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Performance Analysis of Iris Recognition Using Multi Stage Wavelet Transform Decomposition and Bicubic Interpolation Technique

Sunil Swamilingappa Harakannanavar, Prashanth C R, Raja K B

Abstract: Biometric identification is highly reliable for human identification. Biometric is a field of science used for analyzing the physiological or behavioural characteristics of human. Iris features are unique, stable and can be visible from longer distances. It uses mathematical pattern-recognition techniques on video images of one or both iris of an individual's. Compared to other biometric traits, iris is more challenging and highly secured tool to identify the individual. In this paper iris recognition based on the combination of Discrete Wavelet Transform (DWT), Inverse Discrete Wavelet Transform (IDWT), Independent Component Analysis (ICA) and Binariezed Statistical Image Features (BSIF) are adopted to generate the hybrid iris features. The first level and second level DWT are employed in order to extract the more unique features of the iris images. The concept of bicubic interpolation is applied on high frequency coefficients generated by first level decomposition of DWT to produce new set of sub-bands. The approximation band generated by second level decomposition of DWT and new set of sub-bands produced by second level decomposition of DWT are applied on IDWT to reconstruct the coefficients. The ICA 5x5 filters and BSIF are adopted for selecting the appropriate images to extract the final features. Finally based on the matching score between the database image and test image the genuine and imposters are identified. Using CASIA database, training and testing of the features is performed and performance is evaluated considering different combinations of Person inside Database (PID) and Person outside Database (POD).

***Index Terms*: Biometrics, Discrete Wavelet Transform, Independent Component Analysis, Binarized Statistical Image Features, Inverse Discrete Wavelet Transform.**

I. INTRODUCTION

In the modern days biometric identification is more promising and reliable to verify the human identity. Biometric is a field of science used for analyzing the physiological or behavioural characteristics of human. The physiological characteristics includes face, iris, fingerprints, palm prints, etc., and the characteristics of behavioral includes signature, gait, walking style, keystroke, voice etc. Compared to other biometric traits, iris is more challenging and highly secured to identify the human. The human eye is externally visible and highly protected internal organ. In eye image, the physiological trait iris is a colored muscular ring of the eye containing two zones, namely, pupillary zone (inner) and ciliary zone (outer zone). Iris lies in between cornea and lens of the human eye as shown in Figure 1. Iris recognition finds numerous applications such as security screening in airports, hospitals and schools, shopping malls etc.

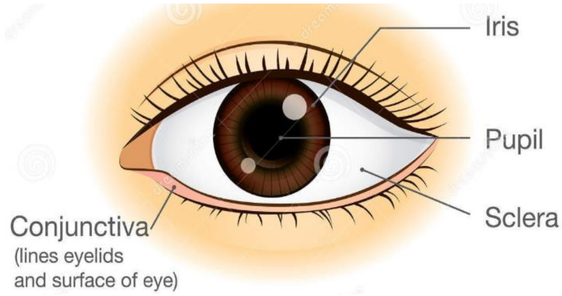

Figure 1: Human Eye

In this paper iris recognition is based on the fusion of DWT, IDWT, ICA and BSIF are adopted and applied on iris template to generate the hybrid iris features. The concept of bicubic interpolation is applied on high frequency coefficients generated by first level decomposition of DWT to produce new set of sub-bands. The approximation band generated by second level decomposition of DWT and new set of sub-bands produced by second level decomposition of DWT are applied on IDWT to reconstruct the coefficients. The ICA 5x5 filters and BSIF are employed for selecting the appropriate images to extract the final features. Euclidean Distance classifier is used to match the features of test image with the database image. The remainder of the paper is organized in such a way that Section II presents the related work of existing systems on iris biometric trait. Section III and IV discuss the methodology and algorithm of proposed model. Section V analyses the performance rate of proposed iris model and Section VI concludes the model on iris biometric trait.

II. RELATED WORK

Jagadeesh et al., [1] adopted Discrete Wavelet Transform (DWT) on vertical and horizontal projection to extract the iris features.

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The iris was segmented and normalized using Circular Hough Transform (CHT) and Elastic sheet model respectively. The obtained iris features from DWT are matched using Hamming Distance.

The experiments are conducted on UPOL database. However the features extracted from normalized images results a low recognition rate and the performance of the iris model needs to be improved by using different pre trained model for various iris datasets. Charan [2] applied Adaptive Histogram Equalization and Pixel Depth Improvement to enhance the quality of images and sharpness of images respectively. The segmentation and normalization procedure of images are carried out using CHT and Rubber sheet model respectively. The normalized iris images are applied on DCT to extract the effective features of iris. The selections of iris features are carried out by BPSO and Rank Match methods to improve the performance rate of the model. Experiments are conducted on CASIA database. Since the model results low recognition rate using DCT, the iris model performance needs to be improved by fusing transform and spatial domains to extract the significant iris features. Choudhary et al., [3] adopted Statistical texture measures that include mean, standard deviation etc., and extracts six significant features form the normalized iris images. The significant features of input iris and trained iris are matched using K-NN classifier. Experiments are conducted on CASIA v2 database. However the features extracted from normalized images results a low recognition rate and the performance of the model needs to be improved by considering different pre trained model for various iris datasets. Anithakumari et al., [4] applied the normalized iris region of interest on three-level Haar wavelet decomposition technique to extract the significant features of iris (such as Horizontal, Vertical and diagonal details of iris texture). Two bit quantizer method is used to quantize the extracted features and the resultant is stored in the database. The Standard Fallacy Clearup Table (FCT) and Reconstruction FCT algorithms are adopted to find out the errors in the iris templates. The Hamming Distance (HD) is used as a matching technique to decide the genuine and imposter images. Experiments are conducted on URIRIS database. However the iris model undesirably increases its recall rate which affects on the performance rate. So a various hybrid data fusion classifiers should be implemented to increase the rate. Akshay et al., [5] applied Redundant Discrete Wavelet Transform (RDWT) on enhanced iris images to extract the texture properties of images. The statistical features, entropy features, Haralick features are extracted from BISM, HIWE and SIMOWT respectively. The obtained features are then concatenated using SVM. The experiments are conducted on IITD, CASIA and UBIRIS iris database. Ivanko et al., [6] applied HE and contrast enhancement techniques to improve the quality of images. The DCT and DFT are applied on the region of interest to extract the informative features of the iris. The obtained significant features are then matched using K-nearest neighbor classifier on UBIRIS database. However the model results low recognition rate using DCT and DFT, the iris model performance needs to be improved by fusing transform and spatial domains to extract the significant iris features. Christian Rathgeb et al., [7] performed row wise convolution in association with Log-Gabor (LG) wavelet to extract the informative features of iris images. The iris code having 512×10 bits is obtained by encoding the real part of phase information. The significant iris codes generated from the LG are matched with the test iris code using fractional Hamming Distance. Experiments are conducted on Bio-Secure CASIA v4 interval iris database. Rabiul et al., [8] extracted 9600 significant features of iris images by applying two dimensional Gabor filter on iris region. The PCA was used to reduce the dimension of the images and finally only 550 features are considered into their account. The obtained features are then classified using multiple discrete Hidden Markov Model (HMM) and Hamming Distance. Experiments are conducted on CASIA-IrisV4 database to test the performance of the iris model. Hence the model results low recognition rates and needs to be improved by considering various noise levels at natural lighting conditions. Gayathri et al., [9] adopted Local Binary Pattern and Gabor wavelets to extract the supportive features of multimodal biometric traits such as iris and palmprint. The obtained features are then fused to generate significant final features. Finally the coefficients are then classified using K-NN. The experiments are conducted on PolyU and UPOL iris database. Vineet et al., [10] combined a thresholding and segmentation techniques to improve the accuracy of unconstrained NIR iris images. Now the CHT was applied on iris images to obtain pupil circle parameters and edge-map creation technique is introduced to reduce the false acceptance of edge details which affects the performance of the iris model. Experiments are conducted on CASIA v4, CASIA v3 and MMU iris database. Faundra et al., [11] applied canny edge detection and CHT to detect pupil edge, center and the radius of pupil respectively. Isolate the important part of iris, based on zigzag collarette area and normalization of iris images are performed using Daugman’s Rubber Sheet model to get fixed dimensions. The performances of iris model are computed with a specific thresholding level technique which helps to remove eyelid and eyelash. Since the model is well suited only for the process of detection and normalization, it needs to be demonstrated for the different combinations of spatial and transform domain descriptors on various iris datasets. Khotimah et al., [12] employed Hough transform and Daugman's rubber sheet model to locate the iris area and to normalize the iris data set into blocks respectively. To extract dimensional values of the iris, box counting technique is applied on normalized data. The k-fold cross method is used to match the extracted features and test features. The test iris data was classified using K-Nearest Neighbor (K-NN) classifier on CASIA V-4 iris dataset. However the features extracted from normalized images results a low recognition rate and the performance of the model needs to be improved by considering different pre trained model for various iris datasets. Bineet et al., [13] introduced discrete orthogonal moment based features which extracts both global and local features from localized iris regions with k-Nearest Neighbor classifier. The obtained iris features are matched with test features using Manhattan distance. Radwan et al., [14] described DWT to extract the effective features of iris and WNN is used as a classifier to match the database images and test image images. In addition to this, WNN is used to solve the issue of orientation and intrinsic features of iris images. Finally, the global optimization techniques viz., Genetic and Meta-Heuristic algorithms are applied to generate the optimal parameter values.

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However the iris model undesirably increases its recall rate which affects on the performance rate. Rocchietti et al., [15] explained CRUZ algorithm for segmenting the inner pupil edge and generates the anatomical standards for the outer edge of iris. The accuracy loss in the segmentation can be improved by applying differential matrix while normalization procedure. The performance of the model is evaluated on CASIA database. Piyush et al., [16] explained CHT approach to estimate the details of iris edge map and Rubber sheet model is applied on segmented iris to convert circular iris into rectangular structure with fixed dimension. The significant features were extracted from the normalized iris using Zigzag, Raster, and Saw-tooth scanning techniques. Finally, the extracted features and test features are matched using mean square error on CASIA v-4 iris database. However the model is limited only to near infrared iris images. So in future, the approach can be adopted for visible spectrum images to recognize iris. Wenqiang et al., [17] employed CNN to train iris data. The NN uses only two connection layer, which decreases the number of parameters in the network and improves the training speed. The over-fitting issue of the model which leads to unable of identifying the iris images are reduced by adopting regularization and dropout method in the training procedure. However, the model has some shortcomings which unable to identify the images corresponding to the classification system and leads difficult to categorize recognition rates.

Ying et al., [18] described SIFT to extract the significant features of iris. In order to select the discriminative features, the strategies based on OPDF and MPDF is employed to reduce the redundant feature key points and to reduce the dimensionality of feature element respectively. In addition to this strategy, fusion of OPDF and MPDF is used to select optimal sub feature. Rabab [19] explained SWT to decompose the iris into sub images and the features of SWT are represented for the three dimensional iris compression systems. The coefficients of Spherical coefficients yield superior adaptation for minimal set of features in its compression capabilities. The coefficients extracted from Haar wavelets generate excellent recognition rates on CASIA iris database. Shylaja et al., [20] explained HT to localize the position of eye images and extract the geometrical features which includes circular and elliptical features of iris images from a given face. The obtained features from HT are then matched using feed forward neural network classifier and the performance of the localization model is analyzed on Yale, Biod and local database. Ibrahim et al., [21] explained dual iris column means approach to extract the significant features of iris. The segmentation of iris images is performed on unwrapped iris and adopts only vertical segments for recognition of dual iris. Finally, to match the database and test image Euclidean Distance is used. The coefficients extracted from Haar wavelets generate better recognition rates on UPOL iris database. Wang et al., [22] developed an optimization model to localize an iris and then SIFT feature is used to represent the boundary of iris along with eyelid for localization. The final points of boundary and eyelids of iris are solved using Supervised Descent Method algorithm and the characteristics of outer boundary and eyelids of iris are generated using IRLS Technique.

III. PROPOSED MODEL

In this section, iris recognition is performed based on the combination of DWT, IDWT, ICA and BSIF are adopted and applied on iris template image to generate the unique iris features. The concept of bicubic interpolation is applied on high frequency coefficients generated by first level decomposition of DWT to produce new set of sub-bands. The approximation band generated by second level decomposition of DWT and new set of sub-bands produced by second level decomposition of DWT are applied on IDWT to reconstruct the coefficients. The ICA 5x5 filters and BSIF are adopted for selecting the appropriate images to extract the final features. The proposed model is shown in Figure 1. The experiments are conducted on CASIA iris database for the various combinations of PID and POD.

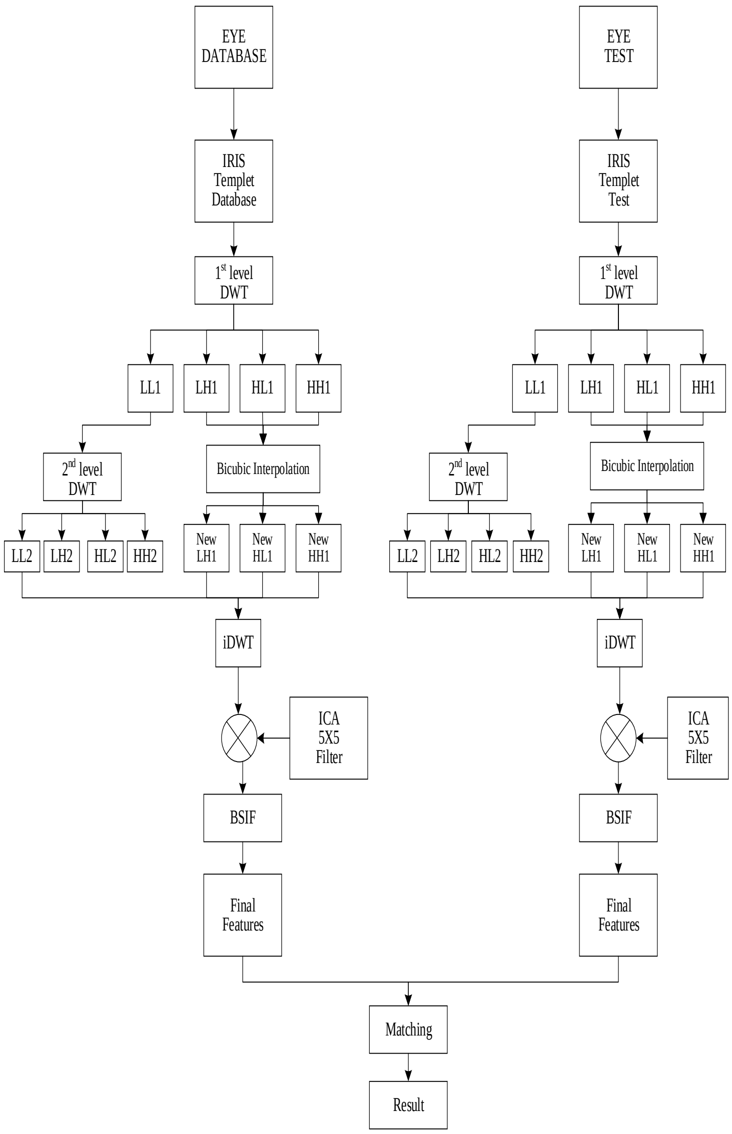


Figure 2: Proposed Iris Recognition Model

A. CASIA Iris Database

The Chinese Academy of sciences Institute of Automation (CASIA) Iris database [16] is used to test the performance of proposed iris model.

The database has seven hundred and fifty six people's iris images from one hundred and eight unique eyes. The eye images are captured in two sessions for each individual with the size of 320×280 in BMP format. The samples of iris images of one person are shown in Figure 3.

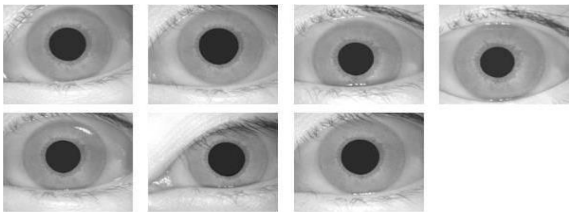
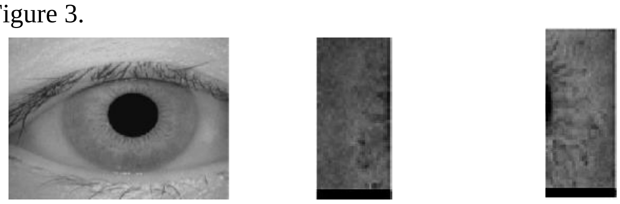


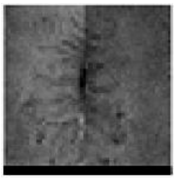
Figure 3: Samples of Iris images of a person

B. Iris Extraction

Iris is circular part of an eye located between pupil and sclera. The circular pupil is darkest portion that is located and can be approximated with suitable intensity threshold values. Some portion of the pupil is omitted to avoid eye lashes. The iris part of left and right side of the pupil is considered having 40 pixel values on each side. Finally the left and right region is concatenated to form an iris image template as shown in Figure 3.



(a) Eye image (i) left region (ii) right region



(b) Iris template

Figure 3: Extracted iris template from the CASIA database image

C. Discrete Wavelet Transform

The DWT is used to convert the time domain signal into transform domain for time and frequency analysis. In one dimensional DWT, input signal $x[n]$ is passed simultaneously through low pass filter of impulse response $h[n]$ and passed through high pass filter of impulse response $g[n]$ to obtain approximate and detailed bands as shown in Figure 4.

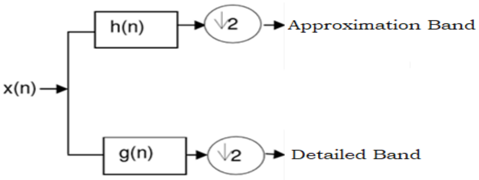


Figure 4: One Dimensional DWT

The proposed model involves two stages of DWT decomposition. In the first level decomposition of two dimensional DWT, the input iris images are converted into DWT coefficients corresponding to low and high frequency components generating approximation band as LL1 and detailed band as LH1, HL1 and HH1. The second level DWT decomposition is performed on the approximation band LL1 to produce new low frequency sub-band (LL2) and high frequency sub-bands (LH2, HL2 and HH2) whereas bicubic interpolation is applied on detailed bands (LH1, HL1 and HH1) to produce new high frequency sub-bands (new LH1, new HL1 and new HH1). The inverse discrete wavelet transform is applied on second level DWT LL2 and features produced from bicubic interpolation of LL1, HL1 and HH1 to produce improved features. The basic decomposition of two dimensional DWT is shown in Figure 5 and two level decomposition of DWT is shown in Figure 6.

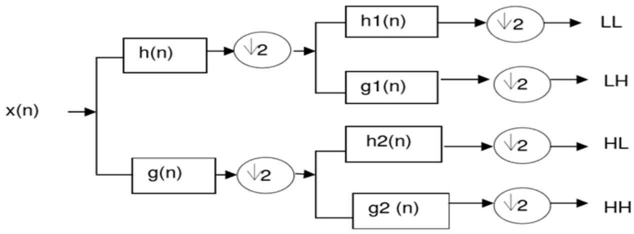


Figure 5: Two Dimensional DWT

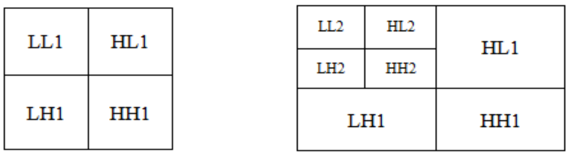
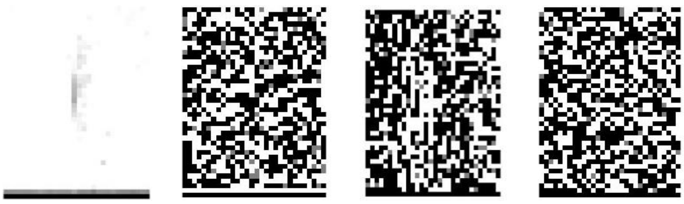


Figure 6: (a) First level DWT Decomposition (b) Second level DWT Decomposition

The two dimensional DWT is applied on the iris template to generate approximation LL1 band that has significant information of iris template and other detailed information such as detailed LH1 band having horizontal edge information, the detailed band HL1 has vertical edge information and HH1 band has information of diagonal edges of iris template. Figure 7 and 8 shows the results of approximate and detailed bands on 1-level and 2-level DWT decomposition on iris template.



(a) LL1 Band (b) LH1 Band (c) HL1 Band (d) HH1 Band

Figure 7: Decomposition of 1st level DWT with size of 40X30

(a) LL2 Band (b) LH2 Band (c) HL2 Band (d) HH2 Band

Figure 8: Decomposition of 2nd level DWT with size of 20X15

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D. Bicubic Interpolation

The concept of bicubic interpolation which is an extension of cubic interpolation is applied on detailed regions (LH1, HL1 and HH1) obtained from first-level decomposition of DWT to enhance their qualities. It is observed that after applied bicubic interpolation new combinations of improved quality images (new LH1, new HL1 and new HH1) are produced. The images resampled with bicubic interpolation having 16 pixels (4x4) are smoother than other surfaces obtained by bilinear or nearest neighbor interpolation. Bicubic interpolation can be accomplished using cubic splines or cubic convolution algorithm. The new sub-bands after bicubic interpolation is shown in Figure 9.

(a)new LH2 band (b) new HL2 band (c) new HH2 band

Figure 9: Sub-bands using Bicubic interpolation

E. Inverse Discrete Wavelet Transform

It is required to reconstruct a signal from sub-bands using IDWT with smaller bandwidths. The dimension of IDWT computation produces the output having same dimensions as input. The reconstruction of image process contains each block having a series of high pass and low pass filters and the signal is recovered from the input sub-bands. The image which is reconstructed will have better characteristics in terms of bandwidth and sample rate than the input sub-bands. The reconstructed output obtained by applying IDWT is shown in Figure 10.

Figure 10: Inverse DWT

F. Independent Component Analysis

Independent Component Analysis is a mathematical tool used for separation of multivariate signal into additive sub component. The sub components assumed are having properties of non-Gaussian and independent of each other. The ICA model having 'N' dimensional random vector R_N are assumed to be a linear mixture of mutually statistically independent sources S_L and is given in equation 1.

$$R_N = MS_L \tag{1}$$

Where, M represents the mixing matrix which is unknown factor and need to find the values of 'M' and S_L. The approximate separating matrix 'W' that verifies is given in equation 2.

$$E_L = WR_N \tag{2}$$

Substitution of equation 1 and 2 provides an 'E_L' for estimation of the 'N' sources R_N

$$E_L = WMS_L \tag{3}$$

Considering equation 3, if 'M' is the inverse matrix of 'W', the independent sources S_L can be recovered accurately. Using iterative method it helps to estimate 'W' so as to make 'S_L' is statistical independent as possible. Hence the ICA filter 'W' is similar to simple cell that responds primarily to oriented edges and gratings.

G. ICA Filter Extraction

The ICA filter is used to select the appropriate images to extract the features. A non-linear filter is applied on each image to increase the high frequency component. Select 'N' patches having size $l_p x l_p$ from the images at random locations as the column of matrix' R_N' in equation 1 and 2. Filters obtained from 5X5 windows with length 8 are used to filter the iris template to obtain binary images.

H. Binariezed Statistical Image Features (BSIF)

Binarization of an image is the method of filtering the image using ICA filter and applying proper threshold condition from equation 5. There are different lengths of binarization is possible with respect to ICA filter length. In the proposed iris model 8-bits BSIF images are considered. Here, the ICA has contained eight 5X5 windows with filter coefficients. The digital filter is used to correlate Iris template and ICA. The output of the digital filter converts to bit streams using threshold condition from the equation 5. Hence in an image, each pixel is converted to 8-bit streams. The two dimensional filter output is given in equation 4.

$$C_i = \sum_{m,n} I(m,n)\ F_i(m,n) \tag{4}$$

Where $I(m,n)$ represent the Iris image, whereas 'm' and 'n'are the size of the iris image. The values of F_i $\forall_i = (1, 2 \ldots \ldots n)$ represents the number of independent filters whose response is computed and binarized to generate binary string and is given in equation 10.

$$b_i = \begin{cases} 1, & if\ C_i > 0 \\ 0, & otherwise \end{cases} \tag{5}$$

Where 'b_i' represent the binary image. At each digital filter response the pixel values are converted to bit value using equation 5. The concatenation of each output bit value to single 8-bit frame is performed to obtain the binariezed BSIF output of iris template as shown in Figure 8.

1 bit 2 bit 3 bit 4 bit 5 bit

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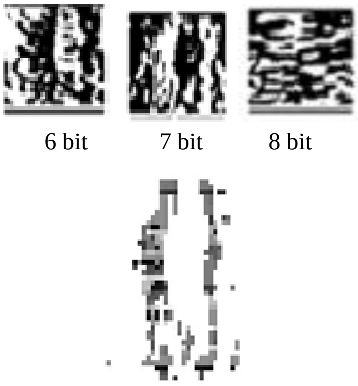

Figure 8: Binariezed output of BSIF

I. Euclidean Distance

Euclidian distance is used to match the final features of test images and the final features of images in the data base to identify a person using equation 6. The performance parameters are computed to validate the proposed iris model.

$$\text{Euclidean Distance} = \sum_{i=1}^{M} (P_i - q_i)^2 \tag{6}$$

IV. PROPOSED MODEL

The new concept of iris recognition using Multi-level decomposition of DWT, ICA, IDWT and BSIF techniques is introduced to obtain the features of iris images for better performance. The proposed algorithm to recognize iris is tabulated in Table 1. The main objectives of the proposed iris model are to increase the success rate and decrease the error rates such as FAR, FRR and EER.

Table 1: Proposed Iris algorithm

Input : Iris Database, Test Iris images
Output: Computing performance parameters such as FAR, FRR and TSR.

1. Read an eye image from CASIA database.
2. The iris template is created by using morphological operations.
3. First level DWT is applied on iris template to decompose into four levels such as LL1, LH1, HL1 and HH1.
4. Second level DWT is applied on LL1 component to decompose into LL2, LH2, HL2 and HH2 sub-bands.
5. Apply Bicubic interpolation on detailed bands generated by 1st level DWT to produce new LH1, new HL1 and new HH1.
6. Inverse DWT is applied on LL2 along with new LH1, new HL1 and new HH1 to obtain the features.
7. The ICA filter of size 5X5 with 8-blocks are used to correlate with iris template is applied on IDWT coefficients to produce final features at an output of BSIF.
8. The ED is used to evaluate final features of database iris template and test iris template to compute performance rates.

V. PERFORMANCE ANALYSIS

The experiments were performed using MATLAB 7.0 software. In this section, the effects of different combinations of Person Inside Database (PID's) and Person outside Database (POD's) on various performance parameters of proposed iris model are investigated. The proposed iris model was evaluated on CASIA iris database. The performance of the FAR, FRR and TSR are evaluated by creating the database of 6 Iris images of first 50 persons. The remaining one, iris image from 50 persons is considered as out of the database and helps for the calculation of FAR.

A. Definitions of performance parameters

In this section, the performance parameters definitions such as FAR, FRR, TSR and EER are defined to validate the proposed iris model.

(i) False Accept Rate (FAR): It is the ratio of imposter subjects that are falsely accepted to the total number of subjects in the database as given in equation 7.

$$\text{FAR} = \frac{\textit{Number of imposter subjects falsely accepted}}{\textit{Total number of subjects in the database}} \tag{7}$$

(ii) False Reject Rate (FRR): It is the ratio of genuine subjects that are falsely rejected to the total number of subjects outside the database as given in equation 8.

$$\text{FRR} = \frac{\textit{Number of genuine subjects falsely rejected}}{\textit{Total number of subjects outside the database}} \tag{8}$$

(iii) True Successive Rate (TSR): It is the ratio of number of genuine subjects that are recognized correctly to the total number of subjects inside the database as given in equation 9.

$$\text{TSR} = \frac{\textit{Number of genuine subjects recognized correctly}}{\textit{Total number of subjects inside the database}} \tag{9}$$

(iv) Equal Error Rate (TSR): It is the difference of FRR and FAR as given in equation 10.

$$\text{EER} = \text{FAR} - \text{FRR} \tag{10}$$

B. Results using variations in PID keeping POD Constant

The percentage of FAR, FRR and TSR with threshold for different combinations of PID and POD of 20:30, 30:30, 40:30, 50:30 and 60:30 are shown in Figure 11, 12, 13, 14 and 15 respectively. The following observations are made on the performance parameters of proposed iris model, the value of FRR decreases with the variations of threshold whereas the values of FAR and TSR are increased with the variations in the threshold. In addition, it is observed that the percentage of OTSR values of proposed iris model are 90, 93.33, 95, 93 and 90 resulting EER values of 10, 6.67, 5, 7 and 10 for different combinations of PID and POD of 20:30, 30:30, 40:30, 50:30 and 60:30 respectively.

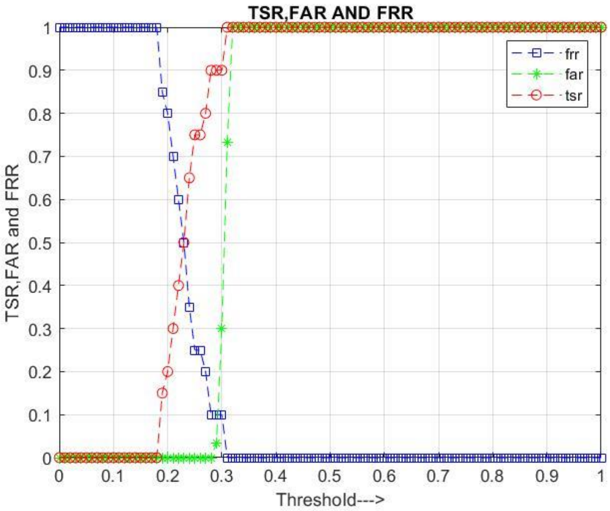

Figure 11: Performance parameters plot for PID and POD of 20:30

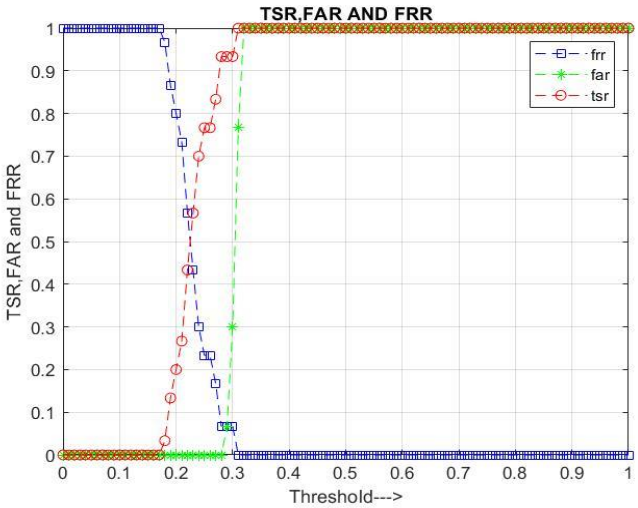

Figure 12: Performance parameters plot for PID and POD of 30:30

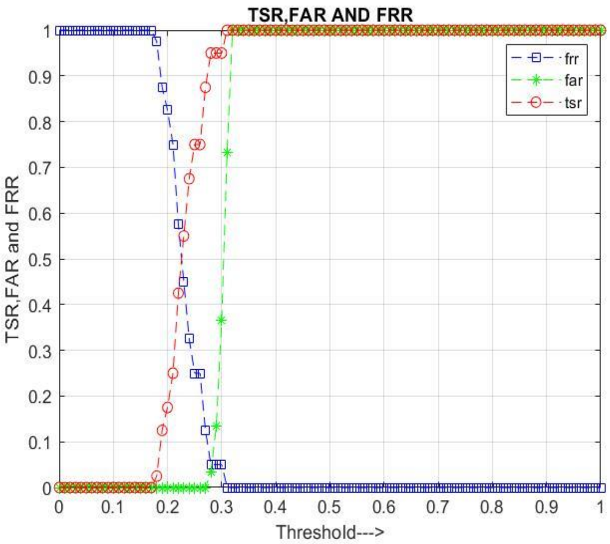

Figure 13: Performance parameters plot for PID and POD of 40:30

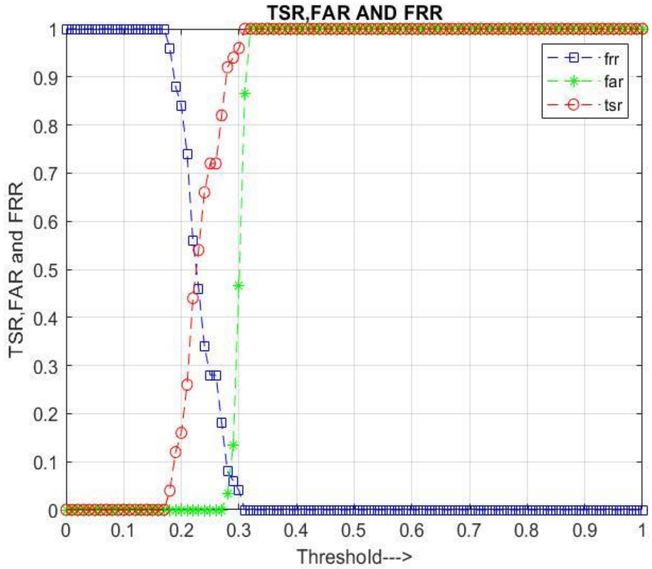

Figure 14: Performance parameters plot for PID and POD of 50:30

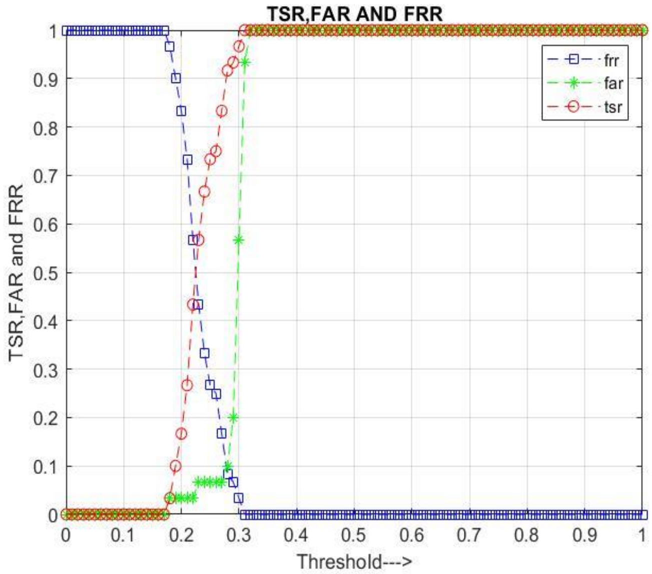

Figure 15: Performance Parameters Plot For PID And POD Of 60:30

For the different combinations of PID's with constant POD at 30, the percentage variations of optimum TSR, maximum TSR and EER are tabulated in Table 2. Hence it is observed that the percentage OTSR and the percentage EER values are not constant with increase in PID's keeping POD constant. The percentage maximum TSR results 100 for the PID's and POD's combinations of 20:30, 30:30, 40:30, 50:30 and 60: 30.

Table 2: Performance parameters for CASIA database keeping POD constant

PID	POD	EER	OTSR (%)	MTSR (%)
20	30	10	90	100
30	30	6.67	93.33	100
40	30	5	95	100

50	30	7	93	100
60	30	10	90	100

C. Results using variations in POD keeping PID Constant

The percentage of FAR, FRR and TSR with threshold for different combinations of PID and POD of 30:20, 30:40, 30:50 and 30:60 are shown in figure 16, 17, 18 and 19 respectively. The following observations are made on the performance parameters of proposed iris model, the value of FRR decreases with the variations of threshold whereas the values of FAR and TSR are increased with the variations in the threshold. In addition, it is observed that the percentage of TSR values of proposed iris model is 95 resulting EER values of 10, 6.67, 5, 7 and 10 for different combinations of PID and POD of 30:20, 30:40, 30:50 and 30:60 respectively.

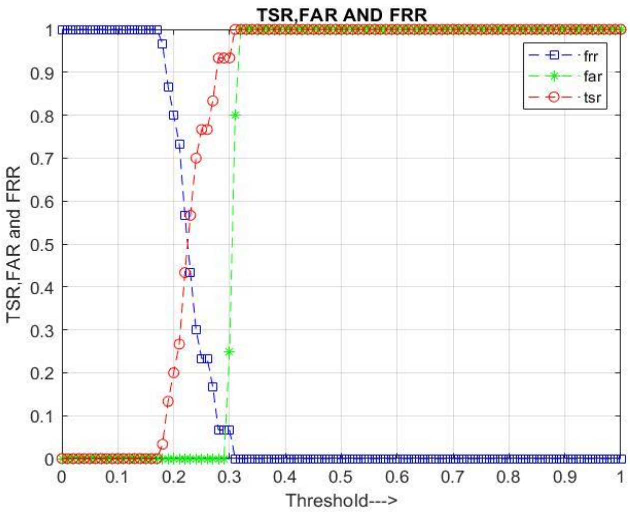

Figure 16: Performance parameters plot for POD and PID of 30:20

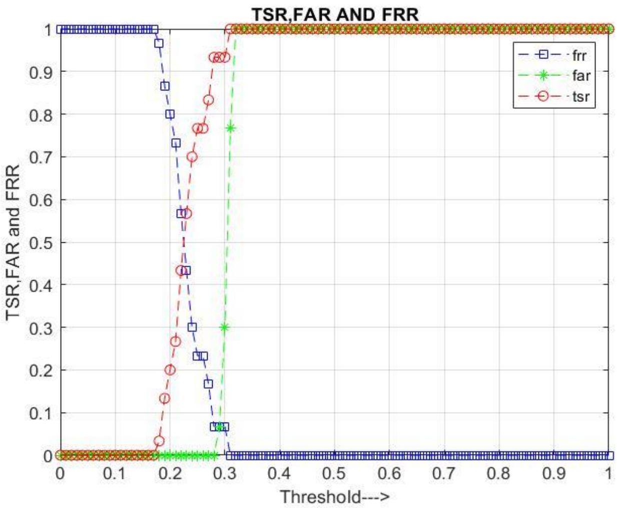

Figure 17: Performance parameters plot for POD and PID of 30:40

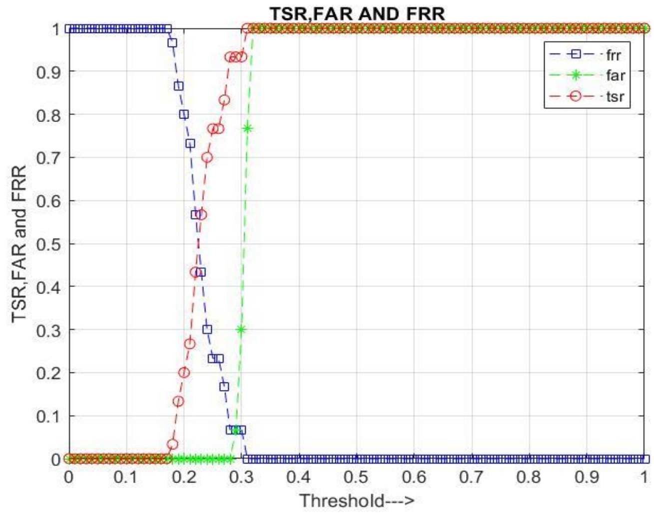

Figure 18: Performance parameters plot for POD and PID of 30:50

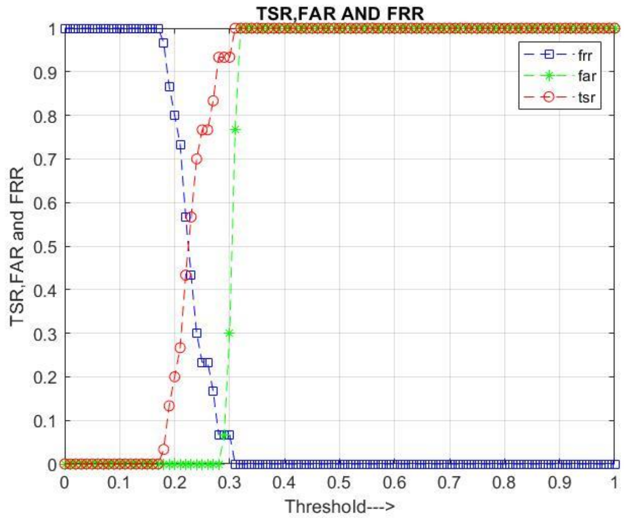

Figure 19: Performance parameters plot for POD and PID of 30:60

For the different combinations of POD's with constant PID at 30, the percentage variations of optimum TSR, maximum TSR and EER are tabulated in Table 3. Hence it is observed that the percentage OTSR is 93.33, whereas the percentage EER values is 6.67, and the percentage maximum TSR is 100 for the combinations of 30:20, 30:40, 30:50 and 30: 60 respectively.

Table 3: Performance parameters for CASIA database keeping PID constant

PID	POD	EER	OTSR	MTSR
30	20	6.67	93.33	100
30	30	6.67	93.33	100
30	40	6.67	93.33	100
30	50	6.67	93.33	100
30	60	6.67	93.33	100

D. Comparison of proposed method with existing methods

The performance of the proposed iris model is compared with the existing method presented by Charan G [2] adopted AHE and DCT techniques to extract iris features and selection of feature process was carried out by BPSO. Further the iris images are matched using ED classifier. Nanik Suciati et al., [23] applied DCT to extract the features of iris image. The features are then matched using SVM to recognize the genuine image. Ayu Fitrie et al., [24] presented unique method for matching score fusion. The two dimensional Gabor filters was adopted to extract phase information of an iris image. Sagar et al., [25] explains multi ICA and HOG techniques to produce the iris features. Further the iris images are matched using Euclidean distance classifier. Rangaswamy et al., [26] proposed straight line concept for iris recognition. The DCT was applied on enhanced iris to extract the features. The obtained features are then matched using ED classifier. The comparisons of proposed iris model with the existing methods on CASIA iris database are tabulated in Table 4.

Table 4: Comparison of Recognition Rate with proposed and existing methods

Author	Feature Extraction	Maximum True Success Rate (%)
Charan [2]	Discrete Cosine Transform	98.66
Nanik Suciati et al., [23]	Feature extraction using DCT and SVM	93.5
Sallehuddin et al., [24]	DOG & based Log 2D Gabor filter	99
G V Sagar et al., [25]	Multi ICA and HoG	97.5
Rangaswamy et al., [26]	Discrete Wavelet Transform	97.50
Proposed Method	Multi-stage DWT+ICA+IDWT+BSIF features.	100%

VI. CONCLUSION

Iris is a physiological trait, which is unique among all the biometric traits to recognize an individual effectively. In this paper iris recognition based on the combination of Discrete Wavelet Transform, Inverse Discrete Wavelet Transform, Independent Component Analysis and Binariezed Statistical Image Features are applied on iris template to generate the hybrid iris features. The first level and second level DWT are employed in order to extract the more unique features of the iris images. The concept of bicubic interpolation is applied on high frequency coefficients generated by first level decomposition of DWT to produce new set of sub-bands. The approximation band generated by second level decomposition of DWT and new set of sub-bands produced by second level decomposition of DWT are applied on IDWT to reconstruct the coefficients. The ICA 5x5 filters and BSIF are adopted for selecting the appropriate images to extract the final features. Finally based on the matching score between the database image and test image the genuine and imposters are identified. The experiments are tested on CASIA database to validate the performance of the proposed iris recognition model. In future, the proposed iris model attempts to extend support using different feature extraction techniques based on spatial and transform domains for the improvement in its recognition rate.

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