MULTI SCALE ICA BASED IRIS RECOGNITION USING BSIF AND HOG

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ABSTRACT

Iris is a physiological biometric trait, which is unique among all biometric traits to recognize person effectively. In this paper we propose Multi-scale Independent Component Analysis (ICA) based Iris Recognition using Binarized Statistical Image Features (BSIF) and Histogram of Gradient orientation (HOG). The Left and Right portion is extracted from eye images of CASIA V 1.0 database leaving top and bottom portion of iris. The multi-scale ICA filter sizes of 5X5, 7X7 and 17X17 are used to correlate with iris template to obtain BSIF. The HOGs are applied on BSIFs to extract initial features. The final feature is obtained by fusing three HOGs. The Euclidian Distance is used to compare the final feature of database image with test image final features to compute performance parameters. It is observed that the performance of the proposed method is better compared to existing methods.

KEYWORDS

Biometrics, Iris recognition, ICA, HOG, ED

1. INTRODUCTION

Biometric access control systems that scan person physical features or Voice or behavior to determine the personnel identification. Physical features include Fingerprint, Face, Palm and Iris. Biometric systems are one of the security system used in modern technology to protect almost all the personnel devices, Files and Access control. Normal password protected systems are time consuming procedure. Biometric systems are able to provide security for financial transactions, personal data and for governments, in the military, and in commercial applications. Network security, government IDs, secure electronic banking, health and social services all are based on biometric identification. Recent technology includes behavioral biometric uses the behavior of the person such as signature, gait and keystroke to identify.

Iris based systems are most secure and high accurate. Iris is a part of eye the lies around the pupil. Iris systems looking for the pattern present in the iris. Attacking is difficult with iris pattern as compared to other systems because of the complex texture pattern of the iris pattern. Contact lens and glasses have little effect on the iris hence doesn’t interfere with the system.

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***Contribution*:** - In this paper Multi-scale ICA based Iris Recognition using BSIF and HOG is proposed. The multi-scale ICA filters are correlated with iris templates to generate BSIF. The HOG is used on each BSIF to obtain HOG coefficients. The final features are extracted by concatenating HOG coefficients

Organization: - The rest of the paper is organized as follows: Section 2 describes Literature Survey Section 3 describes the proposed Iris model; Section 4 describes the Proposed Algorithm. Section 5 explains the Experiment, Section 6discuss the conclusion.

2. LITERATURE SURVEY

Various techniques have introduced in the field of iris biometric for personnel identification. Very early method is to extract iris part from eye image has introduced in Daugman's Iris code [1] is used multi-scale quadrature wavelet to extract texture phase structure information of iris to generate 2048 bit iris code to compare the difference between a pair of iris representation by computing the Hamming distance via XOR gate. Circular Hough Transformation is used for iris localization. Canny Edge detection algorithm to generate edge map and finds out outer boundary of both iris and sclera. For finding out the radius for both iris and pupil to localize pupil part an effective integro-differential operator is used. In order to normalize Iris image, map each point on iris region to pair of polar coordinates. Rangaswamy and Raja [2] proposed an iris extraction system based iris template which localize the iris image based on threshold value by finding out the pupil part and get the centre and radius of the pupil based on the high intensity threshold. Once finds the pupil radius and centre adjust the pixel value to find the iris part and concatenated to form iris template. Baigang Huang *et al.*, [3] proposed a texture extraction method using ICA filters for image classification. Firstly image patches are selected randomly from images in dataset as observation signal, from which a group of filters called ICA filters are extract using ICA method. Image patches are extracted from same image set and passed through non linear filters to enhance the frequency component of the image, and by the use of PCA it produce Eigen vectors and these Eigen vectors will produce a matrix called ICA filters.

Hyvarinen and Oja [4] presented fundamental theory and application about ICA and explains how ICA filters are extracted.ICA is a method that will find a linear representation of non-Gaussian data so that the components are statistically independent. Raghavendra and Christoph Busch,[5] proposesd Iris Presentation Attack Detection Using Multiscale Binarized Statistical Image Features. Experiments are carried out on four different artifact iris databases. This method introduced an algorithm which uses the multi scale Binarized images along with Support Vector Machine (SVM). The Experiment carried out on both complete eye image and extracted iris image, both images are trained using both real and artifact images and decision have been using weighted majority voting.

Raul Malutan *et al.,* [6] described an iris biometric system based on HoG and LIOP. Histogram of Gradient orientation (HoG) procedure calculate occurrence of gradient orientation in the region of interest of an image. Images are divided into small regions, called cells and calculate histogram of gradient edge orientations of the pixels within the cell. Each can further divided into connected blocks and are overlapped in nature, means each cells will contribute more than once in orientation calculation. Zhenan Sun *et al.,*[7] proposed a texture pattern illustration method called Hierarchical Visual Codebook (HVC) is to encode the texture character of iris images. HVC method is a combination of two existing Bag-of-Words models, namely Vocabulary Tree (VT), and Locality-constrained Linear Coding (LLC). The HVC implements a visual coding strategy and takes benefits of both VT and LLC for precise and sparse version of iris texture. Juho Kannala and Esa Rahtu [8] propsed a method to extract the binarized statistical image features using ICA filter for face images, using pre extracted ICA filter from natural texture images and using this filters database images are encoded to binary string. Encoded binary strings have been considered as final feature for matching and SVM is used as a matching technique. Nianfeng Liu *et al.,* [9] proposed A Code-level Approach in heterogeneous iris recognition. Method adapted Markov network to model a non-linear relationship between binary feature codes of heterogeneous iris images. The learnt iris template and weight Map are used to build an iris matcher against the variations of imaging sensors with different condition.

Pattabhi Ramaiah and Ajay Kumar [10] proposed a Cross-Spectral Matching Iris Recognition based on naive Bayes nearest neighbor classification method to estimate which is capable of learning domain knowledge. Method is to approximate visible iris sample from synthesis of iris patches in the near infrared iris images. Shejin Thavalengal *et al.,* [11] described a method for Iris Liveness Detection that utilizes the acquisition workflow for iris biometrics on smart phones using both visible and near infra-red sensor. Pupil characteristics is determined the liveness of the identifier by using a fast, Multi-frame pupil localization technique along with an intermediate classifier related to Jenson-Shannon divergence. This method can identify the presentation attack even with 3-D face model. Jianxu Chen *et al.,* [12] proposed a Human-Interpretable Features based iris recognition using iris crypts. This method is able to capture different crypts in different locations and able to match topological changes in the detection of the same crypt in different acquisitions. Yang Hu *et al.,* [13] introduced a method to generate optimal iris code for iris recognition. Addition to the binarized code effective iris codes are obtained by adding terms to the objective functions to the optimization problem. First one exploits the spatial relationships of the bits in different positions of an iris code and the second objective term reduce the influence of less reliable bits in iris codes. Zhenhua Chai *et al.,* [14] proposed a novel facial feature extraction method called Gabor ordinal measures (GOM), which adds the Gabor features and the robustness of ordinal measures as a \ solution to mutually handle intra person variations and inter person similarity in face images. In the proposed method have different kinds of ordinal measures are derived from magnitude, phase, real, and imaginary components of Gabor images, and then are jointly encoded as visual primitives in local regions.

Adam Czajka *et al.,* [15] proposed an Image orientation recognition for iris spoofing where it find the correct orientation of the iris image whether it is left or right and upright or upside down. This will help to identify the spoofing attacks which generate fake identities by rotating the iris sensor or image at the time of image acquisition. Two well known classifiers SVM and Convolutional Neural Network (CNN) are used for feature learning and classification.

Karen Hollingsworth *et al.,* [16] described an Iris recognition system that uses signal level fusion of frames from a video. From the iris video frames they created an average image. Use of single level fusion method they take benefit of the temporal continuity of iris video to increase matching performance. Fusion is done by pixel by pixel average and log-Gabor filter is used to produce code templates. Javier Galbally *et al.,* [17] introduced image quality estimation for fake biometric detection that is used for multiple systems. They introduced liveness method in fast and non-disturbing manner and also assure the quality of test image is similar to that of the image at the time of acquisition. They trained the system with both the fake and original image sets and additional liveness system makes it more compatible with other recognition systems.

Dakshayadav *et al.,* [18]described the consequence of textured contact lenses on iris recognition system. Use contact lenses will alter the natural iris patterns in iris image and it difficult to identify the person with contact lenses. They also proposed algorithm for same problem based on Modified LBP. Seventeen different classifiers are used to train feature sets of database with and without contact lenses and correct classification rate (CCR) is measured. They also analyzed different existing feature method along with the proposed method to identify the best me

Andrey and Elena [19] proposed a Biometric Identification by Using Low-Frequency Eye Tracker. Eye tracking devices used to collect data and signals essential fragments like Saccades are detected and take out from the raw data by examine the eyes velocities. Shailendra *et al.,* [20] proposed a score level fusion of fingerprint and iris. To obtain iris features Combination of 2-level Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT) are used and for fingerprint features a combination of 2-level DWT and Fast Fourier Transform (FFT) are used. Matching was achieved using Euclidean distance algorithm. Matching scores are fused using linear summation to acquire a combined score. Li Ma *et al.*, [21] introduced a technique which used Hough transformation and extracted features by spatial filter; this procedure first converts the circular image of the iris into rectangular model by image unwrap method. Gabor filter is used for feature extraction. Gabor filtering is a familiar procedure in texture analysis. It can extract useful information in particular band pass channels and also decompose this information into bi orthogonal components in terms of spatial frequencies. Yang Hu *et al.,* [22] proposed a signal-level information fusion method to diminish the influence of noise and degradations for less constrained iris recognition systems using Sparse-Error Low Rank Matrix Factorization method. The low rank component approximates the potential noiseless images, while the error component models the noise. Then, the error components and the low rank components are utilized to achieve signal level fusion producing two individually fused images.

3. PROPOSED IRIS RECOGNITION MODEL

In this section, we present new approach for iris recognition based on combination of ICA, BSIF and HOG. The proposed method is shown in figure 1, experimented using CASIA V 1.0 iris database with different combination of Person inside Database (PID) and Person outside Database (POD).

3.1 Iris Database

The Chinese Academy of sciences Institute of Automation (CASIA V 1.0) Iris database [26] is considered to test the performance of the proposed method. The database has one hundred and eight persons with seven images per person i.e., total number of eye images are seven hundred and fifty six. Three images on the dataset are captured in one session and remaining four images are captured in second session. The captured images are stored in BMP format. The seven images of a person are shown in Figure 2.

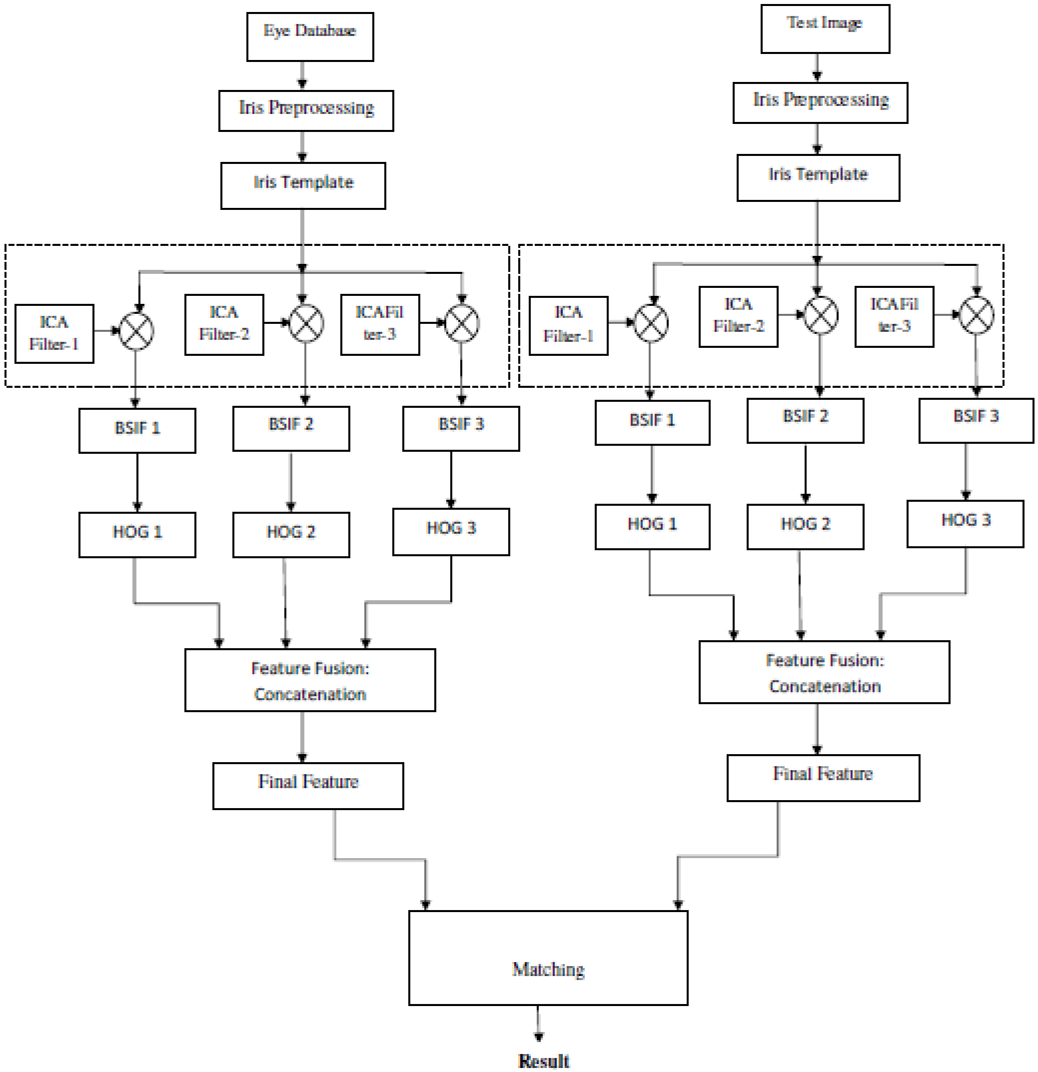


Fig 1: Proposed Iris Recognition Model

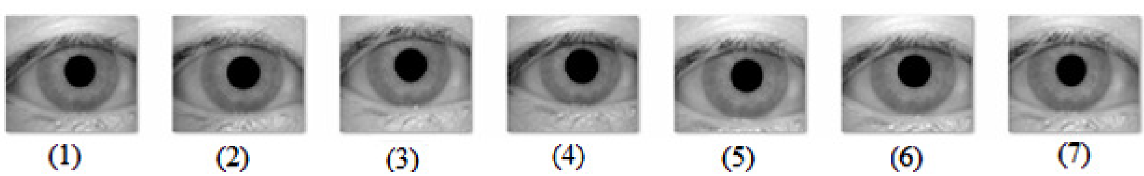
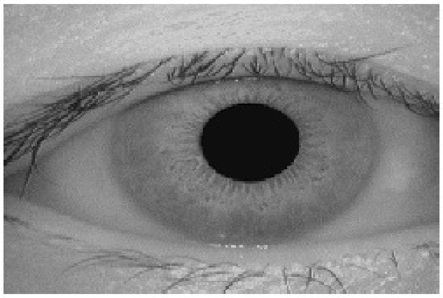


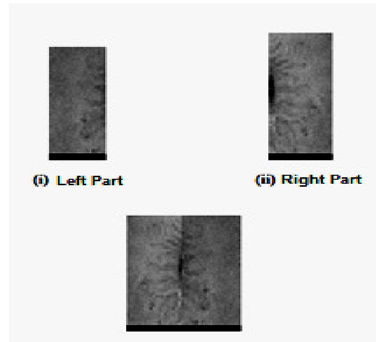
Fig 2 iris images of single person

3.2 Iris Extraction

Iris is the circular part of an eye located between pupil and sclera having pixel intensity value between pupil and sclera. The circular pupil is darkest portion and is located by finding diameter of the pupil based on prefixed threshold value for pixels. The portion above and below the pupil is eliminated to avoid eye lashes. The iris part of left and right side of the pupil is considered 40 pixel values to the end point pupil on each side. The left and right part is concatenated to form an iris image as shown in Figure 3.



(a) Eye Image



(b) Iris Template

Fig.3 Extracted iris template from the database eye image.

3.3 Independent Component Analysis

Independent Component Analysis [4] is a mathematical tool for separating multivariate signal into additive sub component by assuming the sub components are non Gaussian and are independent of each other. . The ICA model has *N* dimensional random vector R_N are assumed to be a linear mixture of mutually statistically independent sources S_L

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

Where, M represents the mixing matrix. M is unknown; aim is to find out the *M* and S_L.
For separation, we must approximate the separating matrix W *that* verifies:

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

Where E_L is an estimation of the N sources R_N.
Substitute (1) into (2) we get

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

From (3), if *M* is the inverse matrix of *W,* the independent sources S_L can be recovered accurately. There is no direct formula to compute the *W* instead it achieved by using multiple iterations. By using these iterating method we estimate *W* so as to make S_L is statistical independent as possible. So the ICA filter *W* are similar to simple cell receptive fields, cell that responds primarily to oriented edges and gratings i.e. they be similar to wavelets or Gabor filters.

3.3.1 Image Representation

Images can be represented by the model in equation (1) and for computational prospect; small image patches $P(x, y)$ are considered which linear superposition of some basic functions $m_i(x, y)$and $c_i$are coefficients is given in Equation 4

$$P(x, y) = \sum_{i=0}^{n} \mathrm{c_i}\, m_{\mathrm{i}}(\mathrm{x}, \mathrm{y}) \tag{4}$$

And Image representation i.e., Two dimensional representation of Mixing matrix M *is as* shown in equation 5

$$M(x, y) = [m_1(x, y), m_2(x, y), \dots \dots \dots.., m_i(x, y), \dots, m_n(x, y)] \tag{5}$$

Images representation i.e., Two dimensional representation of Separating matrix W is *as* shown in equation 6

$$W(x, y) = [w_1(x, y), w_2(x, y), \dots \dots \dots.., w_i(x, y), \dots, w_n(x, y)] \tag{6}$$

An iris image is represented by $I(x, y)$ and Estimation matrix in equation (3) is represented by $E(I(x, y)$

Resolve (4) using ICA, can get $m_{\mathrm{i}}(\mathrm{x}, \mathrm{y})$and $\mathrm{w_i}(x, y)$

$\mathrm{w_i} = (x, y) \;\; \forall\, \mathrm{i} = (1,2, \dots. t)$ Is called ICA filters and these filters are used to analyze an image. Use these *t* filter to filter an image $I(x, y)$ to obtain estimation $E(I(x, y)$ in equation 7

$$E(I(x, y) = (E_1(I(x, y), E_2(I(x, y), \dots \dots \dots.. E_t(I(x, y)))$$

$$= (I(x, y) \otimes w_1(x, y), I(x, y) \otimes w_2(x, y), \dots \dots \dots.., I(x, y) \otimes w_t(x, y)) \tag{7}$$

3.3.2 *ICA filter Extraction*

Selecting images from which the ICA filters will be extracted. Apply a nonlinear filter to each image to increase the high frequency component. Then select N patches with size $l_p \times l_p$ from the images at random location as the columns of matrix $\boldsymbol{R}_N$ *i*n (1) and (2).

PCA is used to reduce the dimension of the matrix $\boldsymbol{R}_N$ and get $\boldsymbol{N}$ eigenvectors. PCA is a commonly used technique for dimensionality reduction. 2 steps are applied

(i) Make ***R***is a zero mean variable by subtracting its mean vector

(ii) Pass ***R*** through whiting matrix W_z

$$W_z = 2 * (COV(R))^{-1/2} \tag{8}$$

These makes covariance of R equal to identity matrix and eliminate second order dependencies from the data. By using the above step we can estimate the W using equation (2) as ***R*** is an identity matrix and get N_i filters consisting of the matrix ***W***.
In the proposed method we used 300 eye images and iris images for extracting ICA filter, and 50000 patches are selecting randomly from these images to train the ICA. Filters obtained from 5X5, 7X7 and 17X17 windows and with length 8, 10 and 12 respectively are used to filter the iris template to obtain binary images.

3.4 Binariezed statistical Image Features (BSIF)

It is the Binarization of an image by filtering the image using ICA filter and applying proper threshold condition from equation (10). Different length of binarization is possible according to the ICA filter length and in this model we are using 8-bit, 10-bit and 12-bit BSIF images.

3.4.1 BSIF 1

ICA.1 has contained eight 5X5 windows with filter coefficients. A 2D-Digital filter is used to correlate Iris template and ICA.1 and output of the 2D-filter will convert to bit streams by using threshold condition from the equation (10). So each pixel of image is converted to 8-bit streams.

2D-Digital Filter output

$$\mathrm{Ci} = \sum_{m,n} I(m,n) F_i(m,n) \tag{9}$$

Where $I(m,n)$ denotes the Iris image, with m and n are the size of the iris image.

$F_i \quad \forall i = \{1,2,\ldots,n\}$ Represents the number of statistically independent filters whose response is computed together and binarized to obtain the binary string.

$$bi = \begin{cases} 1, & if\ Ci > 0 \\ 0 & otherwise \end{cases} \tag{10}$$

Where, b_i represent the binary image, at each digital filter out put the pixels will be converted to bit value using equation 10 and concatenated each output bit value to single 8-bit frame. Figure 4 representing the binariesed BSIF output of the iris template.

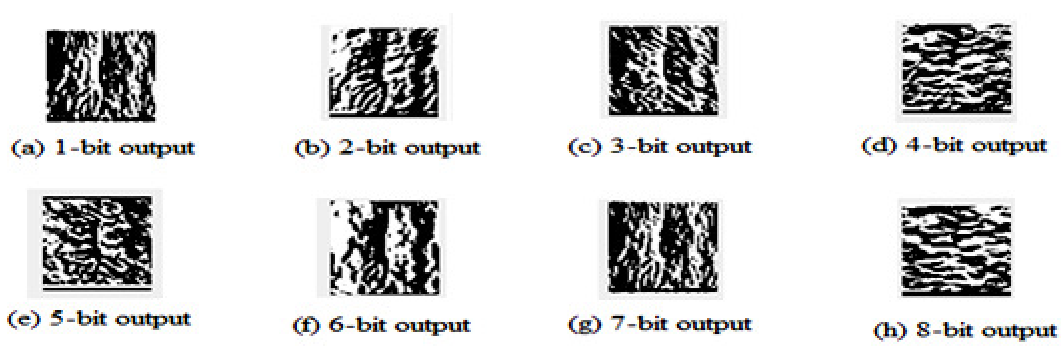


Fig 4 Binariesed output BSIF 1

3.4.2 BSIF 2

ICA filter-2 has contained ten 7X7 windows with filter coefficients. A 2D-Digital filter is used to correlate Iris Template with ICA.2 and output of the 2D-filter will convert to bit streams by using threshold condition from the equation (10). So each pixel of image is converted to 10-bit streams. Figure 5 showing different bit streams and final 10-bit image features.

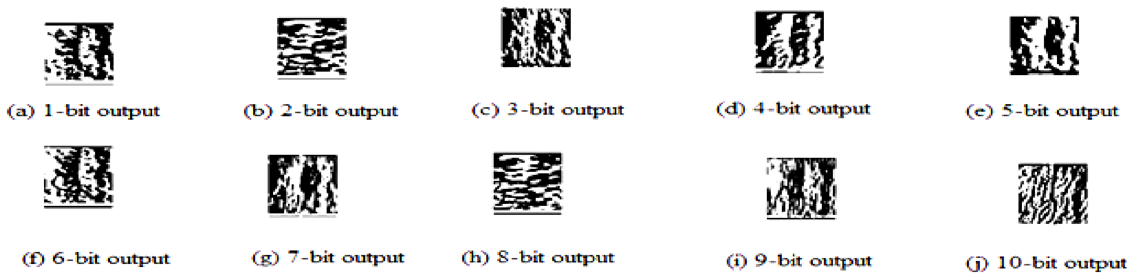


Fig 5 Binarized output of BSIF 2

3.4.3 BSIF 3

ICA Filter 3 contains twelve 17X17 windows with filter coefficients. Iris image is correlated using the filter and obtained the output by binarizing the image using Equation (10). Pixel values contain 12-bits. Figure 6 showing different bit streams and finally obtained 12-bit image of single iris template.

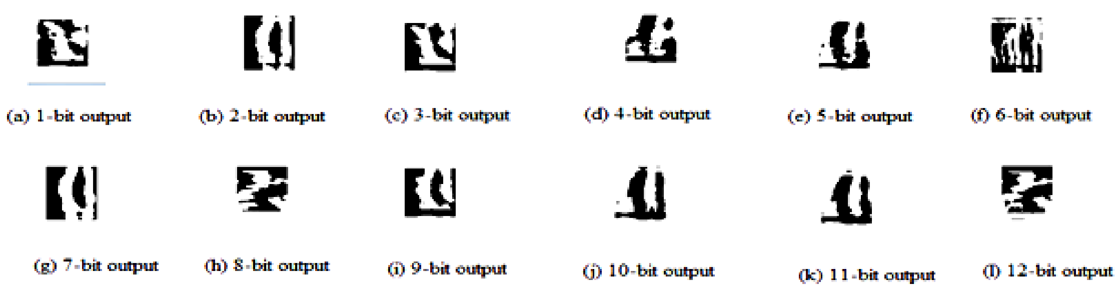


Fig 6 Binarized output of BSIF 3

3.5 Histogram of Gradients (HOG)

It is a fundamental tool in the field of object detection. It calculate occurrence of gradient orientation in sub blocks of an image. Each image is divided into blocks and each block is divided in to cell

Steps used to obtained HoG descriptor

- Output of BSIF is converted to 128X64 image
- Divide image into 16X16 blocks with 50% overlap
- Each block consist of 2X2 cells with 8X8 matrix size
- Quantize the gradient into 9 bins (0-180^0) histogram.
- The concatenate the each cell histogram into single row vector of size 3780.

The horizontal and vertical gradients for each 8X8 matrix are computed using kernels [-1 0 1] and [-1 0 1]^T for X and Y directions. The magnitude and direction of gradients are computed using equation 11 and 12.

$$g = \sqrt{g_x^2 + g_y^2} \tag{11}$$

$$\theta = arctan\frac{g_y}{g_x} \tag{12}$$

g_x And g_y are the gradients in horizontal and vertical direction respectively.

Representation of gradient histogram on each cell is achieved by arranging them in a 9-bin histogram. Histogram is in the form of 0-20^0, 20-40^0…..160-180^0 and amplitude is the sum of gradient magnitude of each angle range. Figure 8 showing an example of cell histogram

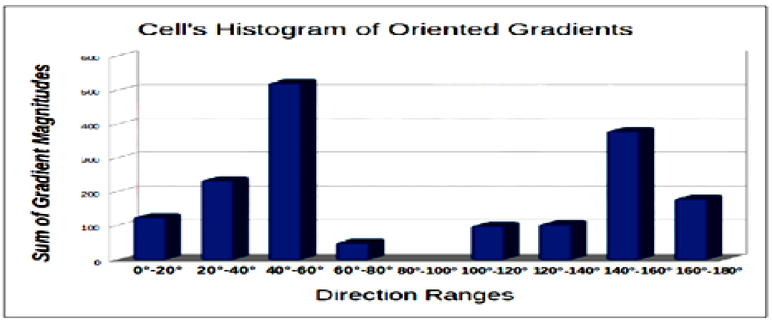


Fig 7 Non-Normalized Histogram of cell

In proposed model we have total 105 overlapped blocks and each having four cells and we compute histogram of each cell arranging them in single array. We divided the range of 0° to 180° into 9 equal bins of 20° each, and summed the magnitudes for each bin from the pixels of the 8x8 pixels sized cell. We have 4 cells in one block, and concatenate all the cells arrays into one array with 36 indices. Finally we represent these values in a normalized histogram. In order to normalize this array values we divide each Value with a normalization factor in equation 13.

$$k = x_1{}^2 + x_2{}^2 + \cdots \ldots \ldots . . + x_n{}^2 + 1 \tag{13}$$

Where, *k* is the norm-factor

$x_1, x_2 \ldots x_n$ are the sum gradient magnitude of each block. Here X_n=36

Figure 8 shows the block normalized histogram of complete image having 105 blocks, so we have total of 3780 normalized value of gradient magnitude.

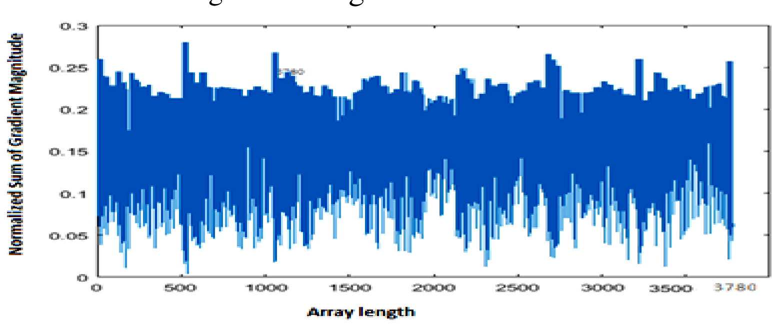


Fig 8 Normalized Histogram of Oriented Gradients of single image.

The HoG-1, HoG-2 and HoG-3 on BSIF-1, BSIF-2 and BSIF-3 are shown in figure 9, 10 and 11 respectively

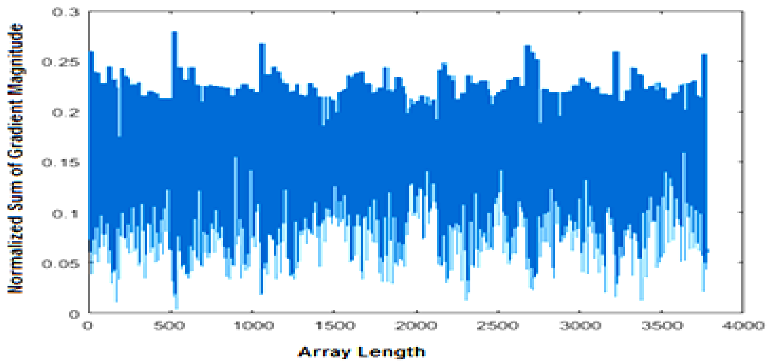


Fig 9 HoG-1 output plot

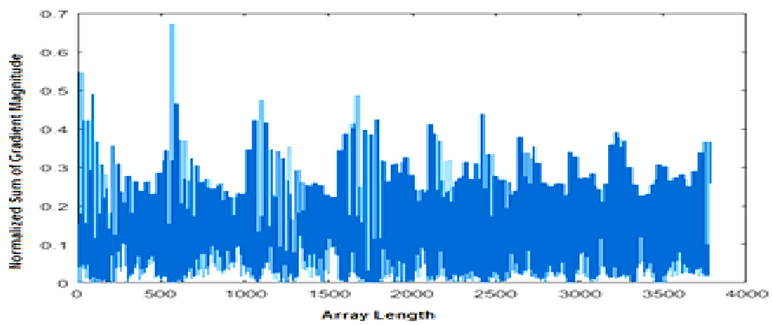


Fig 10 HoG-2 output plot

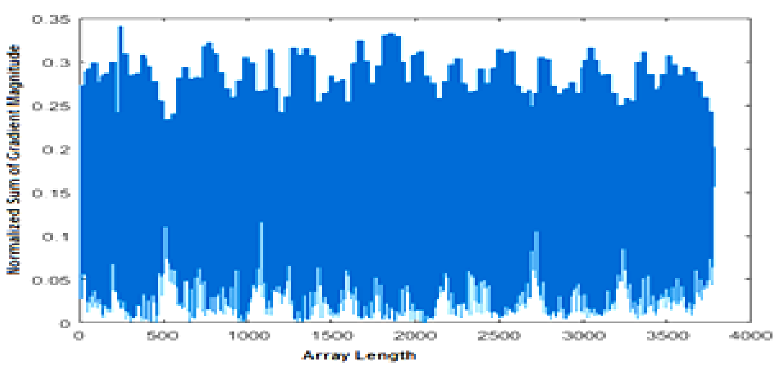


Fig 11 HoG-3 output plot

3.6 Feature Fusion:

Concatenating all the HOG output to single feature vector of size 11340. This feature vector is used as final feature for the matching purpose. The final concatenated HOG is as shown in figure 12

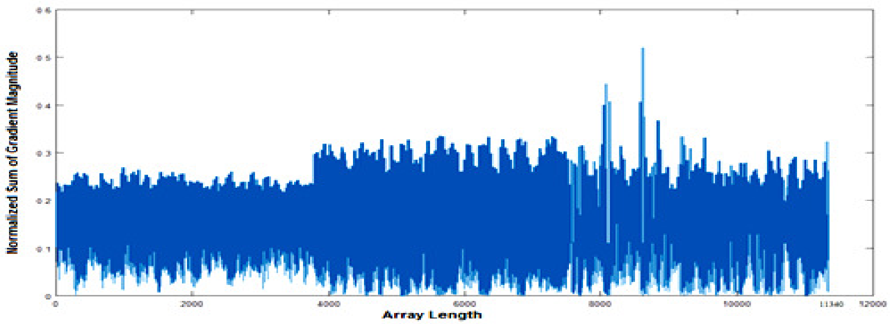


Fig. 12 Concatenated Feature Vector

3.7 Euclidean Distance

Euclidian distance is used as matching technique where the difference between test and load data bases is obtained. And the result is analyzed in terms of FAR, FRR and TSR ratios.

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 (14). The performance parameters are computed to validate the proposed method.

$$ED=\sqrt{\sum_{i=1}^{M}(\mathrm{Pi}-\mathrm{qi}\,)^{2}} \qquad (14)$$

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

The iris recognition based on ICA, BSIF and combinations of HOG's is proposed to identify human beings effectively, and the algorithm is given in Table 1

Objectives: - The iris is used to recognize a person efficiently and objectives are

(i) To increase recognition rate
(ii) To decrease errors such as FRR, FAR and EER

Input :- Iris database, Test Iris images
Output :- Computing performance parameters

1. The eye images from CASIA V 1.0 database are considered.
2. The iris template is created by considering left and right iris portion of pupil leaving top and bottom iris portion of pupil
3. ICA filter of size 5X5, 7X7 and 17X17 with 8-blocks, 10-blocks and 12-blocks respectively are used to correlate with iris template.
4. The ICA filter-1 of size 5X5 with 8-blocks is correlated with iris template to produce an output BSIF 1 with each coefficient 0f 8-bit.

5. The ICA filter-2 of size 7X7 with 10-blocks is correlated with iris template to produce an output BSIF 1 with each t 0f 10-bit.
6. The ICA filter-1 of size 17X17 with 12-blocks is correlated with iris template to produce an output BSIF 1 with each coefficient 0f 12-bit.
7. The HOG-1, HOG-2 and HOG-3 are applied on BSIF 1, 2 and 3 to obtain initial features.
8. The initial features are concatenated to obtain final features.
9. The ED is used to compute final features of iris template database and test iris template to compute performance parameters.

5. EXPERIMENTS

In this section the definition of performance parameters, performance evaluation of proposed method and comparison of proposed method with existing techniques are discussed.

5.1 Definitions of performance parameters

The performance evaluation parameters such as FRR, FAR, EER and TSR are given

5.1.1 False Rejection Ratio (FRR)

It is the measure of falsely rejected genuine persons and given in equation 15.

$$FRR = \frac{Number\ of\ Persons\ Rejected\ falsely}{Total\ number\ of\ Persons\ inside\ the\ database} \qquad 15$$

5.1.2 False Acceptance Ratio (FAR)

It is the ratio of falsely accepted unauthorized persons to total number of persons outside the database and is given in equation 16

$$FAR = \frac{Number\ of\ Persons\ Accepted\ falsely}{total\ number\ of\ Persons\ outside\ the\ database} \qquad 16$$

5.1.3 Equal Error Rate (EER)

It is the error rate at which both FRR and FAR are equal.

5.1.4 Total Success Rate (TSR)

It is the value of accurate matching of test person to training set and obtained by taking the ratio of true matches to total number of samples inside the dataset and is given in equation 17

$$TSR = \frac{Number\ of\ persons\ Matched\ correctly}{Total\ number\ of\ persons\ inside\ the\ database} \qquad 17$$

5.2 Performance Evaluation

The effect of PID and POD's on performance parameters of proposed method are investigated in this section.

5.2.1. Results using variations in PID keeping POD constant

The percentage of FRR, FAR and TSR with threshold for PID and POD combinations of 40:40, 50:40 and 60:40 are shown in Figure 13, 14 and 15 respectively. It is observed that FRR decreases with threshold, whereas the value of FAR and TSR increased with threshold. The percentages of EER vale are 2.5, 6 and 8 for PID and POD combinations of 40:40, 50:40 and 60:40. The percentage of TSR value is maximum i.e., 100 for all the three combinations of PID and POD's

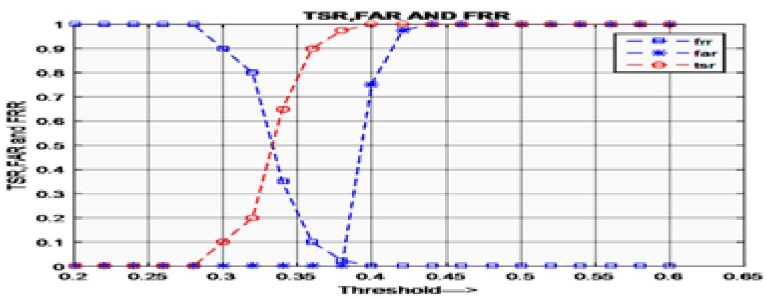


Fig 13 Performance parameters plot for PID 40and POD 40

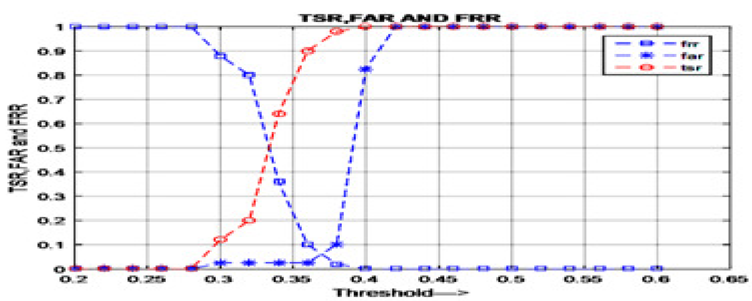


Fig 14 Performance parameters plot for PID 50 and POD 40

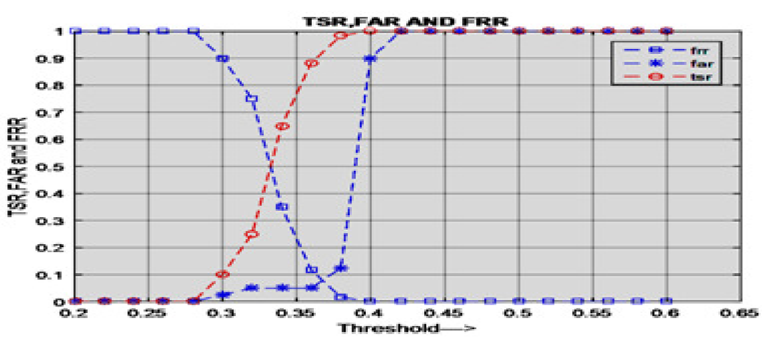


Fig 15 Performance parameters plot for PID 60 and POD 40

The percentage variations optimum TSR, maximum TSR and EER for different combinations of PID with constant POD at 40 is tabulated in Table II. Its observed that the percentage optimum TSR decreases with increase in PID's, whereas the percentage EER values increases with increase in PID keeping POD constant. The percentage maximum TSR requires constant at 100 for the variations in PID.

Table II Performance parameters value with PID and constant POD 40

PID	Optimum TSR (%)	Max TSR (%)	EER (%)
40	97.5	100	2.5
50	94	100	6
60	92	100	8

5.2.2 Results using variations in POD keeping PID constant

The percentage of FRR, FAR and TSR with threshold for PID and POD combinations of 40:40, 40:50 and 40:60 are shown in Figure 16, 17 and 18 respectively. It is observed that FRR decreases with threshold, whereas the value of FAR and TSR increased with threshold. The percentages of EER vale are 2.5, 3 and 3.5 for PID and POD combinations of 40:40, 40:50 and 40:60. The percentage of TSR value is maximum i.e., 100 for all the three combinations of PID and POD's.

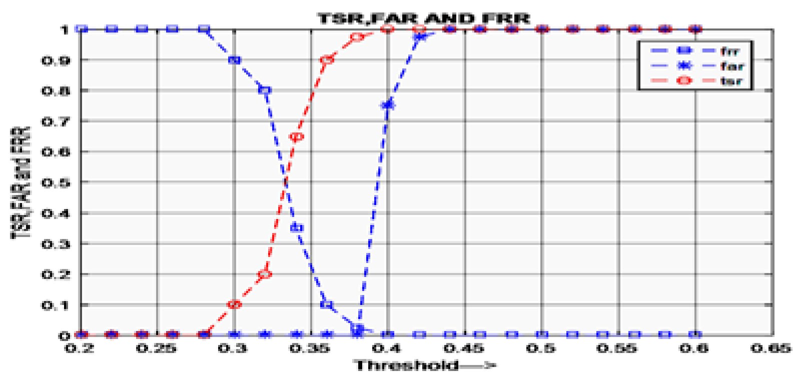


Fig 16 Performance parameters plot for PID 40 and POD 40

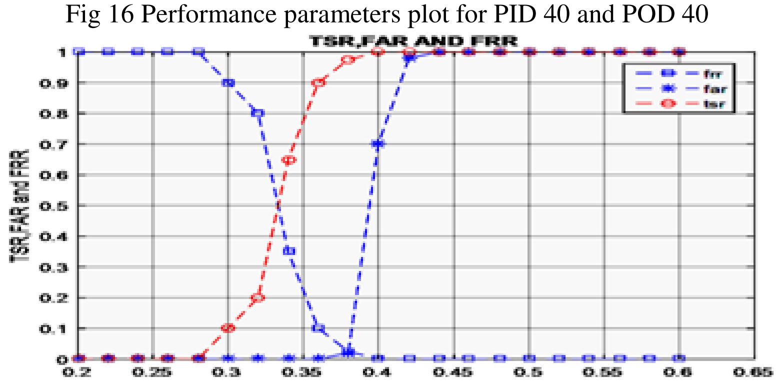


Fig 17 Performance parameters plot for PID 40 and POD 50

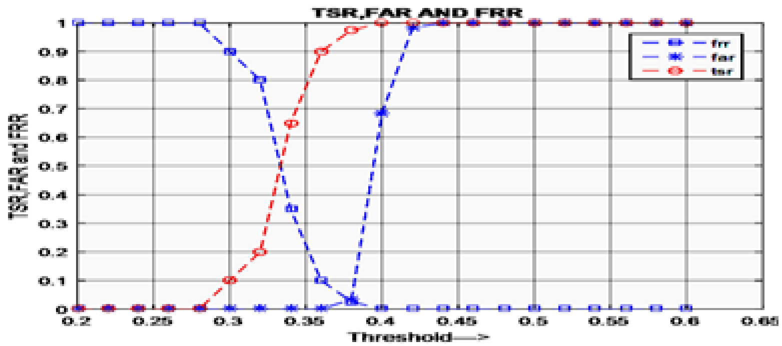


Fig 18 Performance parameters plot for PID 40 and POD 60

The percentage variations optimum TSR, maximum TSR and EER for different combinations of POD with constant PID at 40 is tabulated in Table III. It is observed that the percentage optimum TSR value decreases with increase in POD, whereas the percentage EER values increases with increase in POD keeping PID constant. The percentage maximum TSR requires constant at 100 for the variations in POD.

Table IV Performance parameters value with varying PID and POD

PID	POD	Optimum TSR (%)	Max TSR (%)	EER (%)
30	50	97	100	3
50	30	95	100	5
50	50	94	100	6
60	30	92	100	8

5.2.3 Results using variations in both PID and POD

The percentage of FRR, FAR and TSR with threshold for PID and POD combinations of 30:50, 50:30, 50:50 and 60:30 are shown in Figure 19, 20, 21 and 22 respectively. It is observed that FRR decreases with threshold, whereas the value of FAR and TSR increased with threshold. The percentages of EER vale are 3, 5, 6 and 8 for PID and POD combinations of 30:50, 50:30, 50:50 and 60:30. The percentage of TSR value is maximum i.e., 100 for all the three combinations of PID and POD's.

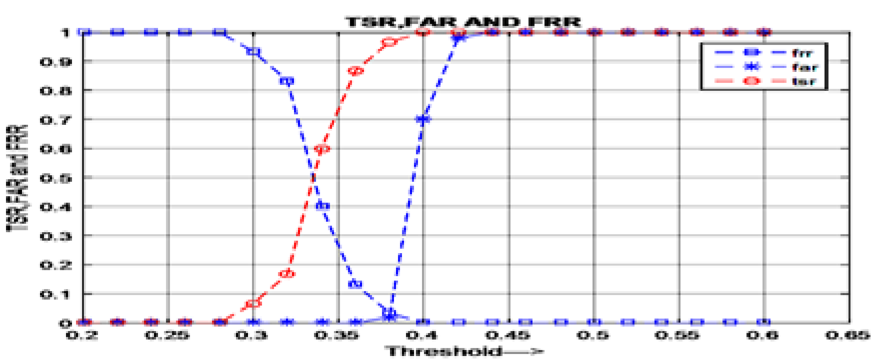


Fig 19 Performance parameters plot for PID 30 and POD 50

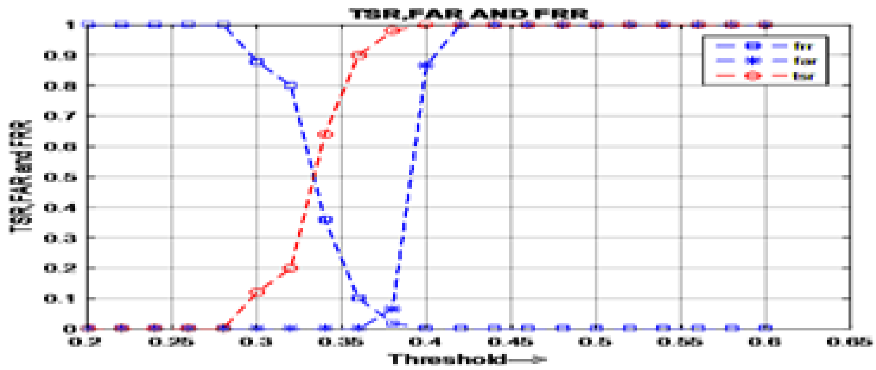


Fig 20 Performance parameters plot for PID 50 and POD 30

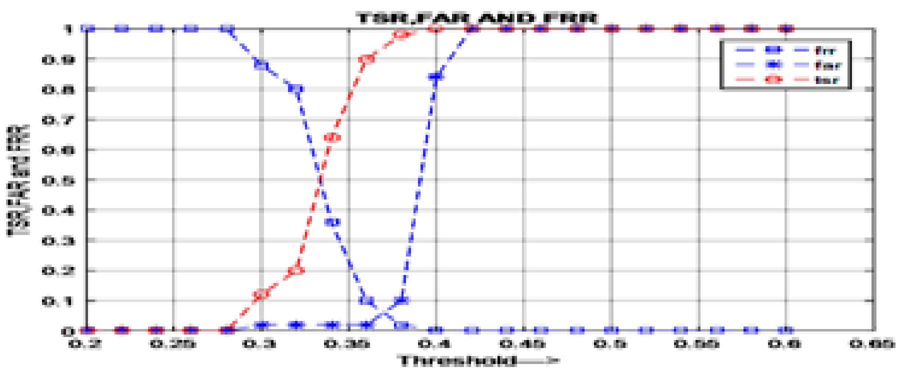


Fig 21 Performance parameters plot for PID 50 and POD 50

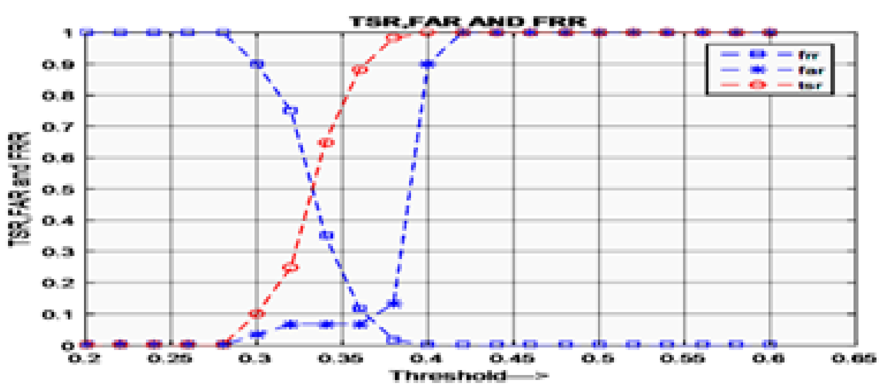


Fig 22 Performance parameters plot for PID 50 and POD 50

The percentage variations optimum TSR, maximum TSR and EER for different combinations of PID and POD is tabulated in Table IV. It is observed that the percentage optimum TSR decreases with increase in PID's, whereas the percentage EER values increases with increase in PID. The percentage maximum TSR requires constant at 100 for the variations in PID and POD.

Table IV Performance parameters value with varying PID and POD

PID	POD	Optimum TSR (%)	Max TSR (%)	EER (%)
30	50	97	100	3
50	30	95	100	5
50	50	94	100	6
60	30	92	100	8

5.2.4 Comparison of Proposed method with existing methods

The performance of Proposed method is compared with existing methods presented by Rangaswamy and Raja [2] Kaushik Roy *et al.,*[23], Wang Anna *et al.*,[24], Conti *et al.*,[25], and Ruihui Zhu *et al.*,[26]. It is validate that the proposed approach achieved superior performance compared to existing methods.The percentage optimum TSR value is high in the case of proposed method compared to existing methods.

TABLE V: Comparison of Optimum TSR with Existing Method

Sl No	Authors	Techniques	Optimum TSR %
1	Rangaswamy and Raja [2]	AHE+HE+Gabor+FFT	90
2	Kaushik Roy *et al.,[*22]	2D-Gabor	97
3	Wang Anna *et al.*,[23]	WNN+WPNN	94.5
4	Conti *et al.*,[24]	Micro-Features	95
5	Ruihui Zhu *et al.*,[25]	SIFT	90
6	Proposed Method	Multi-ICA+HoG	97.5

6. CONCLUSION

Iris recognition system is highly reliable and secure biometric system. in this paper, we proposed Multi-scale ICA based Iris Recognition using BSIF and HOG. The iris template is created by considering only iris horizontal portion between pupil and sclera of an eye image. The ICA filters with multi-scales of 5X5, 7X7 and 17X17 are used to correlate with iris template to generate Multiple BSIF. The HOG is applied on each BSIF to generate initial feature. The final feature are obtained by concatenating three HOG features. The ED is used to compare final features of database and test images to test the performance of the proposed model. It is noticed that, the performance of proposed method is better compared to existing methods. In future, the BISF can be replaced by Local Binary Pattern with appropriate compression techniques to improve further improvement in result.

REFERENCES

[1] J. Daugman, “How Iris Recognition works, ”IEEE Transactions on Circuits and systems for video Technology, vol. 14, no. 1, pp. 21-30, January 2004.

[2] Rangaswamy Y and K B Raja, “Iris Recognition based on Translation of Iris Templates, AHE, HE and Gabor Wavelet Filter, ”International Journal of Computer Science and Network, vol. 5, no. 5, pp. 842-853,October 2016

[3] Baigang Huang, Junshan Li, and Shuangyan Hu, "Texture Feature Extraction using ICA Filters," Proceedings of the World Congress on Intelligent Control and Automation, pp.7631-7635, June, 2008

[4] A. Hyva¨rinen, E. Oja, "Independent component analysis: algorithms and applications," Elsevier International Journal of, vol. 13, no.4, pp.411-430, June 2000.

[5] R. Raghavendra and Christoph Busch, "Robust Scheme for Iris Presentation Attack Detection Using Multiscale Binarized Statistical Image Features," IEEE Transactions on Information Forensics and security, vol. 10, no. 4, pp. 703-715, April, 2015

[6] Raul Malutan, Simina Emerich, Olimpiu Pop and Laszlo Lefkovit, "Half Iris Biometrie System Based on HOG and LIOP," Second International Conference on Frontiers of Signal Processing, pp. 99-103, October 2016

[7] Zhenan Sun, Hui Zhang, Tieniu Tan and Jianyu Wang, "Iris Image Classification Based on Hierarchical Visual Codebook," IEEE Transaction on Pattern Analysis and Machine Intelligence, vol. 36, no. 6, pp. 1120-1133, June 2014.

[8] JuhoKannala and EsaRahtu, "BSIF: Binarized Statistical Image Features", http://www.cse.oulu.fi/Downloads/BSIF.

[9] Nianfeng Liu, Jing Liu, Zhenan Sun, and Tieniu Tan, " A Code-level Approach to Heterogeneous Iris Recognition," IEEE Transactions on Information Forensics and Security, vol.12, no.10, pp.2373-2386, October 2017

[10] N Pattabhi Ramaiah and Ajay Kumar, "Towards More Accurate Iris Recognition using Cross-Spectral Matching," IEEE Transactions on Image Processing, vol.26, no.1, pp.208-221, January 2017.

[11] Shejin Thavalengal, Tudor Nedelcu, Petronel Bigioi and Peter Corcoran, "Iris Liveness Detection for Next Generation Smartphones," IEEE Transactions on Consumer Electronics, vol. 62, no. 2, pp.95-102, May 2016.

[12] Jianxu Chen, FengShen, Danny Z. Chen and Patrick J. Flynn, "Iris Recognition Based on Human-Interpretable Features, "IEEE Transactions on Information Forensics and Security, vol.11, no. 7, pp. 1476 -1485, July 2016.

[13] Yang Hu, Konstantinos Sirlantzis, and Gareth Howells, "Optimal Generation of Iris Codes for Iris Recognition," IEEE Transactions on Information Forensics and Security vol.12, no.1, pp.157-171, January 2017.

[14] Adam Czajka, Kevin W. Bowyer, Michael Krumdick, and Rosaura G. VidalMata, "Recognition of Image-Orientation-based Iris Spoofing," IEEE Transactions on Information Forensics and Security,vol.12, no. 9, pp.2184-2196, September 2017.

[15] Karen Hollingsworth, Tanya Peters, Kevin W. Bowyer, and Patrick J. Flynn, "Iris Recognition Using Signal-Level Fusion of Frames from Video," IEEE Transactions on Information Forensics and Security, vol.4, no.4, pp. 837-848, December 2009.

[16] Javier Galbally, Sébastien Marcel and Julian Fierrez, "Image Quality Assessment for Fake Biometric Detection: Application to Iris, Fingerprint, and Face Recognition IEEE Transactions on Image Processing, vol.23, no. 2, pp.710-724, February 2014.

[17] DakshaYadav,NamanKohli,James S. Doyle,Richa Singh,MayankVatsa andKevin W Bowyer, “Unraveling the Effect of Textured Contact Lenses on Iris Recognition,” IEEE Transactions on Information Forensics and Security, vol.5, no.5, pp.851-862, December 2014.

[18] Andrey V. Lyamin and Elena N. Cherepovskaya,“An Approach to Biometric Identification by Using Low-Frequency Eye Tracker,” IEEE Transactions on Information Forensics and Security, vol.12, no.4, pp.881-891, April 2014

[19] ShailendraTiwari, sudhakar Tripathi and K V Arya, “Score Level Fusion iris and fingerprint using Wavelet Features, ”Fourth International Conference on Parallel, Distributed and Grid Computing, pp.456-461, December 2016.

[20] Li Ma, Y. Wang and T. Tan, “Iris Recognition Based on Multichannel Gabor Filtering,” Proc. of the Asian conference on Computer Vision, vol. 1, pp. 279-283, June. 2002.

[21] Yang Hu, Konstantinos Sirlantzis, and Gareth Howells, “Signal-Level Information Fusion for Less Constrained Iris Recognition using Sparse-Error Low Rank Matrix Factorization,” IEEE Transactions on Information Forensics and Security, vol.11, no.7, pp.1549-1564, July 2016.

[22] Kaushik Roy, Darrel Hudgin, Prabir Bhattacharya and Ramesh Chandra Debnath, “Iris Recognition:A Java based Implementation,” IEEE international conference on Computer and information technology, December 2007.

[23] Wang Anna,ChenYu, Wujie and Zhangxinhua, “Iris Recognition Based on wavelwet Transform and Neural Network,” IEEE International Conference on Complex Medical Engineering, pp.758-761, May 2007.

[24] V. Conti, G. Milici, F. Sorbello and S.Vitabile, ”A Novel Iris Recognition System Based on Micro-Features,” IEEE Workshop on Automatic Identification Advanced Technologies, pp.253-258, June 2007.

[25] Ruihui Zhu, Jinfeng Yang and Renbiao Wu, “Iris Recognition Based on Local Feature Point Matching,” IEEE International Symposium on Communications and Information Technologies, pp.451-454, October 2006.

[26] http://forensics.idealtest.org/casiav1

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