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Novel Iris Recognition Algorithm without Normalization Phase

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ABSTRACT

Background: The study of biometrics deals with identifying the individuals perfectly for security reasons. Out of various biometric traits, this proposed method deals with iris recognition for user identification and verification. This paper presents the novel iris recognition algorithm by extricating the iris localization and normalization phase.
Objective: After identifying the pupil boundary, iris regions around the pupil region are segmented with the aid of specially designed two wedges. Due to the presence of two special wedges, uniform dimensional iris strip is segmented even in the absence of normalization process. After the feature extraction process, classification of individual is carried out. Grey Level Co-occurrence Matrix is used for feature extraction and K-nearest neighbor is used for classification processes. **Results:** This proposed method is tested on CUHK Iris Image Dataset. Implementation of two special wedges for segmenting the iris region of 60 x 30 pixels size without the normalization process greatly reduces the computational complexity in this proposed iris recognition system. When tested with thirty classes of individuals with seven samples for each, almost all the individuals are identified correctly. Out of seven samples, four samples are used for training and three samples are used for testing purposes. **Conclusion:** When compared with the various existing iris recognition algorithms, this proposed iris recognition system results in robust iris recognition accuracy in the absence of iris localization phase and normalization phase. Moreover, the pupil localization phase is done accurately irrespective of its shape. With the help of tiny iris strip of 60 x 30 pixels size itself, this proposed method exactly authenticates an individual as an authorized or unauthorized individual.

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INTRODUCTION

Biometrics is the process of identifying a person either by physiological or behavioural characteristics. Jain *et al*. (2004) and Daugman (2004) showed that, out of various biometrics such as, DNA, ear, iris, retina, face, fingerprint, palm print, gait, odour, signature, vein, and voice, iris recognition is said to be the reliable biometric technology. The traditional iris recognition system consists of following processes: (a) Eye image acquisition, (b) Pupil & Iris localization, (c) Iris Segmentation, (d) Normalization, and (e) Feature extraction and matching process. Figure 1 shows the framework for the traditional iris recognition approach. Pupil and iris localization deals with identifying the pupil and iris boundaries, respectively. To have the uniform and fixed iris strip, normalization process takes place after identifying the iris boundary. After extracting the iris features from the normalized iris strip, they are stored in the database. This process is called as Enrollment Stage. During the matching process, the extracted iris feature of the presented eye image is verified with all the iris features of eye images already stored in the database, to find the exact matching iris template. This process is called as Verification Stage.

Goal of this proposed iris recognition system is to identify the individual person with the help of their iris structure. In contrast to the traditional iris recognition system, this proposed method segments the iris region in such a way to form the fixed dimensional iris strip without the need for normalization phase with the help of two special wedges. After the iris segmentation process, feature extraction process follows through Grey Level Co-occurrence Matrix (GLCM). During the enrolment process, the extracted features are stored in the database. Then, during the verification process, these enrolled iris features are matched against with the presented iris feature by using k-Nearest Neighbor (KNN) classifier.

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A. Literature Review of Earlier Iris Recognition Algorithms:

Nithyanandham *et al*. (2011) used cryptographic techniques for providing security to the generated iris code. Here, 2D Gabor Wavelets are used for feature extraction. Kannan *et al*. (2012) used GLCM for feature extraction process and hybrid KNNSVM for classification of Magnetic Resonance Images. Vasantha *et al*. (2010) used GLCM for feature extraction process and decision tree algorithm for classifying the mammography images. Patil and Udupi (2010) used GLCM for extracting features from chest X-rays in the lung cancer classification process. Aroquiaraj and Thangavel (2011) used GLCM for extracting texture features of mammograms and K-means clustering algorithm for classifying the clusters based on the texture regions.

Viju (2011) used Gaussian Hermite moments for feature extraction and Fisher Linear Discriminant for classification process. Arora (2012) used left and right eyes for identifying individuals on distantly acquired images. Yuan and Uyanik (2013) used texture-based iris segmentation with the help of sobel operator and achieved good results. Randive and Patil (2013) implemented multimodal biometrics system by fusing iris and fingerprint. Umarani *et al*. (2010) used Kd-tree data structure for indexing the iris through color indices. Here, Speeded-Up Robust Features is used for extracting features and Euclidean distance is used for matching process.

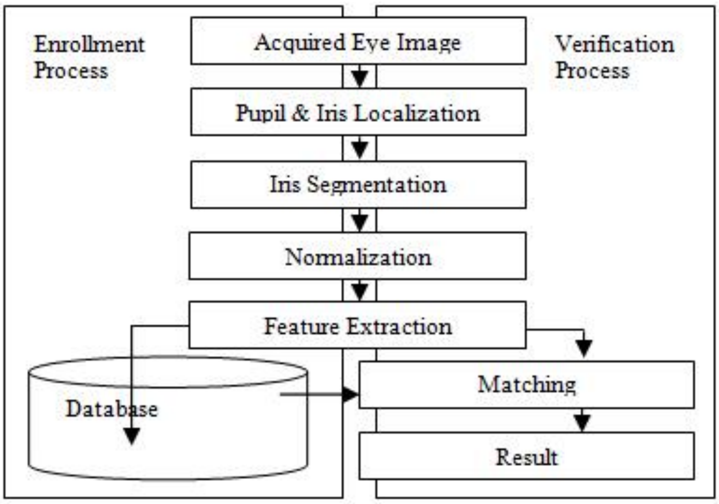

Fig. 1: Framework of the traditional Iris Recognition System.

Sundaram and Dhara (2011) used 2D Haar Wavelet and GLCM based Haralick features for feature extraction process. Rashad *et al*. (2011) used Local Binary Patterns and histogram properties for feature extraction and Combined Learning Vector Quantization for classification purpose. Gu *et al*. (2011) used steerable pyramids and variant fractal dimensions for feature extraction with Fuzzy Support Vector Machines as classifier. Jhamb and Khera (2011) used Scale Invariant Feature Extraction for feature extraction. Zhang *et al*. (2012) showed that, the Perturbation-enhanced Feature Correlation Filter results in better iris matching results.

Tsai *et al*. (2012) used Gabor filters to extract the local iris features and Possibilistic Fuzzy Matching for matching process. Dhavale (2012) used Fast Walsh Hadamard Transform for feature extraction process and also achieved good recognition rates with reduced computational time for iris recognition. Suganthy and Ramamoorthy (2012) used Principal Component Analysis for feature extraction process with reduced dimensionality. Poursaberi and Araabi (2005) used Daubechies wavelet for iris feature extraction and represented the iris features in the form of binary code.

MATERIALS AND METHODS

This proposed iris recognition method includes the following four processes, namely, (i) Pupil Localization Stage (PLS), (ii) Iris Segmentation Stage (ISS), and (iii) Feature Extraction, and (iv) Classification Stage. Figure 2 shows the framework of the proposed system. After acquiring the input eye image, the identification of pupil boundary is done in PLS. Then follows the ISS, where the uniform and consistent dimensional iris strip is segmented from the annular iris region even in the absence of normalization phase. It is accomplished by fixing special wedges on left and right sides of the iris region along the horizontal axis of the pupil region. These wedges are 30 x 30 pixels size each. By combining these two segmented 30 x 30 pixels size each iris regions horizontally, the rectangular iris strip of 60 x 30 pixels size is formed without the need for normalization phase. The CUHK Iris Image Dataset (from Online (a)) is used to evaluate this proposed method. The process of iris segmentation takes place through PLS and ISS as explained in our previous work, Ramkumar and Arumugam

(2014). After segmenting the iris region, the feature extraction takes place and the extracted features are stored in the database. This constitutes the Enrolment Stage.

A. Feature Extraction Stage:

GLCM suggested by Haralick *et al*. (1973) is used for extracting the iris features after the iris segmentation process. GLCM is defined as, how a pixel with intensity value ‘i’ differs from another pixel with the value ‘j’ in a specific spatial relationship. GLCM is used specifically to detect the variations in the pixel brightness values in an image. Calculation of GLCM is based on two factors namely, the displacement ‘d’ and the orientation ‘ϕ’. Usually the displacement ‘d’ will have the values 1, 2, 3, 4, and so on and the orientation ‘ϕ’ will have the values 0°, 45°, 90°, and 135° respectively. These orientation values are called as offset and it is represented by [0 1], [-1 1], [-1 0], and [-1 -1] vales in the Matlab. For this proposed method, the offsets [0 1] and [-1 1] with d = 1 are used. The inbuilt Matlab command graycomatrix() (from Online (b)) is used to calculate the GLCM features of the segmented iris region. Thus, GLCM is a matrix with number of rows and columns equal to the number of gray levels in an image. With the help of GLCM features, several image statistics are derived. They are Contrast, Correlation, Energy, and Homogeneity. Table 1 shows the various statistics of randomly selected five images from CUHK Iris Image Dataset database. After the feature extraction process, these features are stored in the database. When the probe image is presented for the verification purpose in this proposed method, the extracted GLCM feature of the probe image is matched with all the previously stored GLCM features of the gallery image. This constitutes the Verification Stage.

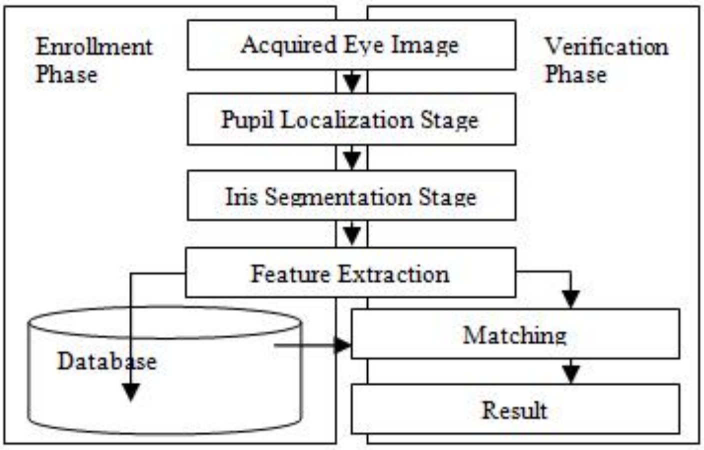

Fig. 2: Framework of the Proposed Iris Recognition System.

Table 1: Various statistics of randomly selected five images from CUHK Iris Image Dataset Database.

Sl. No.	Image Name	GLCM Features							
		Contrast		Correlation		Energy		Homogeneity	
1	‘iris3.bmp’	0.1158	0.1695	0.8388	0.7652	0.4381	0.4009	0.9421	0.9160
2	‘iris5c.bmp’	0.1339	0.2034	0.8174	0.7252	0.3693	0.3199	0.9361	0.9014
3	‘iris15c.bmp’	0.0966	0.1613	0.8636	0.7733	0.4036	0.3609	0.9517	0.9217
4	‘iris28f.bmp’	0.1927	0.8212	0.8849	0.8212	0.2112	0.1778	0.9088	0.8634
5	‘iris33.bmp’	0.1113	0.1520	0.7954	0.7222	0.4758	0.4461	0.9444	0.9240

B. Classification Stage:

For the classification process, KNN classifier is used. This is the machine learning algorithm used to classify the objects based on the “distance” metrics with its neighbours. The parameter ‘k’ specifies the number of nearest neighbours to be considered for classification process, and the default value is 1. Here, classification is done on the basis of majority voting of its neighbour’s class, and usually these neighbours are taken from samples. The distance metric used (to calculate the closest point(s)) is “Euclidean Distance”. The inbuilt Matlab command knnclassify() (from Online (c)) is used to classify the input test image. If the exact match is found in the database, presented test eye image is recognized correctly and the result is success. Otherwise, the presented test eye image is either an unauthorized sample or not an enrolled sample.

Experimental results:

This proposed method is tested on Matlab Version 7.12 in the Intel Pentium P6200 2.13 GHz processor machine with 2GB DDR3 RAM. CUHK Iris Image Dataset is used for evaluating this proposed method.

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Accuracy (A) of this proposed method is determined as the ratio of total number of test samples recognized accurately (T_r) to the total number of images present in the database (T_d), and it is given in equation (1).

$$A = T_r / T_d * 100 \quad (1)$$

Table 2 shows the iris recognition accuracy (A) and the average execution time of this proposed iris recognition system. Figure 3 shows the enrolment of biometric sample with the help of this proposed method. Figure 4 shows the absolute recognition, i.e., success in identification of test sample and subsequently the figure 5 shows the unauthorized access, i.e., success in identification of scam entry or success in identification of not enrolled sample.

Table 2: Accuracy of the Proposed Iris Recognition Algorithm.

Sl. No.	Name of the Iris Database	No. of Images	Iris Recognition Accuracy (%)	Average Execution Time (s)
1	CUHK Iris Image Dataset	210*	100 %	1.0687 seconds

*Randomly selected

A. Discussion:

This proposed iris recognition method recognizes the individual as authorized or unauthorized person without the need for normalization process as in the traditional iris recognition system. The computational complexity for iris localization process and subsequently the normalization process is exempted in this proposed method. After the pupil localization process, two special wedges are fixed over the iris region in such a way to avoid the maximum occlusions due to eyelids and eyelashes. The size of the special wedge is 30 x 30 pixels each. Thus, the iris regions beneath these two wedges are segmented and combined horizontally to form the uniform dimensional iris strip of 60 x 30 pixels size. The iris segmentation accuracy is about 98.4126% and represented in our previous work, Ramkumar and Arumugam (2014).

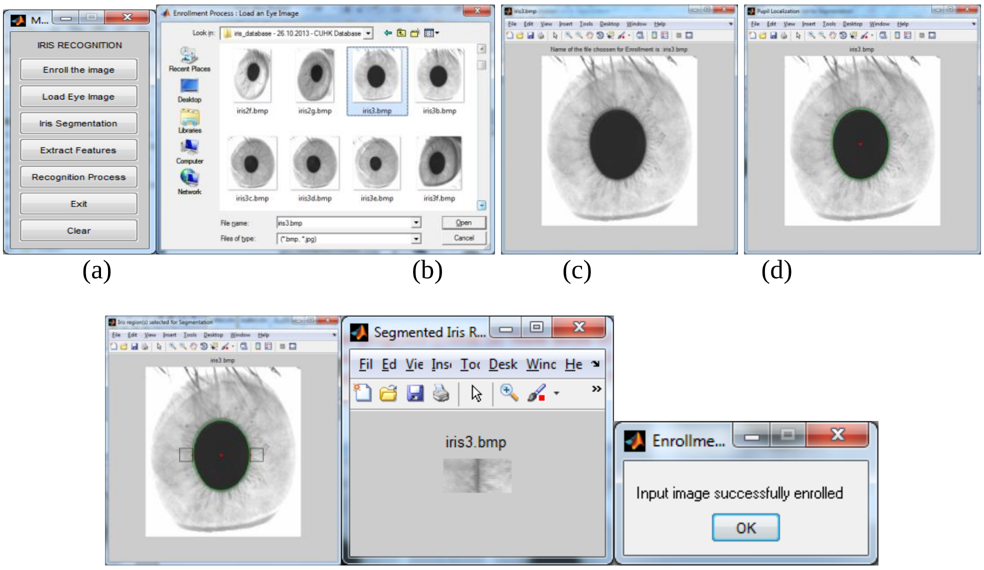
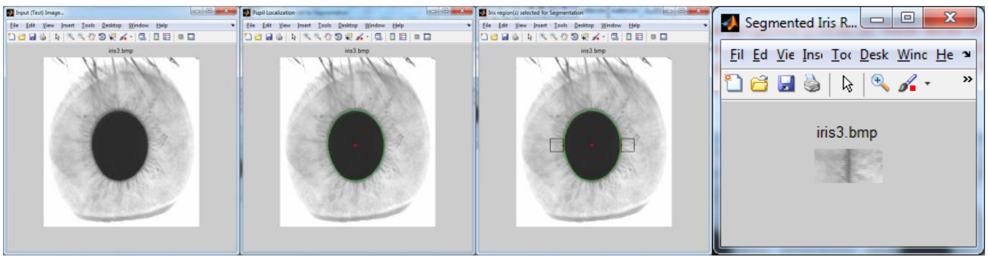
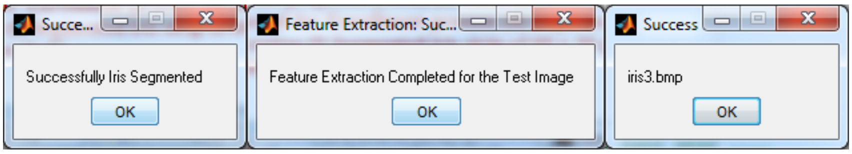


Fig. 3: Enrollment of sample eye image “iris3.bmp” in this proposed system (a) Main menu of the proposed system (b) Open dialogue box for choosing the Test image (c) Eye image “iris3.bmp” selected for Enrollment process (d) Pupil Localization Stage (e) Iris regions selected for segmentation by fixing the two special wedges over iris region (f) Segmented iris strip of 60 x 30 pixels size of eye image “iris3.bmp” (g) Message box showing the message “Input image successfully enrolled”



(a) (b) (c) (d)

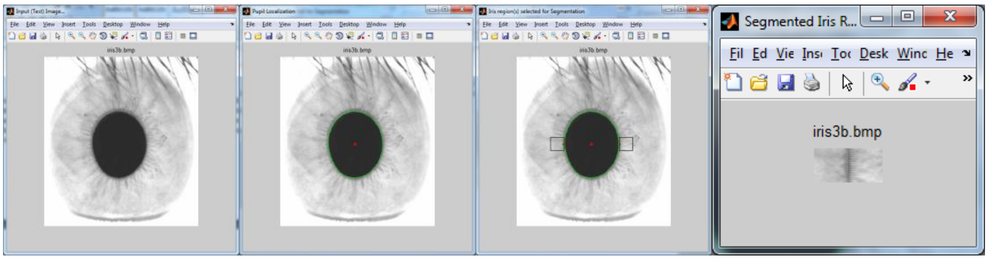


(e) (f) (g)

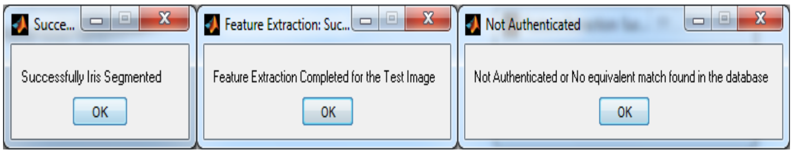
Fig. 4: Success in identifying the Authorized access (for enrolled eye image "iris3.bmp"). (a) Input Eye Image (b) Pupil Localization Stage (c) Iris regions selected for Segmentation (d) Segmented Iris Regions (e) Message showing "Successful Iris Segmentation" (f) Message showing "Successful Feature Extraction" (g) Message showing "Success" for authorized access to eye image "iris3.bmp".

To test the iris recognition accuracy of this proposed method, 30 classes of different individuals with each having seven samples, are randomly selected from CUHK Iris Image Dataset. Thus, totally two hundred and ten images are selected for evaluation purpose. Out of seven samples from each class, four images are used for training purpose and rest of the three images are used for testing purpose. Therefore, for 30 classes, totally 120 images are used as training samples and 90 images are used as testing samples.

When compared with the existing iris recognition algorithm's performance shown in table 3, this proposed method results in better recognition accuracy with reduced computational complexity. With the help of very small extracted iris regions of about 60 x 30 pixels size itself, this proposed iris recognition system authenticates the test image as an authorized or unauthorized individual.



(a) (b) (c) (d)



(e) (f) (g)

Fig. 5: Success in identifying the Unauthorized access (for not enrolled eye image "iris3b.bmp"). (a) Input Eye Image (b) Pupil Localization Stage (c) Iris regions selected for Segmentation (d) Segmented Iris Regions (e) Message showing "Successful Iris Segmentation" (f) Message showing "Successful Feature Extraction" (g) Message showing "Not Authenticated" or "No Match found" for unauthorized access to eye image "iris3b.bmp".

Table 3: Comparison of various existing Iris Recognition Algorithms and their performances.

Algorithm	Pupil Localization	Iris Localization	Iris Normalization	Feature Extraction	Matching Process	Database Used	Matching Efficiency (%)
Based on Nithyanandam *et al.* (2011)	Canny edge detection		Daugman's Rubber Sheet Model (RSM)	2D Gabor Wavelets	Hamming Distance (HD)	General	93.6
Based on Viju (2011)	Canny edge detection and Circular Hough Transform		Daugman's RSM	Gaussian Hermite moments	Fisher Linear Discriminants	CASIA Iris Version 1	96.6
Based on Arora (2012)	Circular Hough Transform		Daugman's RSM	1D Log Gabor Wavelets	Hamming Distance	CASIA Version 4 (Distance)	FAR:2.85 FRR:32.9
Based on Yuan and Uyanik (2013)	Morphological processing	Sobel Operator	Daugman's RSM	2D Gabor filters	Euclidean Distance (ED)	CASIA Version 1 and 3	90 to 100
Based on Randive and Patil (2013)	Daugman's Integro Differential Operator (IDO)		Daugman's RSM	Haar Wavelets (fusion of Iris & Fingerprint)	Hamming Distance	CASIA Iris & Fingerprint	97.27

Based on Sundaram and Dhara (2011)	Circular Hough Transform		Daugman's RSM	GLCM	Probabilistic NeuralNetwork	UBIRIS	97
Based on Rashad *et al*. (2011)	Canny Edge Detection & Circular Hough Transform		Daugman's RSM	LBP & Histogram properties	CLVQ	CASIA, MMU1, MMU2, LEI	99.87
Based on Gu *et al*. (2011)	Standard Deviation		-	Steerable pyramids & variant fractal dimensions	FSVM	CASIA V1, V3, UPOL	99.14
Based on Jhamb and Khera (2011)	Daugman's IDO		-	SIFT	ED	CUHK	-
Based on Zhang *et al*. (2012)	-	-	-	PFCF	HD	CASIA-Iris-Lamp Iris-Thousand ICE	Very low EER
Based on Tsai *et al*. (2012)	Fuzzy curve tracing	Fuzzy gray-scale curve tracing	-	Gabor filters	PFM	CASIA-Iris-V3 UBIRIS-V1	Very low FRR
Based on Dhavale (2012)	Canny Edge Detection & Hough Transform		Daugman's RSM	FWHT	HD	BATH	Lesser FRR & FAR
Based on Suganthy and Ramamoorthy (2012)	Morphological Processing		-	PCA	KNN	CASIA V1 & V3	98
Based on Poursaberi and Araabi (2005)	Thresholding	Extended Minima morphology operator	Daugman's RSM	Daubechies2 (db2) wavelet	ED	CUHK Database	95.71
Proposed Method	Morphological Processing	Not Required	Not Required	GLCM	KNN	CUHK Database	100 (almost)

B. Advantages of this proposed method:

(a) In this proposed system, pupil localization is done absolutely irrespective of its shape, and there is no need for iris localization process.
(b) When compared to other existing iris recognition algorithms, this proposed method authenticates the enrolled eye image(s) with reduced computational complexity due to the lack of normalization phase.
(c) This proposed method has very small iris strip of 60 x 30 pixels size. Therefore, this enhances the handling of huge database very easily.

C. Limitations of this proposed method:

(a) Occlusions and the reflections in the segmented iris strip reduce the iris segmentation accuracy of this proposed system, under certain unavoidable circumstances.
(b) Since the two iris regions of 30 x 30 pixels size each (on left and right sides of pupil region) alone are segmented and considered for iris recognition process in this proposed method, there is a possibility of rejection of enrolled image if the input eye image is rotated or tilted to a specific angle.

Conclusion:

This proposed method ensures a robust iris recognition method even in the absence of normalization phase. Many earlier algorithms considers the size of the pupil and iris regions as circular in nature and the entire algorithm fails if it is not so. Whereas, this proposed method detects the pupil region perfectly irrespective of its shape. Further this proposed method results in better accuracy when compared with earlier iris recognition algorithms. Authors are working on this proposed method to improve its recognition accuracy further by incorporating the compensation of rotated input images, so that this proposed algorithm can be used for real time applications.

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