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IREMD: An Efficient Algorithm for Iris Recognition

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ABSTRACT

The iris pattern is an important biological feature of human body. The recognition of an individual based on iris pattern is gaining more popularity due to the uniqueness of the pattern among the people. In this paper, the iris images are read from the database and preprocessing is performed to enhance the quality of images. Further the iris and pupil boundaries are detected using circular Hough transform and normalization is performed by using Dougman's rubber sheet model. The fusion is performed in patch level. For performing fusion, the image is converted in to 3x3 patches for mask image and converted rubber sheet model. Patch conversion is done by sliding window technique. So that local information for individual pixels can be extracted. The desired features are extracted by block based empirical mode decomposition as a low pass filter to analyze iris images. Finally the matching between the database image and test image is performed using Euclidean Distance classifier. The experimental results shows 100% accuracy on CASIA V1.0 database compared with other state-of-art methods.

Keywords - **Hough Transform, Normalization, Localization, Euclidean Distance, Dougman's Rubber Sheet model.**

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I. INTRODUCTION

Biometrics refers to the measurement of physiological and behavioral characteristics of humans to authenticate an individual. The physiological traits include fingerprints, palm, face, thumb, foot print and iris where as behavioral characteristic includes way of walking, keystroke dynamic, voice, signature analysis and so on. Recently the biometrics technology has ever growing field due to its high reliability and capable of human identification applications. Iris recognition has been adapted to encourage for high security biometric application compared to other traits. The biometric trait iris is a colored muscular ring around the pupil of the eye that contains two zones namely the inner zone is called pupillary zone and the outer zone is called ciliary zone and the iris lies between cornea and lens of the human eye. Iris based recognition provides better usage in large sectors such as transportation (iris as a living passport). In addition to this, it can also be found at airports and border crossing, such as for immigration control without passport or gain access for airports crew to restricted areas. The iris pattern consists of high discrimination pattern lying in different scale and orientations.

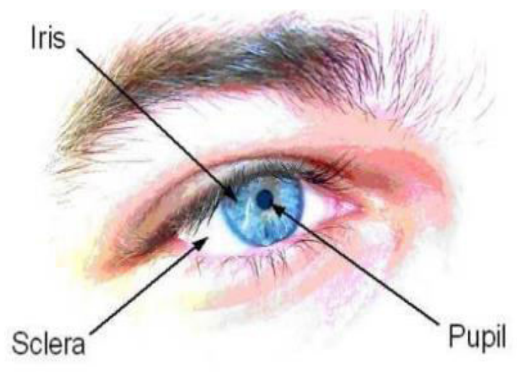

Fig 1: Human Eye

In most of iris recognition works, firstly iris region is segmented and it is mapped to a rectangular region in polar co-ordinate and then features are extracted from this region. The features obtained are compared with test images using matching techniques to finalize the genuine user. In this paper, the iris images are read from the database and preprocessing is performed to enhance the quality of images. Further the iris and pupil boundaries are detected using circular Hough transform and normalization is done by using Doughman's rubber sheet model. The desired features are extracted using block based empirical mode decomposition approach. Finally the matching between the database image and test image is done by using Euclidean Distance (ED) classifier. The rest of this paper is as follows: Section II deals with the related work on iris recognition. Section III described the proposed methodology. Section IV explains the algorithm on proposed model. Section V gives the results on the proposed IREMD model and Section VI gives the conclusion of the proposed IREMD model.

II. LITERATURE SURVEY

Rocky Dillak et al., [1] designed the pre-processing approach using amoeba median filter and Gaussian filter to enhance the effective area of iris region. Then histogram equalization is applied to the detected area of iris to enhance the quality of iris images. The iris features are extracted using multiple three dimensional GLCM approach. Finally, neural network is used as a classifier to match the database images and test images. The experiments are conducted on CASIA-V4 and CASIA-V1 database. Maha Sharkas et al., [2] explained canny edge detection and Hough transform to detect and enhances the iris images. The fusion of 2D-DWT and Fourier transform techniques are used to extract the features. The ANN is used as classifier. The experiments are conducted on CASIA-V3 iris database. Arif L Mozumder et al., [3] introduced modular neural network consisting of six modules with score level fusion to recognize the iris. The AHE is applied to enhance the iris images. The discrete cosine transform is applied on iris image to extract the features. The classifiers SVM and Gabor wavelet filters are used to match the database features and test features of iris images. Experiments are performed on MMU2 database. Mohamed R M Rizk et al., [4] explained canny edge detection and Hough transform are used to detect the iris boundaries. The HAAR wavelet transform is used for extracting features from the normalized iris recognition. Feed-forward neural network gravitational search algorithm and feed-forward neural network particle swarm optimization classifiers are used to match the database and test images. The CASIA–V3 database is used to evaluate the proposed system. Habibeh Naderi et al., [5] introduced fusion of iris, palm-print and fingerprint model. The canny edge detection and Hough transform are used to detect and enhance the quality of images. The two dimensional Gabor filter is used to extract the features of iris. Maximum Inverse Rank is used as a classifier to match the database features and test features of iris images. Experiments are conducted on CASIA-V3 database. Ayu Firtin Sallehuddin et al., [6] explained Hough transforms and canny edge detection are used to detect and select the area of interest. The NN and SVM are used as a classifier to match the iris images. Experiments were conducted on CASIA database to evaluate the performance of the proposed model. Rangaswamy Y et al., [7] proposed a straight-line concept based on iris recognition. The AHE and HE are used to enhance the iris image. The Discrete Cosine Transform technique is used to extract the features of iris. The ED is used as a classifier to compare the database and test images. Experiments are conducted on CASIA database. Sheravin Minaee et al., [8] proposed VGG-Net for deep feature extraction in iris model. The Canny edge detection is used to detect and enhances the quality of images. The SVM is used as a classifier to match the iris images. Experiments are conducted on CASIA database. Charan S G et al., [9] explained AHE is applied on iris images to obtain sharpen images. The two dimensional DCT is applied on sharpened images to extract the features. Finally, ED is used as a classifier to compare database and test images of iris. The experiments are carried out on CASIA database. Nishant Rao P et al., [10] introduced dynamic binary particle swarm optimization to optimize global test vector in order to reduce the number of selected features. The median filter and histogram equalization is used to enhance the quality of iris images. The DCT is applied on preprocessed images to extract the iris features. Finally SVM and ED are used as classifiers. The experiments are carried out on CASIA database. Kiran B Raja et al., [11] developed steerable pyramids to compare the ocular images captured using NIR and the images captured using visible spectrum. The BSIF and SIFT descriptors are used to extract the features of Iris. Finally SVM classifier is used to match the database features and test features of iris images. The experiments are conducted on GMR and FMR database. Krishna Devi et al., [12] explained iris model with gray level co-occurrence matrix descriptor. The AHE is applied on iris images to enhance the quality of images. The GLCM is applied on iris images to extract the features. The SVM is used as a classifier to match the database and test images. The experiments are conducted on CASIA database. Simina Emerich et al., [13] introduced patch based descriptors such as LBP, LPQ and DE are used to extract the features of iris images. Here canny edge detection is used as detect and enhance the iris images. The linear SVM is used as classifier to match the iris images. Experiments are conducted on CASIA database to evaluate the performance of proposed method. Nanik Suciati et al., [14] used canny edge detection to detect the iris boundaries. The statistical moments of wavelet transform is used to extract the features from the normalized iris images. Finally, the linear SVM is used as classifier to compare database and test images. The CASIA database is used to evaluate the performance of proposed method. Ujwala Gawande et al., [15] described unique approach to detect noisy pixels those are present in the pupil of an eye. The HE is applied on input iris images to enhance the quality of images. The LBP is applied on normalized images to obtain the features of iris. Finally, the neural network is used as classifier to classify the images. The experiments were conducted CASIA, MMU and IITD databases. Ritesh Vyas et al., [16] introduced two dimensional Gabor filter and XOR-Sum code based iris model. The AHE is used to enhance the quality of iris images. The HAAR wavelet transform and two dimensional Gabor are applied on pre-processed iris images to obtain the iris features. The experiments are conducted on IITD database. Sushilkumar S Salve et al., [17] introduced iris model based on SVM and ANN classifiers. The Hough transform is applied on iris images to enhance the quality of images. Now one dimensional log Gabor is applied on normalized images to extract the iris features. The SVM and ANN classifiers are used to match the database images and test iris images. The experiments are evaluated using CASIA database. Deepanshu Kumar et al., [18] introduced histogram equalization and median filter to enhance the quality of images. The DWT and DCT are used extract the features from the normalized images. Experiments are conducted on IITD database. Sheela et al., [19] used canny edge detection to enhance the quality of images. The Hough gradient approach is used to detect the boundaries and extracts the features of iris. The adaboost classifier is used to match the iris database and test images. The performance of proposed method is evaluated using CASIA database. Ankita Satish et al., [20] developed iris model during blinked eye in non-ideal condition. The canny edge detection is used to enhance the quality of images. The Gabor filter is applied on pre-processed iris images to extract the features. The k-out-of-n classifier is used to match the images. The experiments are conducted on CASIA-V2 database.Chun Wei Tan et al., [21] introduced two dimensional median filters to enhance the quality of images. The log gabor approach is applied on normalized iris images to extract the features. The hamming distance is used as a classifier to classify the database and test images. Kavita Joshi et al., [22] used canny edge detection to enhance the quality of images. The log Gabor wavelet and Haar wavelet techniques are applied on normalized images to obtain the iris features. Finally, the database images and test images are compared using HD classifier. The experiments are conducted on CASIA database. Khary et al., [23] explained canny edge detection to detect the iris image. The LBP is applied on normalized iris images to obtain the features. The features of database images and test images are compared using SVM classifier. The experiments are evaluated on CASIA database. Manikantan K et al., [24] introduced two models based on DWT and DCT descriptors for iris model. The HE is applied on images to enhance the quality of iris images. Firstly top-Hat filters and bottom-Hat filters are developed for iris model. Secondly, the fusion of DWT and DCT are used to extract the iris features. The experiments are conducted on IITD and MMU database. Arunalatha J S et al., [25] introduced Hough transform to enhance the quality of the images. The dual tree complex wavelet transform and over-lapping LBP descriptors are applied on normalized iris images to generate final features. The ED is used as a classifier to test the images. The experiments are performed on CASIA-V1 database. Aparna G Gale et al., [26] introduced Gaussian filter to enhance the quality of iris images. The combination of HAAR transforms and block sum algorithm descriptors are used to extract the final features. The ANN is used as a classifier to match the iris images. The experiments are conducted on CASIA V-1 database. Kien Nguyen et al., [27] explained AHE to enhance the quality of iris image. The convolution neural network is used to extract the iris features from the normalized images. The SVM is used as the classifier to match the database images and test images. The experiments are conducted using CASIA database. Mohtashim Baqar et al., [28] introduced deep belief networks to recognize iris using contour detection. The specular highlight is removed from an Iris image using Gaussian filter. The NN is used as a classifier to match the features of database and test features of iris image. The performance is evaluated using CASIA database. S Alkassar et al., [29] explained Sclera segmentation and validation techniques for iris model. The AHE is applied on input images to sharpen the images. The two dimensional Gabor filter is used to extract the iris features. The SVM is used as classifier to match the database and test images. The experiments are conducted on UBIRIS-V-1 database. Zexi Li et al., [30] explained canny edge detection and Hough transform to sharpen the iris images. The two dimensional Gabor filter is used to extract the features from the normalized iris image. The ED is used as a classifier to compare the database features and test features of iris images. The performance is evaluated using CASIA database. Li Su et al., [31] focused on pupil area in the iris image and detected on the basis of area property of label matrix. The canny edge detection is used to enhance the quality of images. The experimental results are demonstrated using CASIA-V3 database. Ximing Tong et al., [32] explained AHE is used to enhance the quality of iris images. The two dimensional Gabor wavelets transform is applied on iris image to obtain the final features of iris. The SVM classifier is used to match the features of database and test images. The experiments are demonstrated using CASIA database. Sunil S Harakannanavar and Veena I Puranikmath [33] briefed about various methods of preprocessing, feature extraction and classification methods to recognize iris.

III. MODEL

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

A. DEFINITIONS

(i) False Rejection Rate (FRR): It is the measure of biometric security system that incorrectly rejects an access attempt by an authorized user and is given in Equation 1.

$$FRR = \frac{Number\ of\ persons\ rejected}{Total\ Number\ of\ persons\ in\ database} \quad \text{……………………………(1)}$$

Volume: 09 Issue: 05 Pages: 3580-3587(2018) ISSN: 0975-0290

(ii) False Acceptance Rate (FAR): It is the measure of biometric security system that incorrectly accepts an access attempt by an unauthorized user and is given in Equation 2.

$$FAR = \frac{\textit{Number of unauthorized persons accepted}}{\textit{Total number of persons out of database}}$$

……………………………(2)

(iii) Total Success Rate (TSR): It is the probability that different images of the same person are matched and is given in Equation 3.

$$TSR = \frac{\textit{Number of persons correctly matched}}{\textit{Total number of persons in the database}}$$

…………………………...(3)

(iv) Equal Error Rate (EER): It is defined as the optimum error between the FAR and FRR and is shown in equation 4.

$$EER = FAR - FRR \quad \text{……………………(4)}$$

B. PROPOSED MODEL

In this section, proposed model of iris recognition is discussed and is given in Figure 2. The iris images are read from the database and preprocessing is performed to enhance the quality of images followed by iris segmentation and normalization. The fusion is performed in patch level. For performing fusion, the image is converted in to 3x3 patches for mask image and converted rubber sheet model. Patch conversion is done by sliding window technique. So that local information for individual pixels can be extracted. The desired features are extracted by block based empirical mode decomposition as a low pass filter to analyze iris images. The matching between the database image and test image is done by using Euclidean Distance classifier.

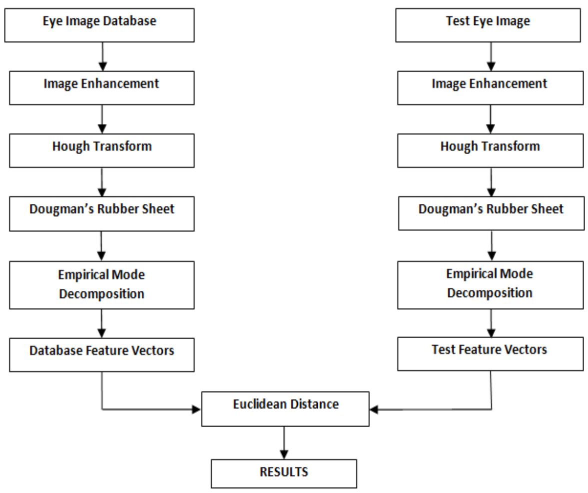

Fig 2: Block diagram of IREMD

1. Iris CASIA V1.0 Database:

The Chinese Academy of Sciences Institute of Automation (CASIA) datasets contained thousands of Chinese Asian, eye images for general research purposes. Each image is an 8-bit gray-scale image ranging in size from 320×280 pixels up to 640×480 pixels. The CASIA database has released four groups of datasets. The original CASIA V1.0 consists of single dataset of 108 individuals with seven images of each eye collected during two sessions. Totally the database has 756 images. The first six out of seven images per person are considered to create the iris database. The seventh image of each person is used as test image to compare with six images in the database. The samples of CASIA V1.0 database is shown in Figure 3.

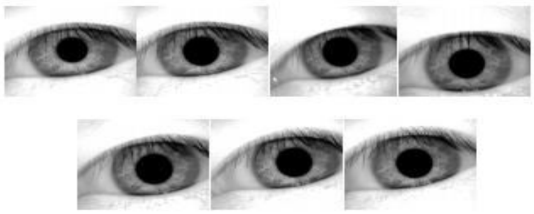

Fig 3: Iris Samples of One person from CASIA V1.0 database

2. Iris image preprocessing: The acquired image that contains irrelevant parts such as eyelid, eyelash, pupil, etc should be removed. For the purpose of recognition and enhancement, the original image needs to be preprocessed. Figure 4 shows the preprocessed image. The preprocessing is composed of two steps: iris localization/ segmentation and normalization.

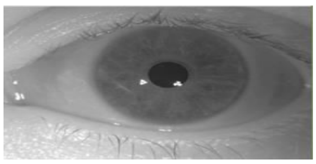

Fig 4: Preprocessed Image

The preprocessing is composed of two steps: iris localization/ segmentation and normalization.

i) Iris Localization/ Segmentation: In iris recognition process, the first step is to isolate the iris region from eye image labeled in Figure 1. The iris region can be approximated by two circles, one for the pupil/iris boundary and other for the iris/sclera boundary. Prior to detection of these two boundaries, the edge of the eye image is detected using canny edge detector. The circular Hough transform is applied on edge image to detect the centers and radii of the two boundaries as shown in Figure 5. The eyelids and eyelashes present in upper and lower parts of the iris region that does not contain any significant information. So it is required to isolate and exclude these parts.

Volume: 09 Issue: 05 Pages: 3580-3587(2018) ISSN: 0975-0290

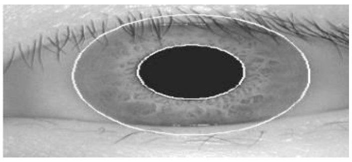

Fig 5: After Hough Transform

The circular Hough transform (CHT) can be used to detect the circles of a known radius in an eye image. The transform is computed by drawing circles of a given radius at every point in the edge image. The mathematical equation for circle is shown in equation 5.

$$r^2 = (x - a)^2 + (x - b)^2 \quad \ldots\ldots\ldots\ldots(5)$$

Where r is the radius of the circle, a and b are the center coordinates. In parametric form, the points on the equation of a circle can be written as shown in equation 6.

$$x = a + r\cos(\theta)$$
$$y = b + r\sin(\theta) \quad \ldots\ldots\ldots\ldots(6)$$

ii) Iris Normalization: Normalization process involves un-wrapping the iris and converting into polar equivalent using Daugman's rubber sheet model. The variations such as size of iris, position of iris, orientation of iris and images collected at different timings with different distances leads to produce different patterns of eye images. Hence iris normalization is required to arrange all variations of iris images of a person to similar dimensions.

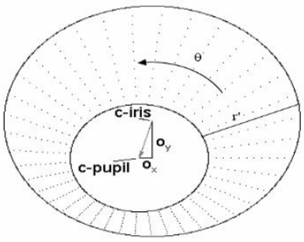

Fig 6: Concept of Normalization

Now let us consider center of the pupil as the reference point and a remapping formula helps to convert the points on the Cartesian scale to the polar scale using equation 7 and 8 as shown in the Figure 6.

$$r^1 = \sqrt{\alpha\beta} \mp \sqrt{\alpha\beta^2 - \alpha^2 - r_1^2} \quad \ldots\ldots\ldots\ldots(7)$$

Where, r^1 is iris radius and r_1 is the distance between edge of the pupil and edge of iris at θ. And $\alpha = O_x^2 + O_y^2$ where O_x and O_y represents displacement of the center of pupil in iris image.

$$\beta = \cos(\pi - \arctan(o_y/o_x) - \theta) \quad \ldots\ldots\ldots\ldots(8)$$

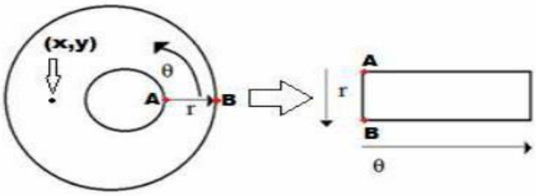

Fig 7: Daugman's Rubber sheet model

The rubber sheet model, introduced by Daugman is shown in Figure 7. It remaps each point within the iris region to a pair of polar coordinates where the radius r is on the interval (0, 1), and the angle is on the interval [0, 2π]. Then the normalized iris region is unwrapped into a rectangular region is shown in Figure 8.

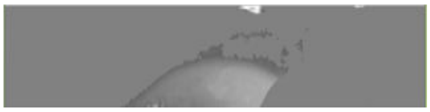

Fig 8: Effect of Normalization

2) Iris Feature Extraction: After completion of normalization process, the normalized image is applied on block empirical mode decomposition (EMD) as a low pass filter to extract the features for recognition. EMD is a multi-resolution decomposition technique and suitable to analyze non-linear and non-stationary signals. EMD can decompose a signal into several Intrinsic Mode Functions (IMFs). The features of EMD are formed by a summation of all individual IMF's.

3) Template Matching: The features extracted from database eye images are compared with the test images using Euclidean Distance (ED). The final feature vectors are modified EMD coefficients, which are not in binary form and hence ED is used as a classifier for matching. The minimum ED gives the similarity between iris images. The final features of the test image are compared with features of image in the database using ED given by the equation 9.

$$ED = \sqrt{\sum_{i=1}^{N}(p_i - q_{mi})^2} \quad \ldots\ldots\ldots\ldots(9)$$

Where, i – number of features in each image
m – number of persons in the database
p_i – features of test images
q_{mi} – features of images in database.

IV. PROPOSED IREMD ALGORITHM

Problem definition:

The iris is used to identify a person. The block based EMD is used to generate features individually. The objectives are

1. Recognize a human using Iris
2. To increase TSR value
3. To decrease EER value

The recognition of a person using iris by block based EMD features is explained in detail in the Table 1.

Table 1. Proposed IREMD Algorithm

Input: Eye images from CASIA V1.0 database.
Output: Recognition of eye images

Step 1: Eye image is read from the database.
Step 2: Enhancement of eye images using thresholding model (Converting to Gray and Normalize to Double Precision).
Step 3: Apply Circular Hough Transform on Preprocessed images to localize the iris from eye image.
Step 4: Dougman's Rubber sheet model is applied for normalization.
Step 5: Create Mask and fusion is performed.
Step 6: Apply block based EMD as a low pass filter on normalized images to obtain final features.
Step 7: Repeat steps 1-6 for test image.
Step 8: Test image features are compared with the block based EMD features of images using ED classifier to accept or reject the images.

V. RESULT ANALYSIS

It is observed that the values of TSR and FAR increase, whereas FRR decreases with increase in threshold values. The TSR in the case of the proposed iris model is around 100% with low values of FAR and FRR.

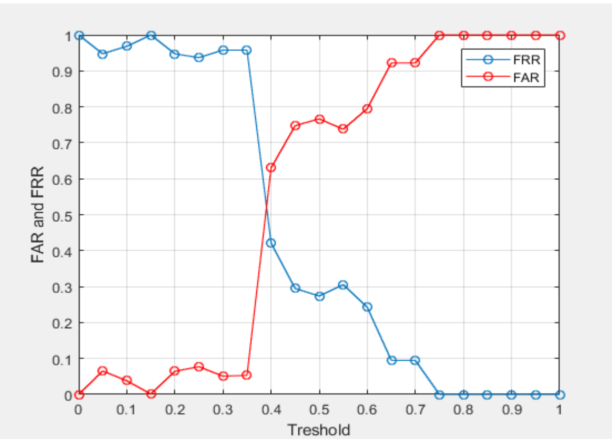

Fig.9. Plot of FAR and FRR v/s threshold

The recognition rate of proposed model is compared with existing methods explained by Rangaswamy and K B Raja [7], Charan S G [9], Ujwalla Gawande et al., [15] and Ankita Satish [20] is shown in table 2. It is found that the performance of the proposed method is better than the existing methods for CASIA V1.0 database.

Author	Techniques	Recognition Rate
Rangaswamy et al., [7]	DWT+ED	97.5%
Charan S G [9]	2D-DCT + ED	98.66 %
Ujwalla Gawande et al.,[15]	LBP + NN	97 %
Ankita Satish et al., [20]	Gabor filter + ED	95 %
Proposed Model	**Block based EMD + ED**	**100%**

Table 2. Comparison of proposed model with existing systems for CASIA V1.0 database

VI. CONCLUSION

The recognition of an individual based on iris pattern is gaining more popularity due to the uniqueness of the pattern among the people. In this paper, the iris and pupil boundaries are detected using circular Hough transform and normalization is performed by using Dougman's rubber sheet model. The fusion is performed in patch level. For performing fusion, the image is converted in to 3x3 patches for mask image and converted rubber sheet model. Patch conversion is done by sliding window technique. So that local information for individual pixels can be extracted. The final features of iris images are extracted by block based empirical mode decomposition as low pass filter to analyze iris images. Finally the database images and the test image are compared using Euclidean Distance (ED) classifier. The experimental results shows 100% accuracy on CASIA V1.0 database compared with other state-of-art methods.

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