape variations due to age and environmental changes etc. The performance of the face recognition system depends on feature extraction techniques and classification techniques. There are mainly three types of features such as spatial domain features, transform domain features and hybrid domain features. In spatial domain feature extraction approach, the pixel values are manipulated directly using techniques such as standard deviation, variance, Principal Component Analysis (PCA) [1], Local Binary Pattern (LBP) [2] etc. In transform domain feature extraction, the spatial domain is converted into the frequency domain and the corresponding frequency coefficients are manipulated to derive transform domain features. The examples of frequency domain techniques are Fast Fourier Transform (FFT) [3], Discrete Cosine Transform (DCT) [4], Discrete Wavelet Transform (DWT) [5] etc. The spatial domain and transform domain features are fused to obtain hybrid coefficients in hybrid domain techniques [6].

Contribution: In this paper, MSB based face recognition using compression and dual matching technique is proposed. Only four bits of each pixel are considered for feature extraction using DWT. The dual matching technique such as ED and ANN are used to compare performance parameters.

Organization: The rest of the sections are as follows, chapter 2 contains the literature survey, chapter 3 gives the description of our proposed model, chapter 4 provides the algorithm for the proposed model. In Chapter 5 we evaluate the performance parameters and also compared proposed method with the existing methods, chapter 6 enunciates the conclusion.

2. LITERATURE SURVEY

In this section, the literature appraisal of current techniques to distinguish the human beings based on physiological biometric trait face pictures are explained. The numerous methods of preprocessing, feature extraction and matching presented by many investigators are given.

Vikash, and Rajesh Parihar [7] presented evaluation between DFT and Wavelet based image alteration methods. It is based on approximation and elimination of distortion in the altered images. The comparison was done between DFT based JPEG and Wavelets based JPEG 2000 modification techniques on the Image Quality, Modification Ratio, MSE and PSNR etc. The, distortion cannot be avoided during visual data acquisition, processing and transmission and exhibit as the random variation of brightness or color in images and should be removed for image quality assessment, restoration and enhancement. Thamizharasi Ayyavoo and Jayasudha John Suseela [8] presented Discrete wavelet transform enhanced contrast limited adaptive histogram equalization (DWT E-CLAHE) in the illumination pre-processing to identify the front view face images. The face images are upgraded using the Gamma intensity correction (GIC) and split into low-frequency and high-frequency components using 2D DWT. The logarithmic transform, GIC and CLAHE are applied in the sequential order low-frequency components. The face recognition of DWT ECLAHE is made using Gabor magnitude features.

Zied Bannour Lahaw et al., [9] proposed face recognition using PCA, ICA, LDA based on DWT, and SVM algorithms. The DWT is used in preprocessing to compress input images and considered approximation band image for further processing. The PCA, ICA, and LDA are used to extract features. The classifier SVM is used to categorize the images for recognition. Govardhan Mattela and Sandeep K. Gupta [10] presented Gabor-mean-DWT for automatic facial expression recognition from video image sequences and its illumination invariant. Gabor filter is used to extract edges and texture pattern features of face images, but the limitations of huge dimension and high redundancy. This limitation is reduced by average-DWT feature reduction technique. Jyothi Ravikumar et al., [11] proposed the convolution based feature extraction technique of face recognition using Discrete Wavelet Transform (DWT) and Histogram of Oriented Gradient (HOG). The DWT is applied on face images to a obtained compressed number of transform domain LL band coefficients. The HOG is used on the LL band to further compress LL coefficients to obtain oriented gradients. The ultimate features are obtained by convolving LL and HOG coefficients. Sumathi and Christopher Derairaj [12] proposed the occlusion, pose and illumination variations face recognition. The Principal Component Analysis and DWT are applied to extract the features. The SVM is used for classification and on the way to compute performance parameters of the system. Rifha Ilyas Bendjillali et al., [13] proposed the facial expression and emotion recognition. The method applied Viola-Jones as face detection, Contrast Limited Adaptive Histogram Equalization to adjust the histogram and obtained the extracted features using DWT. The classification stage is applied Convolution Neural Network as the classifier. Taif Alobaidi and Wasfy B. Mikhael [14] proposed a face recognition system based on two domains. The DWT is applied on face images to obtain initial features and applied DCT to achieve the final features. The ED matching technique is used to calculate the minimum matching distance among training features and testing features.

3. PROPOSED METHOD

In this section, the novel approach of binary bit segmentation of pixels and considered Most Significant Bits (MSB) for further processing to extract features is proposed. The method includes pre-processing, feature extraction and classification. The proposed approach of face identification system is shown in Figure 1.

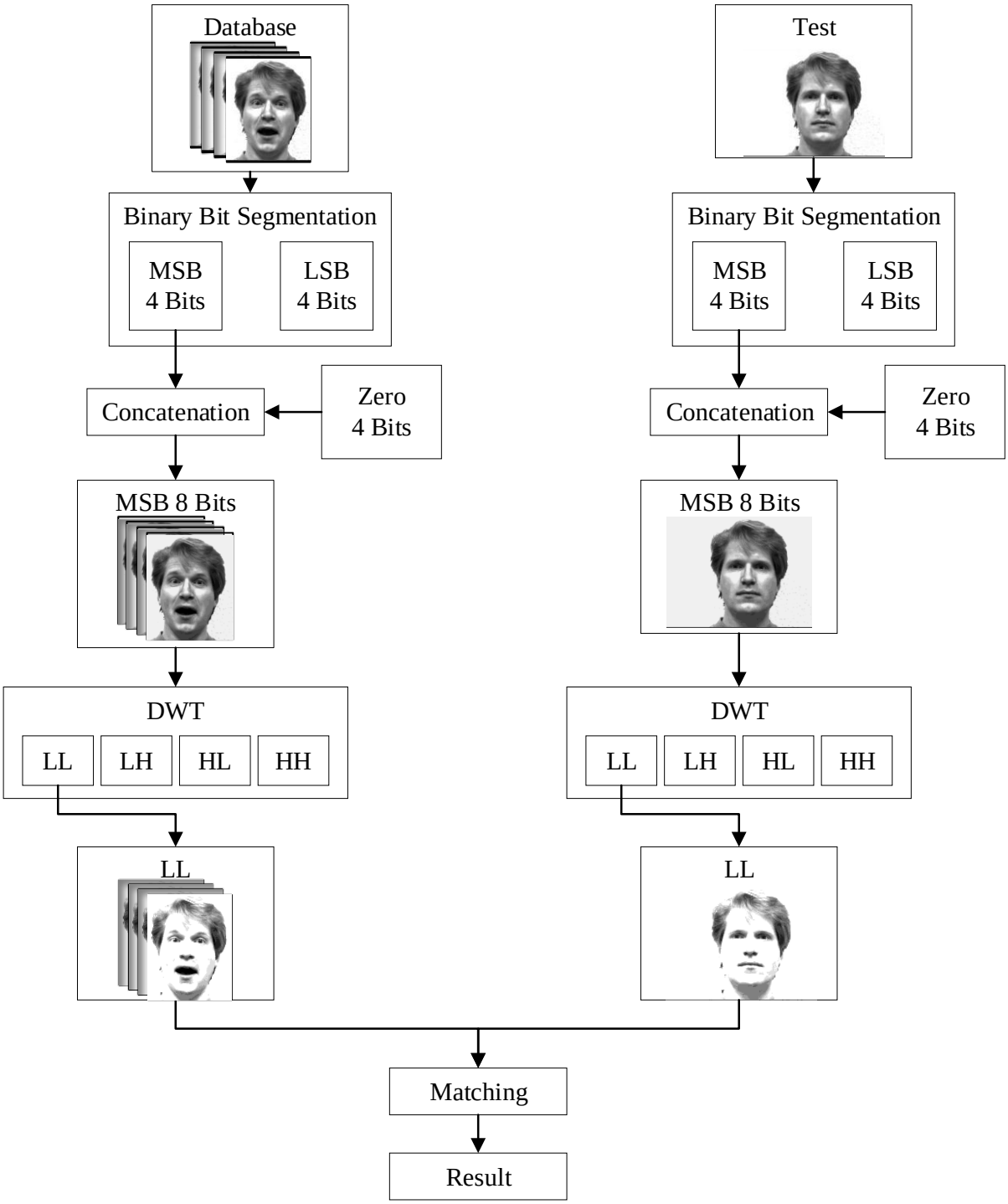

FIGURE 1: Proposed Approach of Face Recognition.

3.1 Face Database

The performance of the proposed face recognition model is evaluated using various typical face databases such as ORL, YALE, EYB, and JAFFE.

3.1.1ORL Database [15]: It is a typical face database contains face images of ten dissimilar images of each of 40 distinct persons ie., 400 images in total. The images are taken under changeable lighting, dissimilar facial expressions and various facial particulars. All the images of an individual are captured in an upright and frontal position. The size of each image is of 92x112 pixels. The ORL face image samples of one person is shown in Figure 2.

FIGURE 2: ORL Face Database Samples of One Person.

3.1.2 Japanese Female Face Expression (JAFFE)[16]: In the Japanese Female Face Expression (abbreviated as JAFFE), database there are twenty images of each of 10 individual subjects, 200 images in total. The size of each image is 256 x 256 pixels, the 2D nature of the matrix. All images were taken against an upright, Frontal position. The JAFFE face image samples of one person is shown in Figure 3.

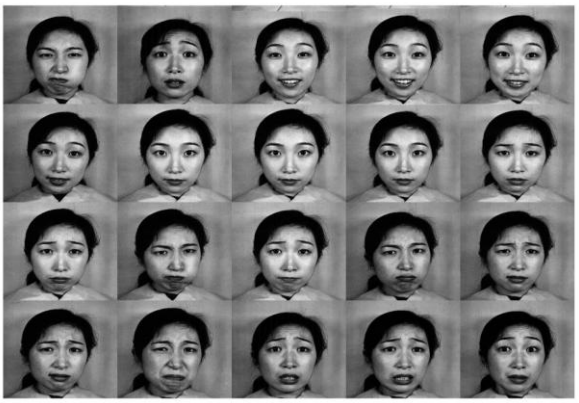

FIGURE 3: Sample Face of JAFFE Face Database.

3.1.3 Yale [17]: The face database consists of 165 face images of 15 subjects. Each individual is having different facial expression and captured with occlusion. Image resolution of this database is 320×243.

FIGURE 4: Sample Face of YALE Face Database.

3.1.4 EYB [18]: The Extended Yale B (EYB) face database contains 2141 face images of 38 subjects. The face images are captured under altered illumination circumstances. All the images are in cropped version and resize to the size of 192X168.

FIGURE 5: Sample Face Images of the EYB Face Database.

3.2 Binary Bit Segmentation of Pixels

The novel concept of effective MSB decimal values utilization of pixels to reduce 256 gray levels to 16 gray levels is introduced in the proposed model for effective face recognition. The images are collected from face databases and the decimal values of each pixel are converted into binary of eight bits. The binary bits of every pixel are segmented into two parts ie., four bits Least Significant Bits (LSB) and four bits Most Significant Bits (MSB). The four MSB bits of every pixel contain significant information of an image while the four LSB bits having insignificant information of an image. The MSB bits only considered for feature extraction by replacing four LSB bits with zeros to convert four MSB bits to eight bits. The decimal equivalent values of four-bit MSB varies between 0 and 240 with only sixteen gray scale values using (1). By considering four MSB bits, the technique rejects 240 gray levels and retain only 16 gray levels. The decimal values of four MSB bits are significant compared to original pixel values of an image.

$$MSB\ Decimal = \sum_{n=5}^{8} x(n)(2^{n-1}) \quad (1)$$

Where *n* is the bit position from the right side.

(a) Original Image **(b)** MSB Image **(c)** LSB Image

FIGURE 6: Binary Segmentation Images.

The binary segmentation of an image is shown in Figure 6, it is seen that the image corresponding to MSB is almost same as the original image, whereas the image corresponding to LSB not same as the original image. The lead of binary segmentation is to increase the speed of computation and also decrease complexity is an architecture for real time systems.

3.2.1 Discrete Wavelet Transforms (DWT)

The transformation is employed on the rows of the image using a low pass filter and high pass filters concurrently. The detailed part (high frequency) and approximation part (low frequency) are obtained through the filters and down sampled by a factor of 2. The operation is repeated with the columns of an image. The four sub-images obtained as an approximation (LL), vertical (LH), horizontal (HL) and diagonal (HH) bands for every level of decomposition. The wavelet coefficients are used in three ways as (i) All the four band coefficients are used directly as features. (ii) Only approximation band coefficients are used as features. (iii) The approximation band coefficients are combined with other types of features to obtain final features. The horizontal subbands are insensitive to the varying illuminations while approximation subbands are insensitive to the varying facial expressions [19]. Sellahewa and Jassim [20] had shown that the approximation subband is suitable for recognition under controlled illumination, but it is affected by the varying illuminations. The horizontal and vertical subbands are reasonably robust to the varying light. However, these were affected by geometrical changes like varying facial expressions and pose. The identification of facial images under poor and uncontrolled lighting is a challenge for horizontal and vertical subbands. The DWT is applied to MSB image and the corresponding four band images are shown in Figure 7. It is realized that, the LL band is almost same as the original image and consists of significant information. The images corresponding to LH, HL, and HH are not same as the original image and has insignificant information. The features for classification of face images are extracted from the LL band only, which reduces the number of features.

(a) MSB Image

(b) LL Image

(c) LH Image

(d) HL Image

(e) HH Image

FIGURE 7: DWT on MSB Image.

3.2.2 Matching

In this paper, Artificial Neural Network (ANN) and Euclidean Distance (ED) are used to classify the face images using the proposed algorithm.

1. **ANN:** It is computational models capable of machine learning as well as pattern recognition. It has 3 layers as input layer, hidden layer and output layer. The efficiency of the proposed model using ANN is shown by plotting the confusion matrix, which is the simplest metric used to determine the precision and accuracy of the model. There are four terms associated with confusion matrix to compare the cases between the actual class and the predicted class as True Positives (TP), True Negatives (TN), False Positive (FP) and False Negative (FN). In order to determine the performance of the proposed model, there are two significant parameters.

    i. Classification Accuracy: It is the proportion of the complete number of correct predictions against number of training images is given in (5).

(5)

$$Overall\ Accuracy = \frac{TP+TN}{TP+FP+TN+FN} = \frac{No.of\ Correct\ Match}{No.\ of\ Training\ Images}$$

ii. Test Accuracy: It is the proportion of the complete number of correct predictions against number of testing images is given in (6).

$$Test\ Accuracy = \frac{No.of\ Correct\ Match}{No.\ of\ Testing\ Images} \quad (6)$$

2. ED: There are four parameters used in ED Matching to test and analyze the performance of the proposed model are as follows

i. False Acceptance Rate (FAR): It is the ratio of number of Persons Outside Database (POD) falsely accepted as Persons Inside Database (PID) to the total number of POD as given in Equation (7).

$$FAR = \frac{No.\ of\ false\ acceptance\ from\ POD}{Total\ No.of\ POD} \quad (7)$$

ii. False Rejection Rate (FRR): It is the ratio of number of Persons Inside Database (PID) falsely rejected as Persons Outside Database (POD) to the total number of PID as given in Equation (8).

$$FRR = \frac{No.\ of\ \ PID\ rejected\ as\ outside}{Total\ No.of\ PID} \quad (8)$$

iii. Equal Error Rate (EER): It is the value where both FAR is equal to FRR. The values of FAR and FRR are equal at optimum threshold value.

iv. Total Success Rate (TSR): It is the ratio of the total number of PID are correctly matched to the total number of PID. The TSR can be computed using Equation (9).

$$TSR = \frac{No.\ of\ persons\ correctly\ matched\ in\ PID}{Total\ No.of\ PID} \quad (9)$$

v. Optimum Total Success Rate (OTSR): The value of TSR corresponding to EER.
Vi. Maximum Total Success Rate (MTSR): The maximum value of TSR.

4. PROPOSED ALGORITHM

Problem Statement: The robust algorithm for face recognition using only four MSB's of image pixels for feature extraction is developed in identifying a person.

The proposed algorithm is given in Table-1.
Objectives: Face recognition algorithm is developed with the following objectives

i. To reduce FRR, FAR and EER
ii. To increase TSR
iii. To increase speed of computation and reduce hardware complexity by compressing number of features.

Input: Standard Face Images	
Output: Performance parameters	
1	Various face image databases viz., ORL, YALE, EYB, JAFFE and L-SpaceK are used to test the algorithm
2	The eight bits of pixels are segmented into four MSB and four LSB groups
3	Only four MSB's are considered for feature extraction, which reduces biometric system complexity and also increases speed of computation
4	The DWT is applied on image matrix with only four MSB's for each pixel
5	The LL sub-band coefficients of DWT is considered as features
6	The final features are compressed version with only MSB's and DWT
7	The database image features and test image features are compared using ED and ANN to compute performance parameters
8.	The computer performance parameters of proposed method are better than the existing methods.

TABLE 1: Proposed Algorithm.

5. EXPERIMENTAL RESULT

In this section, the performance evaluation of the proposed method is tested using ORL, YALE, EYB, and JAFFE face databases.

5.1 Performance Analysis of Proposed Model using The ED Matching Technique

The performance parameters such as EER, OTSR and MTSR using ORL, Yale, EYB and JAFFE face databases are computed. The total Number of Persons (NOP), Images Per Person (IPP) and size of each face image for face databases are given in Table 2. The performance parameters for various combinations of Persons Inside Database (PID) and Persons Outside Database (POD) for face databases are tabulated. The final number of features used to recognize face images are $1/4^{th}$ of initial dimensions of original face images. It is observed that, the percentage MTSR for all four face databases are maximum for almost all combinations of PID and POD's. The percentage OTSR is maximum in the case of EYB face database, whereas lowest in the case of JAFFE face database. The percentage EER is higher in the case of JAFFE and lower in the case of EYB face database. The percentage OTSR decreases with increase in PID. The percentage EER increases with increase in PID and decrease with POD.

Databases	NOP	IPP	Image size	No. of Feature	IPP (Train)	PID	POD	Optimum Threshold	EER	OTSR	MTSR
ORL	40	10	112X92 (10304)	2576	8	10	30	0.32	10	90	100
						10	20	0.32	10	90	100
						10	10	0.364	10	90	100
						20	10	0.319	15	85	100
						30	10	0.292	16.67	83.33	100
Yale	15	10	243X320 (77760)	19520	9						
						7	8	0.1259	12.5	85.71	100
						8	7	0.1259	14.29	75	87.5
						10	5	0.1258	20	80	90
EYB	31	64	192X168 (32256)	8064	62						
						15	11	0.788	6.67	93.33	100
						15	15	0.747	13.33	86.67	100
						20	11	0.7423	15	85	100
JAFFE	10	20	256X256 (65536)	16384	19						
						3	7	0.92	33.33	66.67	100
						5	3	0.79	20	80	100
						5	5	0.80	20	80	100
						7	3	0.95	14.29	85.71	100

TABLE 2: Recognition Rate of proposed model using ED with various face databases.

The variations of FRR, FAR and TSR with threshold values for ORL, YALE, EYB and JAFFE face databases are plotted in Figures 8, 9, 10 and 11. It is observed that as threshold value increases, the values of FRR values decrease from maximum to minimum. The values of the FAR and TSR increases with increase in threshold values. The value of the EER is 10% on the optimal threshold value of a 0.364 for an ORL database with a PID and POD combination of 10 and 10. The value of the EER is 12.5% on the optimal threshold value of 0.1259 for a YALE database with a PID and POD combination of 7 and 8. The percentage values of EER and OTSR of 6.67 and 93.33 at optimum threshold value of 0.788 for EYB database with PID and POD combinations of 15 and 11. At the optimum threshold of 0.95, the corresponding percentage EER and OTSR values are 14.29 and 85.71 with PID and POD combination of 7 and 3 for JAFFE face database. The optimum threshold values are lower in the case of YALE face database, whereas higher values in the case of JAFFE face database.

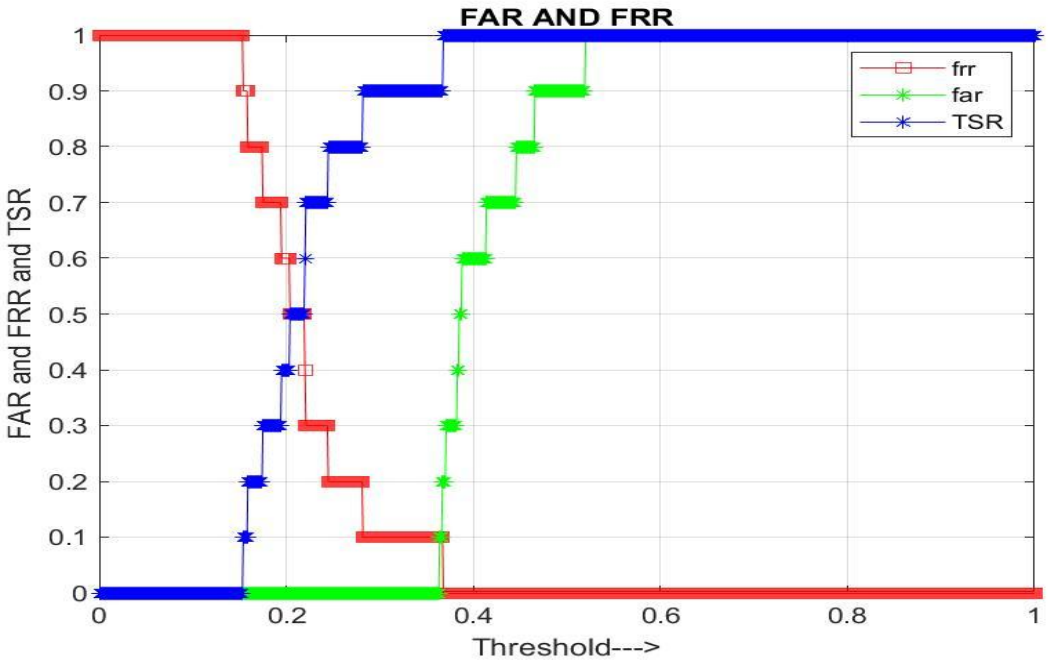

FIGURE 8: Variations of performance parameters for PID &POD of 10&10 using ORL Database.

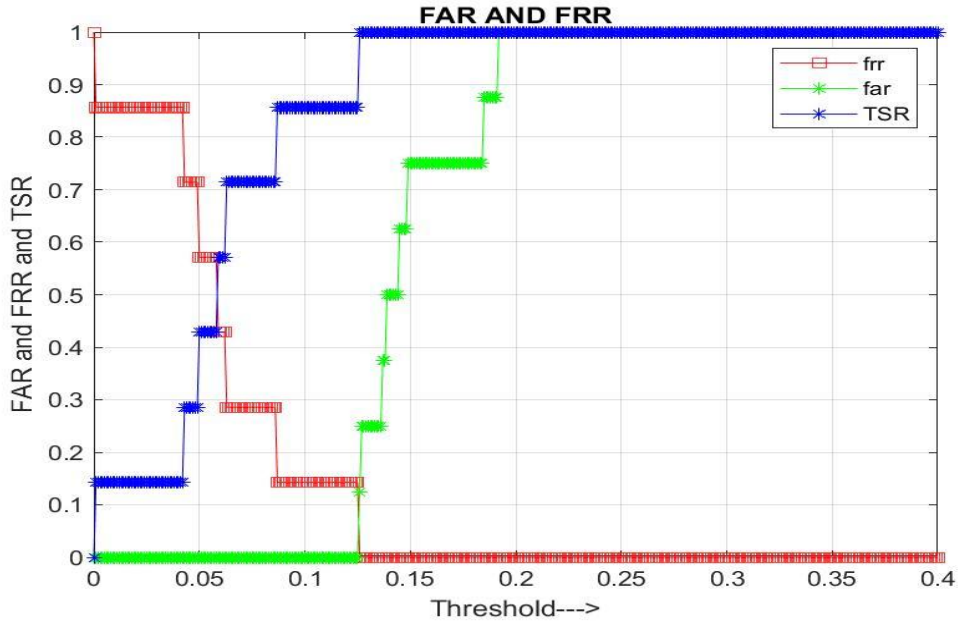

FIGURE 9: Variations of performance parameters for PID &POD of 7&8 using YALE Database.

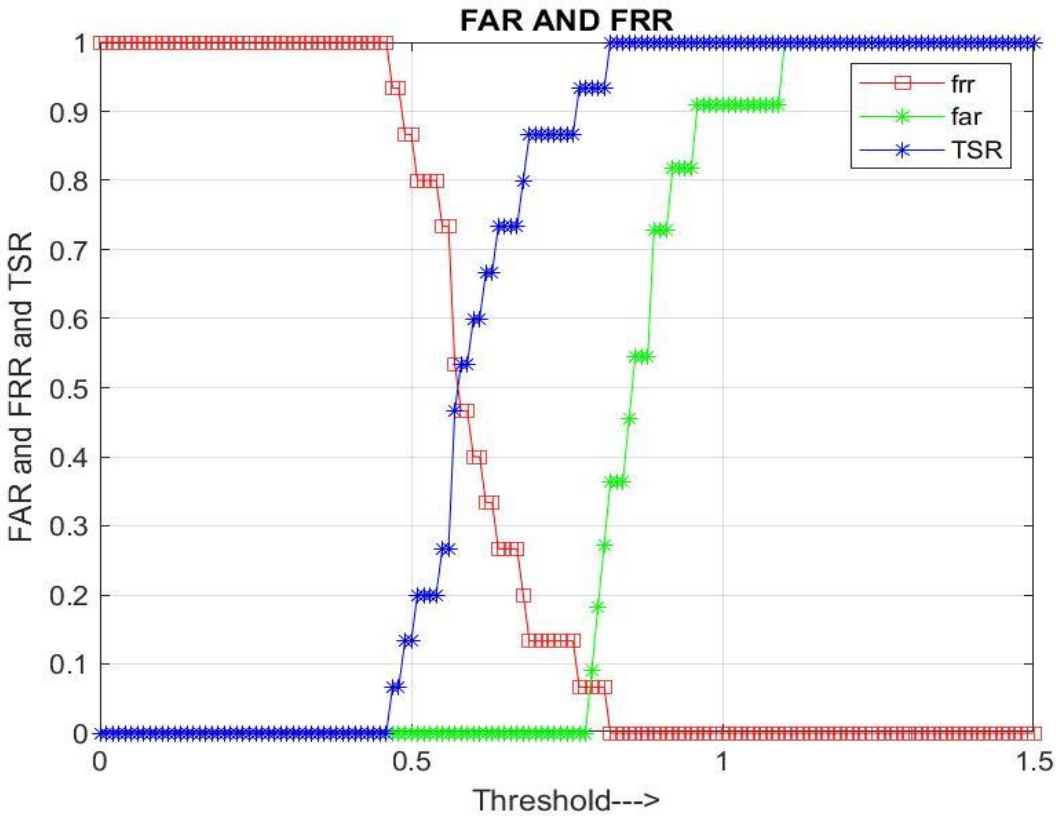

FIGURE 10: Variations of performance parameters for PID &POD of 15&11 using EYB Database.

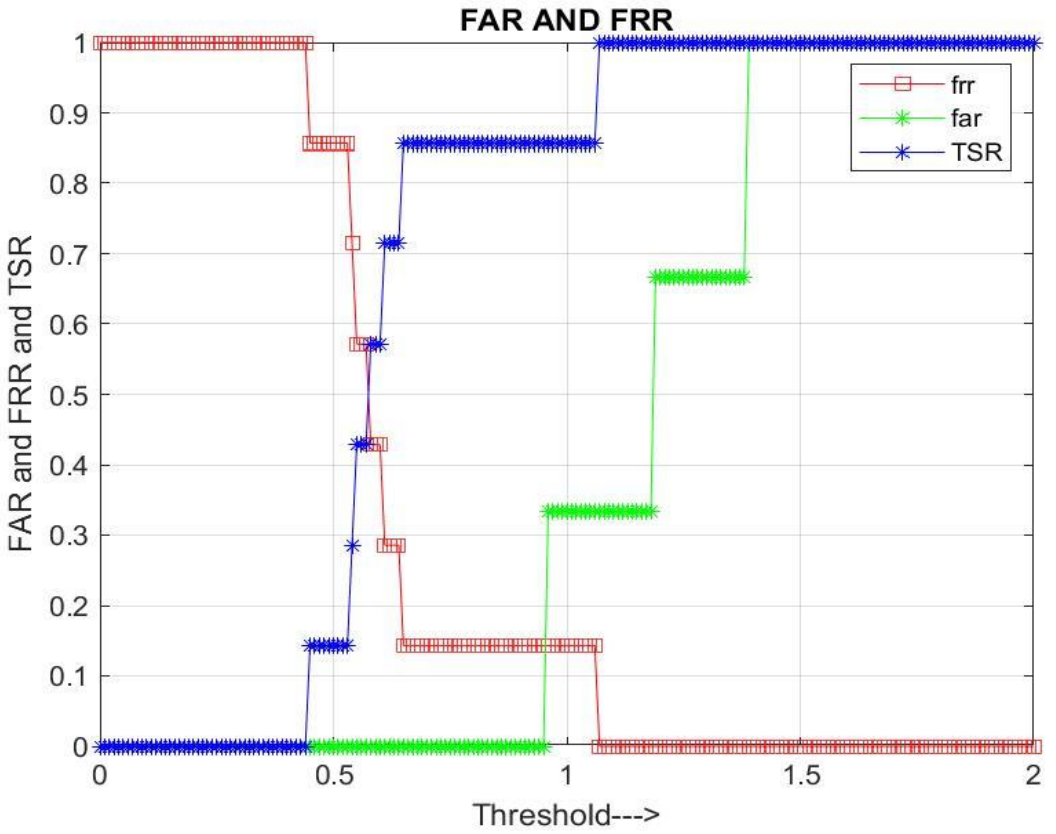

FIGURE 11: Variations of performance parameters for PID &POD of 7&3 using JAFFE Database.

5.2 Performance Analysis of Proposed Model using ANN Classifier

The overall accuracy of the proposed method is computed using ORL, Yale, EYB, JAFFE and L-spaceK face databases. The total Number of Persons (NOP), Images Per Person (IPP) and size of each face image for face databases are tabulated in Table 3. The overall accuracy is calculated by varying images per person (IPP) in training by keeping the number of hidden layers constant for each face database. The number of final features are to almost $1/4^{th}$ of original image dimensions. It is observed that, the overall accuracy increases with an increase in the number of images per person in training. The performance of the proposed method is better using EYB face database.

Database	NOP	IPP	Image size	No. of Feature	Hidden Layers	IPP (Train)	Overall Accuracy
ORL	40	10	112X92 (10304)	2576	22	2	52.5000
						4	71.2500
						5	80.2500
						6	88.2500
						8	98.2500
Yale	15	10	243X320 (77760)	19520	19	2	72.6667
						4	91.3333
						5	96.0000
						6	99.3333
						8	99.3333
EYB	31	64	192X168 (32256)	8064	25	10	94.5060
						20	100.0000
						32	100.0000
						40	100.0000
						50	100.0000
Jaffe	10	20	256X256 (65536)	16384	23	4	77.5000
						8	95.5000
						10	98.5000
						12	99.5000
						16	99.0000
L-spaceK	152	20	200X180 (36000)	9000	25	4	51.6447
						8	79.1118
						10	88.4539
						12	94.5395
						16	99.3092

TABLE 3: Overall Accuracy of proposed model using ANN for various face databases.

5.3 Performance Comparison of The Proposed Method using ED and ANN Matching Techniques

The percentage recognition rate of the proposed method using ORL, Yale, EYB and JAFFE face databases with ED and ANN matching techniques is given in Table 4. It is observed that, the ANN matching technique is better compared to ED technique. The recognition rate is almost 100% in the case of ANN matching technique for all face databases.

Database	Percentage Recognition Rate	
	ED	ANN
ORL	90	98.2500
Yale	85.71	99.3333
EYB	93.33	100.0000
Jaffe	85.71	99.50

TABLE 4: Percentage Recognition Rate comparison of proposed method using ED and ANN.

5.3 Performance Comparison of Proposed Method with Existing Methods

The accuracy of the proposed method is compared with existing methods for face databases such as ORL, YALE, JAFFE and EYB use ANN matching technique in Table 5. The percentage accuracy is 98.05 which is high compared to 91.5 and 95.25 of existing methods presented by W. Yu et al., [21]

and Sharif et al., [22] using ORL database. The proposed method with ANN is compared with existing methods presented by Bhaskar Anand and Prashant K Shah [23] and Riddhi A. and S.M. Shah [24] using YALE face database and observed that our method has better accuracy. The existing methods presented by Biao Yang et al. [25] and Yuanyuan Ding et al. [26] are compared with our method using JAFFE face database and observed that our method gives better accuracy of 99.50. The EYB face database is used to compare the accuracy of the proposed method with existing methods presented by Yuqi Pan and Mingyan Jiang [27] and Shih-Ming Huang and Jar-Ferr Yang [28] to show that our method is superior and has accuracy 100%. In a summary, the proposed method is better compared to existing methods for ORL, YALE, JAFFE and EYB face databases.

Database	*Author*	*Accuracy (%)*
ORL	W. Yu et al. [21]	91.50
	Sharif Muhammad et al. [22]	95.25
	Proposed with ANN	98.25
YALE	Bhaskar Anand and Prashant K Shah [23]	97.78
	Riddhi and Shah [24]	98.18
	Proposed with ANN	99.33
JAFFE	Biao Yang et al. [25]	92.21
	Yuanyuan Ding et al. [26]	94.84
	Proposed with ANN	99.50
EYB	Yuqi Pan and Mingyan Jiang [27]	91.60
	Shih-Ming Huang and Jar-Ferr Yang [28]	96.37
	Proposed with ANN	100

TABLE 5: Percentage Accuracy Comparison of Proposed Method with Existing Methods.

The contributions of the proposed method are as follows

(i) The right bits of each image pixel are segmented into two group viz., MSB and LSB
(ii) Only four MSB bits of each pixel are considered for feature extraction which leads to a reduction in the total number of bits of an image to 50%, that increases speed of computation and reduction in hardware complexity
(iii) The final features are extracted from an image with only four MSB bits for each pixel using DWT
(iv) The LL band coefficients of DWT are considered as final features.
(v) The ED and ANN matching techniques are used to test the performance of the proposed method
(vi) The proposed method is efficient for real time implementation as total number bits in an image compressed to 50% and dimensions of an image is also reduced by considering only LL band of DWT.

6. CONCLUSION

Face is a powerful biometric trait to recognize persons for security issues. In this paper, MSB based face recognition using compression and dual matching technique is proposed. The eight bits of each pixel of original face images are segmented into two part viz., MSB and Least Significant Bits (LSB). The MSB's are having significant information of an image even without LSB's. Hence MSB's are considered further to extract final features using LL-DWT band coefficients. The matching techniques such as ED and ANN are used to compare the database and test image features to test the performance of the proposed method. It is observed that, the performance of the proposed method is better than existing methods. In future, the proposed method can be implemented using the real time systems as the complexity of the hardware architecture is less.

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