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Proposed Iris Recognition Algorithm using Combination of Image Processing Techniques

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Abstract

Iris recognition has very high recognition accuracy in comparison with many other biometric features. The iris pattern has not changed since the age of 8 months, and no two are exactly the same iris even right and left eye of the same person is different and unique. This paper proposes an algorithm to recognize people based on iris images. The algorithm consists of three stages. In the first stage, the segmentation process using circular Hough transforms to find the region of interest (ROI) of a given eye images. After that, a proposed normalization algorithm using a modified Daugman's Rubber sheet model is employed to convert and divide the iris region into 16 small constant dimensions. Starting from the normalized image, Gray-Level Co-occurrence Matrices (GLCM) technique is then applied to calculate and extract texture features. Here, the features extracted are contrast, correlation, energy, and homogeneity of the iris. In the last stage, a classification technique, discriminant analysis (DA) is employed for analysis of the proposed normalization algorithm and for recognition process. The DA technique is arranged to be a model with multi input and multi output structure. For analysis of the proposed normalization algorithm, we have compared the proposed normalization algorithm in this paper to the other nine normalization algorithms. For the recognition purpose, the DA algorithm produces a good classification performance with 100% accuracy. We also compare our results with previous results and find out that, the proposed iris recognition algorithm is an effective system.

Keywords: Discriminant Analysis; Feature extraction; GLCM; Iris Recognition; ROI; Textures

1. Introduction

In recent years, with increase in number of security breaches and transaction frauds, secure personal identification and verification technologies have gained importance. A large number of systems thus require some kind of reliable personal authentication. The purpose of such systems is to ensure that the rendered services are being accessed by a legitimate user and not by anyone else. To obtain a high level of security it needed a system that has a unique key for each user. Therefore, it is developed a system that uses human body parts or a particular digit as the key biometric system.

Biometrics is applied for personal identification which consists of two kinds of both modern and traditional. The personal identification system modernly is based on physical characteristics (iris, fingerprint, face) and behavior of individuals (voice, signature, and handwriting) and the personal identification system traditionally is based on knowledge base (charging password / PIN) and a token base (using a magnetic card or smart card / smart card). Disadvantages of using the knowledge base that is easily forgotten and can be guessed by anyone, while the disadvantages of using the token base that is easily lost, stolen and duplicated so can be forged by others. In the other hand, personal identification using behavior of individuals is better than the traditional system. However, it also suffers some limitations. It can be copied by other people and cannot be used for forensic applications due to the human have died. While, the physical characteristics can be used as human identification though the human have died or lives.

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Nowadays, a typical biometric recognition system mainly consists of four modules, acquisition and detection of biometric characteristics, extraction of a feature set, representation of the extracted feature set, and matching between this feature and other template features in the database. During the first time the biometric system is used, the biometric features of the user are enrolled as a template in a database. For each subsequent use, the biometric features are acquired again and compared with the template features previously stored in the database. If the similarity between the acquired features and the template features is less than a predetermined threshold, they are identified as the same person. Recently, personal identification by using physical characteristics is the best research topics due to the capability of the characteristics. Most biometric applications extract the features from individuals including facial features [1, 2], fingerprints [3, 4], iris [5-7], palm-prints [8], hand vein [9], and retina [10-12]. The capability of these applications has published in the cited papers. These applications are convenient and secure as compared to traditional personal identification methods.

As of now, iris recognition is one of popular technique for personal identification. There are some reasons stated that iris biometric is a good trait for identification. The iris pattern has not changed since the age of 8 months and its location protected by the cornea and aquaeus humor. No two are exactly the same iris, iris and even right and left eye of the same person is different and is unique. Identical twins have the same DNA pattern but have different iris patterns and truly unique. Since the iris recognition system has compared and approved more reliable and capable technique with lower error recognition rate than face, palm-prints, vein, and fingerprints recognition as reported in [13], iris recognition has received increasing attention in the recent years.

The research in the area of iris recognition has been receiving considerable attention and a number of techniques and algorithms have been proposed over the last few years. For iris recognition, the techniques for converting an iris image into an easily manipulated code are important process. Thus, we first take a brief overview the techniques used in recent work. Several approaches have been used for iris recognition systems, the major difference being the method used for extracting and analyzing iris features. In general, iris recognition approaches can be roughly divided into four main categories: phase-based approaches [14, 15], zero-crossing representation [16], intensity variation analysis-based methods [17, 18], and texture analysis [7], [19-23].

Daugman's algorithm [5], adopted the two-dimensional (2D) Gabor filters for feature extraction to demodulate the iris phase information. Each phase structure is quantized into one of four quadrants in the complex plane. The Hamming distance was further used to calculate the distance between iris codes of 2048 bits. In the past decade, Daugman had constantly modified and improved his recognition algorithms. Based on active contours, a recent paper [15] presented alternative segmentation methods to transform an off-angle iris image into a more frontal view. Moreover, a description of new score normalization scheme was used for computing the Hamming distance that would be accounted for the total amount of unmasked data available in the comparison. At this time, essentially all of the large scale implementations of iris recognition are based on the Daugman iris recognition algorithms [24]. The difference between a pair of iris codes was measured by their similarity distances.

Boles and Boashash [25] calculated a zero-crossing representation of one-dimensional wavelet transform to represent distinct levels of a concentric circle on an iris image, and two dissimilarity functions were applied for matching the iris features obtained. To extend the approach of Boles and Boashash, Sanchez-Avila and Sanchez-Rellio [16] further proposed using different distance measures (such as Euclidean distance and Hamming distance) for feature matching. L. Ma et al. [17, 18] recommended a local intensity variation analysis-based method and adopted the Gaussian-Hermite moments, using stabilized iris encoding and zernike moments phase features [26], dyadic wavelet [18], active contours [27] to distinguish iris images for recognition.

Wildes [7] combined the method of edge detection with Hough transform for iris location and used the Laplacian pyramids to analyze the iris texture. However, the parameters need to be precisely set and lengthy location time is required. Lim et al. [19] decomposed an iris image into four levels with different frequency components using the 2D Haar wavelet transform and the fourth-level with high frequency information was quantized to form an 87-bit code. Then a modified competitive learning neural network was used for classification. L. Ma et al. [20] proposed a well-known texture analysis method (multi-channel Gabor filtering) to capture both global and local details from an iris image. Recently, Tisse et al. [21] constructed the analytic image (a combination of the original image and its Hilbert transform) to demodulate the iris texture. Emergent frequency functions for feature extraction were in essence samples of the phase gradient fields of the analytic image's dominant components. Please note that all of those algorithms are using gray images without color information. This is because of that the most discriminating information for iris recognition (i.e., texture variations) is the same as in both gray and color images. Huang et al. [28] decomposed an iris image into four levels using 2D Haar wavelet transform and quantized the fourth-level high-frequency information to form an 87-bit code. A modified competitive learning neural network was adopted for classification. Makthal et al. [22] presented a technique for synthesizing iris images by characterizing the texture using Markov Random Field (MRF) modeling. The difference between a pair of iris codes was measured by Manhattan distance.

Also, in the last year only, the iris takes the attention of many researchers and different ideas are formulated and published. For example, [29] applied a rectangular area technique to localize pupil and detect the inner circle of iris for localization purpose. After normalization and enhancement, Neural Network (NN) is used to recognize the iris patterns. Chang et al. [24] modified Empirical Mode Decomposition (EMD) as a low-pass filter to analyze the iris images for feature extraction. It appears to be suitable for non-linear, non-stationary data analysis. Similarity metric used is the mean of the Euclidean distance (MED). Ma et al [30] proposed texture segmentation and representation based on Ant Colony Optimization (ACO) with excellent effectiveness and practicability especially for images with complex local texture situations. The ACO based image segmentation algorithm and a texture representation method are then presented for automatic iris image processing. Abhyankar and Schuckers [31] presented a bio-orthogonal wavelet based iris recognition system, which modified and demonstrated to perform off-angle iris recognition. An efficient and robust segmentation of noisy iris images for non-cooperative iris recognition is described by Tan et al. [32, 33]. Iris image segmentation and sub-optimal images is discussed by Matey et al. [34]. Farouk et al. [35] presented a method for iris recognition based on elastic graph matching and Gabor wavelets.

Besides iris image quality in the acquisition and detection of biometric characteristics step, features extraction plays an essential role in the performance of iris recognition system. Designing a robust method for iris recognition is challenging. The main difficulty comes from the fact that there is no quick and efficient technique to extract unique features. Traditionally, decomposition techniques such as Fourier decomposition or Wavelet decomposition using basis functions are selected to analyze real world signals [36]. Also, Fourier and Wavelet descriptors have been used for feature extraction [28]. However, the main drawback of those approaches is that the basic functions are fixed and not necessarily matching varying nature of signals. In addition, to improve accuracy, most of the biometric authentication systems store multiple templates per user to account for variations in biometric data. Therefore, these systems suffer from storage space and computational overheads. Furthermore, suitable features comparison and classification systems for iris pattern must be developed. In order to address these issues, this paper presents a proposed iris recognition algorithm with combination of the segmentation, normalization, features extraction, and classification techniques to optimize the performances of the recognition system. The proposed iris recognition algorithm is combination process of segmentation using modified circular Hough transform with canny edge detection, the proposed normalization using modified Daughman Rubber sheet model, then to divide the normalized image into small contrast dimension. The GLCM technique is used for texture features extraction and the discriminant analysis is used for classification technique.

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The rest of this paper is organized as follows; Section 1 explores the introduction and briefly reviews previous work on iris recognition techniques, Section 2 highlights the techniques collaborated in the iris recognition algorithm. The results and discussion are tabulated and explored in Section 3. Section 4 gives the conclusion.

2. Materials and Methods

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2.1 Iris Database

In this work we have used a large publicly and freely available iris databases, CASIA-Iris version 3-Interval. The CASIA iris database is a large open iris database and we only use a subset for performance evaluation. This database includes 249 different eyes (hence, 249 different classes) with 1664 images. Each image has a resolution of 320x280 in 8-bit gray level. In the preprocessing stage, we checked the segmentation accuracy of the iris boundaries subjectively and obtained an accuracy rate of (185 images, 11 classes are not used), which shows different causes resulting in the failure of iris locating.

2.2 Proposed iris recognition algorithm

A new iris recognition algorithm is proposed in this paper. The algorithm consists of segmentation, proposed normalization, features extraction, and classification as presented in Figure 1. The algorithm is developed as combination process of several algorithms. The segmentation involves circular Hough transforms to find the region of interest (ROI) of a given eye images, modified Daugman's Rubber sheet model as a proposed normalization algorithm and divided the region to be 16 regions, and Gray-Level Co-occurrence Matrices (GLCM) for texture features extraction process, then the classification is conducted by using discriminant analysis (DA) classifier. In the combination algorithm, we proposed a normalization algorithm by adding the step enhancement and divide the enhanced image to be 16 regions. Thus, the proposed normalization algorithm is analyzed by comparing other nine methods.

a. Segmentation

For this paper, the iris segmentation has achieved by the following three main steps. The first step locates the center and radius of the iris in the input image by using circular Hough transform. Then a set of points is taken as pupil initialization from nearby points to the iris center. The last step locates the pupil boundary points by using the region-based active contours. There are several segmentation techniques that have been applied for iris recognitions. They are Hough transform [21], [35], [37, 38], Daugman's intero-differential operator [5], active contour models [15], and eyelash and noise detection [39]. The Hough transform is a standard computer vision algorithm that can be used to determine the parameters of simple geometric objects, such as lines and circles presented in an image. However, it suffers some limitations such as (i) it requires threshold value to be chosen for edge map, (ii) it may not suitable for real time applications due to limitation (i). Thus, enhanced of the Hough transform are proposed by Wildes [37] namely circular Hough transform.

Wildes [37] proposed the Gaussian smoothing function to obtain an edge map of the image for enhanced the Hough transform. The edge map is obtained by thresholding the magnitude of the image intensity gradient. From the edge map, votes are cast in Hough space for the parameters of circles passing through each edge point. These parameters are the center coordinates x_c and y_c, and the radius r, which are able to define any circle according to the equation 1.

$$x_c^2 + y_c^2 - r^2 = 0 \qquad (1)$$

A maximum point in the Hough space will correspond to the radius and center coordinates of the circle best defined by the edge points. Wildes [37] also make use of the parabolic Hough transform to detect the eyelids, approximating the upper and lower eyelids with parabolic arcs, which are represented as equation 2.

$$\left(-(x-h_i)\sin\theta_j + (y-k_j)\cos\theta_j\right)^2 = a_j\left((x-h_j)\cos\theta_j + (y-k_j)\sin\theta_j\right) \qquad (2)$$

where a_j controls the curvature, (h_j, k_j) is the peak of the parabola, θ_j is the angle of rotation relative to the x-axis.

In this paper, it was decided to use circular Hough transform for detecting the iris and pupil boundaries. This involves first employing Canny edge detection to generate an edge map. Gradients were biased in the vertical direction for the outer iris/sclera boundary. Vertical and horizontal gradients were weighted equally for the inner iris/pupil boundary. A modified version of Kovesi's Canny edge detection MATLAB function was implemented, which allowed for weighting of the gradients. The circular Hough transform can be employed to deduce the radius and center coordinates of the pupil and iris regions. In the eye images, recognition of a circle can be achieved by considering the strong edges in an image as the local patterns and searching for the maximum value of a circular Hough transform.

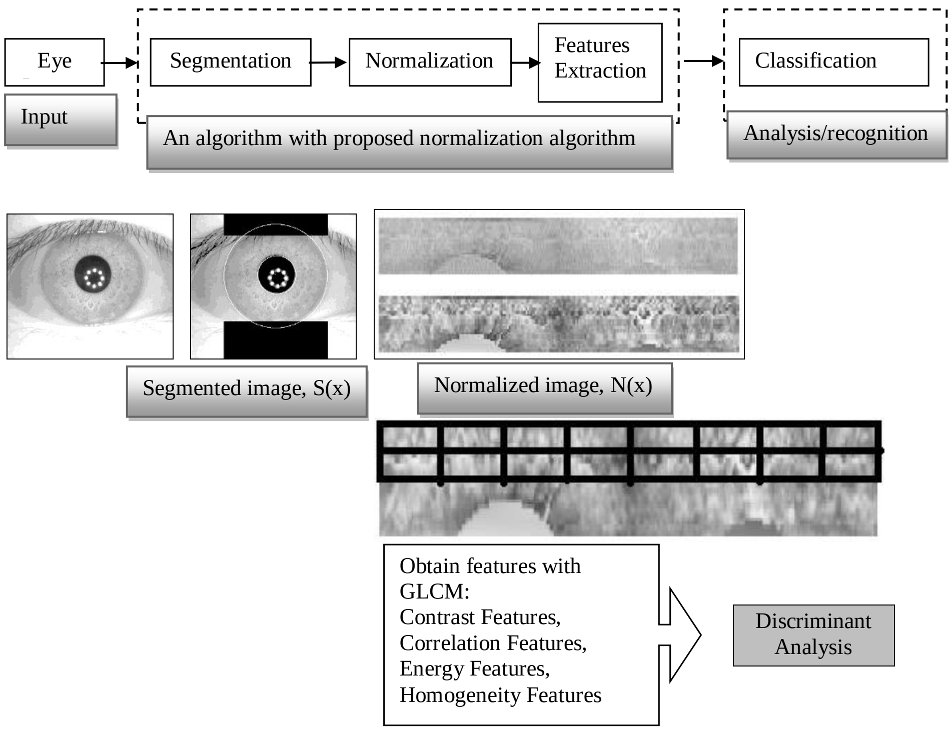

Figure 1. Proposed iris recognition algorithm

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An automatic segmentation algorithm based on the circular Hough transform is employed by [37], [21], [38], [35]. The localization method, similar to Daugman's method, is also based on the first derivative of the image. Currently, the enhanced circular hough transform based on Masek [38] is used in this paper. The enhanced algorithm for segmentation purpose is presented in Figure 2.

b. Proposed Normalization Algorithm

Once the iris region is successfully segmented from an eye image, the next stage is to present each iris image as a graph of a fixed iris region so that it has fixed dimensions in order to allow comparisons. The normalization is done in order to eliminate the noise from eyelashes. One of the problems for fixing dimensions is caused by stretching of the iris. The stretching of the iris is caused by pupil dilation from varying levels of illumination. The normalization process will produce iris regions, which have the same constant dimensions, so that two photographs of the same iris under different conditions will have characteristic features at the same spatial location. Another point of note is that the pupil region is not always concentric within the iris region and is usually slightly nasal. This must be taken into account if trying to normalize the 'doughnut' shaped iris region to have constant radius [38].

Most of normalization techniques have been applied for iris recognition such as Daugman rubber sheet model [38], image registration [37], and virtual circles [25]. Modifications of the Daugman's normalization technique were proposed by [40-42]. The homogenous rubber sheet model devised by Daugman remaps each point within the iris region to a pair of polar coordinates (r,θ) where r is on the interval [0,1] and θ is angle [0,2π] as presented in Figure 4. The remapping of the iris region from (x,y) Cartesian coordinates to the normalized non-concentric polar representation is modelled as

$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta) \quad (3)$$

With

$$x(r,\theta) = (1-r)x_p(\theta) + rx_1(\theta) \quad (4)$$

$$y(r,\theta) = (1-r)y_p(\theta) + ry_1(\theta) \quad (5)$$

where $I(x,y)$ is the iris region image, (x,y) are the original Cartesian coordinates, (r,θ) are the corresponding normalized polar coordinates, and x_p y_p and x_l y_l are the coordinates of the pupil and iris boundaries along the θ direction. The rubber sheet model takes into account pupil dilation and size inconsistencies in order to produce a normalized representation with constant dimensions. In this way the iris region is modelled as a flexible rubber sheet anchored at the iris boundary with the pupil center as the reference point.

Even though the homogenous rubber sheet model accounts for pupil dilation, imaging distance and non-concentric pupil displacement, it does not compensate for rotational inconsistencies. In the Daugman system, rotation is accounted for during matching by shifting the iris templates in the θ direction until two iris templates are aligned.

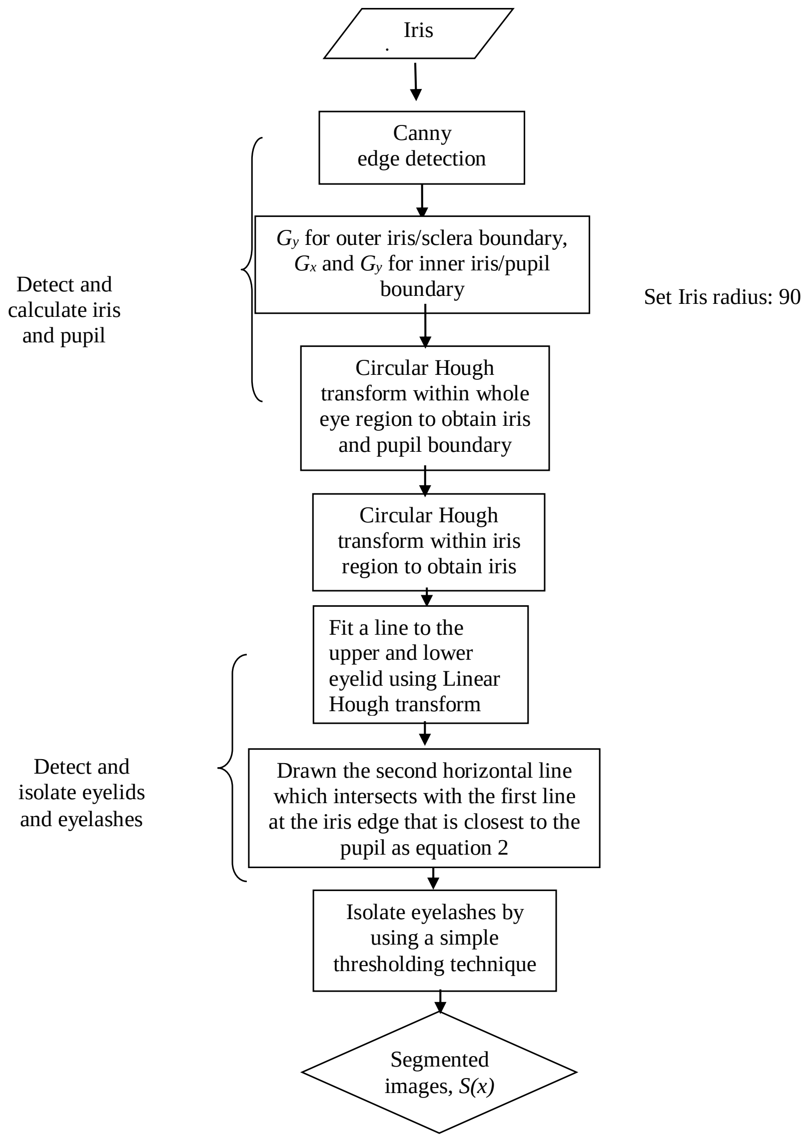

Figure 2. Flowchart for segmentation step

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In the other hand, there are other sources of the dimensional inconsistency include, varying imaging distance, rotation of the camera, head tilt, and rotation of the eye within the eye socket [33].

Daugman's rubber sheet model is one of the popular normalization techniques used due to easy to implement. There are several studies that have conducted the modified normalization techniques based on Daugman's rubber sheet model in order to obtain good performance in recognition [42]. In our work, normalized image based on Daugman rubber sheet model is enhanced and cropped half of it as shown in Figure 3, then the half of the enhanced normalized image is divided into 16 partitions. The main purpose of enhancement and cropping is to obtain a clear image and to remove noise from the normalized image as the deleted half of it. Thus, the ROI of the enhanced of normalized image is the better image which have the same constant dimensions.

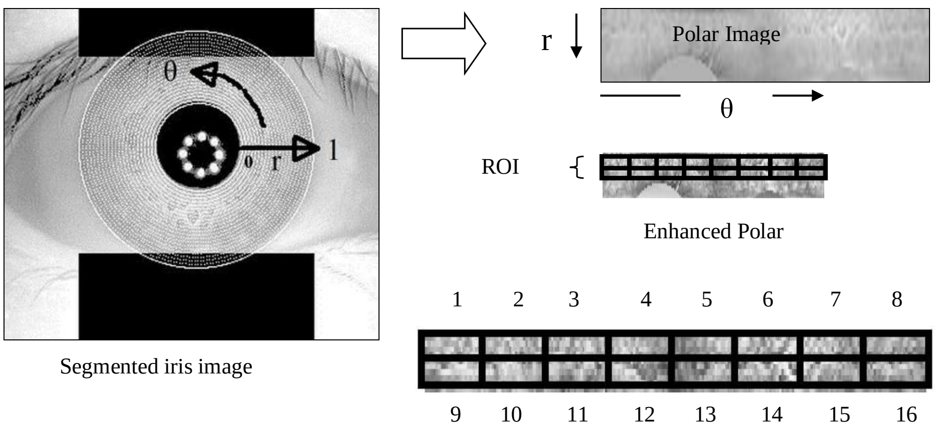

Figure 3. Schema of proposed normalization technique

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c. Features extraction

In this work, the GLCM technique is implemented to extract texture features differentiating iris of person for classification. This technique has been used in our previous work [43, 44]. This technique depends on second order statistics of the pixel intensities. The main aim of this technique is to obtain the features matrix used for the comparison purpose. The co-occurrence matrix estimates the joint probability distribution function of gray level pairs in an image. It provides a simple approach to capture the spatial relationship between two points in a texture pattern. In this paper, the matrices are constructed using Matlab function for the GLCM at a distance of d=2 and at angles incremented from θ= 0°, 45°, 90°, and 135°. Contrast, correlation, energy, and homogeneity of pixel values are extracted as features for this research. They are calculated from the partition of the enhanced normalized iris image using pixels as primary information.

The specific features considered in this research are defined as follows:

1. Contrast : $$f1 = \sum_{n=0}^{N_g-1} n^2 \left\{ \sum_{i=1}^{N_g} \sum_{j=1}^{N_g} p(i,j) \Big| |i-j| = n \right\} \qquad (6)$$

2. Correlation: $$f2 = \frac{\sum_i \sum_j (ij) p(i,j) - \mu_x \mu_y}{\sigma_x \sigma_y} \qquad (7)$$

3. Energy: $f_3 = \sum_i \sum_j p(i,j)^2$ (8)

4. Homogeneity: $f4 = \sum_i \sum_j \frac{1}{1+(i-j)^2} p(i,j)$ (9)

The algorithm for the features extraction by using the GLCM is presented below:

1. Obtain the pixel values of 16 partitions of the enhanced normalized image from Sub section 2.2
2. Apply the GLCM techniques in terms of distance and angle, d= 2 and θ=0° to 135°
3. Calculate the contrast, correlation, energy, and homogeneity values for the partitions simultaneously using equation 17 to 20.

2.3 Discriminant analysis

Hamming distance, Euclian distance, neural networks are employed by several researchers in iris recognition. As reviewed, they have good capability to classify iris classes. Their capabilities and performances are compared with our approach in term of accuracy with different data, amount of data, and classifiers. To ensure our approach capability and robustness, several techniques are also tested using our data and same classifier. In this study, discriminant analysis (DA) is chosen as a classifier tool for differentiating iris classes of the used eye images. DA is method implemented in numerous software and easy to be implemented as classification tools. The technique has direct analytical solution and very good at detecting global phenomena. The technique is simply defined and implemented, especially if there is insufficient data to adequately define sample means and covariance matrices.

Based on section 2.2, a proposed iris recognition algorithm includes segmentation, proposed normalization, features extraction, and classification. The algorithm contains segmentation using circular Hough transform, new normalization technique based on Daugman rubber sheet model, texture features extraction using GLCM technique, and classification using discriminant analysis. To compare the capability of the proposed normalization algorithm performance, there are nine types of different normalization techniques (i.e. T1=full iris 20x240 pixels, T2= 20x240 pixels plus enhancement, T3= 20x120 pixels for first of half iris, T4= 20x120 pixels plus enhancement for first of half iris, T5= 20x120 pixels for second of half iris, T6= 20x120 pixels plus enhancement for second of half iris, T7= 10x240 pixels, T8= 10x240 pixels using 8 partitions, and T9= 10x240 pixels using 8 partitions plus enhancement) then follow by the GLCM technique and DA classifier for features extraction and classification, respectively. Therefore, ten types of data input based on ten different normalization techniques are then fed into the DA classifier to test each performance. The comparison of each of the normalization techniques are conducted in four datasets:

1. based on contrast matrix features,
2. based on correlation matrix features,
3. based on energy matrix features,
4. based on homogeneity matrix features.

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3. Results and Discussion

3.1 Segmentation, normalization, and features extraction

The segmentation model proved to be successful. The CASIA version 3 interval databases provided good segmentation, since those eye images had been taken specifically for iris recognition research and boundaries of iris pupil and sclera were clearly distinguished. For the CASIA database, the segmentation technique managed to correctly segment the iris region from 1484 out of 1664 used eye images, which corresponds to a success rate of around 89.2%. The problem images had small intensity differences between the iris region and the pupil region. The eyelid detection also proved quite successful and managed to isolate most occluding eyelid regions. One problem was that it would sometimes isolate too much of the iris region, which could make the recognition process less accurate, since there is less iris information. However, this is preferred over including too much of the iris region, if there is a high chance it would also include undetected eyelash and eyelid regions. The eyelash detection implemented for the CASIA version 3 interval database also proved to be successful in isolating most of the eyelashes occurring within the iris region as shown in Figure 4. A slight problem was that areas where the eyelashes were light, such as at the tips, were not detected. However, these undetected areas were small when compared with the size of the iris region. Therefore, cropping the iris area after normalization process is important to obstacle some previous problems in segmentation using circular Hough transform.

The normalization process proved to be successful as presented in Figure 4. The rectangular representation is constructed from 4.800 data points or 20x240 pixels in each iris region. As stated in previous section, the rectangular representation is the suitable form for comparison purpose due to same dimension. To obstacle the problem existing after segmentation process and to improve accuracy, the normalized image is enhanced and determined the region of interest (ROI) for further process in extraction features.

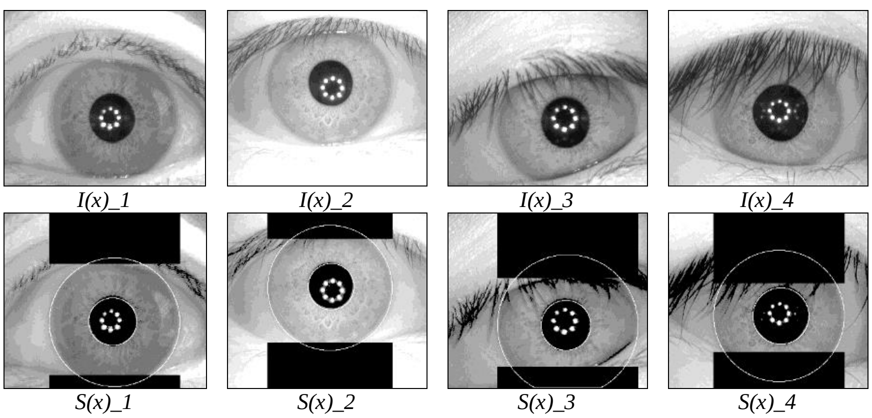

Figure 4. Original iris images and it's segmentation images

The region of interest in this study is 10x240 pixels. To obtain representative features, the ROI is divided to be 16 partitions as presented in section 3.2.1c. Features (i.e. contrast, correlation, energy, and homogeneity) are extracted in each partition. Therefore, the features for each enhanced normalized image are 16x8 contrast values, 16x8 correlation values, 16x8 energy values, and 16x8 homogeneity values. It means that each partition has 8,8,8,8 of contrast, correlation, energy, and homogeneity features values respectively. Therefore, each image has 128 contrast features, 128 correlation features, 128 energy features, and 128 homogeneity features.

3.2 Classification

For presenting the objective of comparison as presented in section 2.3, nine types of normalization are used to compare the capability and performance of the proposed normalization algorithm as tabulated in Table 1. The datasets are fed into DA employed as classifier tool to differentiate the used data. To demonstrate the robustness of the proposed approach, in our experiments, a large publicly and freely available iris databases, CASIA, are used as stated in previous section.

DA based features	Correct classification rate (CRR)%									
	Proposed algorithm	T1	T2	T3	T4	T5	T6	T7	T8	T9
contrast	100	40.7	56.2	35.0	42.3	47.5	60.4	59.9	99.5	99.9
correlation	100	45.0	56.9	36.4	41.8	52.5	63.3	62.8	99.6	100
energy	96.6	19.0	26.8	16.2	19.9	18.2	23.1	32.1	95.6	91.2
Homogeneity	100	38.7	34.5	33.4	28.7	37.4	31.3	36.7	99.5	99.0

Table. 1 Classification results of the features matrix of ten different normalization techniques

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Based on Table 1, the proposed normalization algorithm is the best between nine other techniques. All of used features can achieve more than 95% of accuracy if it is used as input features into classifier. In the other hand, performances of T8 and T9 techniques are also achieved high accuracy values 91.2 to 99.9% of accuracy for all used features by using the GLCM technique. Therefore, it approves that the GLCM technique is a good technique to extract texture features.

At present, only small data sets are used to evaluate recognition performance for iris recognition by most algorithms as tabulated in Table 2. As presented in Table 2, there are several researchers using characteristic similarity distance as classifier [5], [17], [18], [24]. Daugman [5] achieved good accuracy performance by using their own captured data, Gabor filter as features extraction and hamming distance as classifier. In 2004, Ma et al. [18], [17] by using 2 255 iris images, a particular class of wavelets, Gaussian-Hermit moments extracting 50 features, and Euclian distance or nearest center classifier based on cosine similarity measure as classifier can achieved 98.25% and 98.73% of accuracy, respectively. Chang et al. [24] used Empirical Mode Decomposition (EMD), Mean of the Euclidean distances (MED) for 249 classes reduced by failure iris locating images of CASIA database using 16384 features which they obtained good performance.

Techniques and Classification Results	Correct recognition rate (CRR)%
2D Gabor filter, and Hamming distance [5]	99.78%
Gaussian–Hermite moments, and Euclian Distance [18]	98.25%
Gaussian–Hermite moments, and nearest center classifier based on cosine similarity measure [17]	98.73%
Fourier-wavelet , and modified neural network Huang et al. [28]	94.37%
Linear Hough, and neural network Abiyev & Altunkaya [29]	99.25%
Empirical Mode Decomposition (EMD), Mean of the Euclidean distances (MED) Chang et al. [24]	98.22%
ant colony optimization (ACO) based segmentation and a self-organized feature map (SOFM) neural network Ma et al. [30]	93.9%
Circular Hough transform, and Elastic graph matching (EGM) Farouk [35]	98.7%
Proposed system based contrast or correlation, or homogeneity features	100%

Table 2 The correct recognition rates achieved by four matching measures using the CASIA

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In the other hand, there are several studies using neural network for classification purpose that also obtaining good performance [28], [29], [30]. Huang et al. [28] extracted features using Fourier-wavelet technique then they achieved 94.37% of accuracy. While, Abiyev & Altunkaya [29] applying Linear Hough transform to extract features achieved 99.25% of accuracy. Ant colony optimization (ACO) based segmentation and a self-organized feature map (SOFM) and neural network are applied by Ma et al.

[30] for 900 used images achieved 93.9% of accuracy. Farouk [35] used circular Hough transform as features extraction technique for 249 classes reduced by failure iris locating images of CASIA database, and Elastic graph matching (EGM) for classifier. This study achieved good performance with 98.7% of accuracy.

Only the approaches proposed by Ma et al. [17], Chang et al [24], Ma et al. [30], Farouk [35], and our approaches have been tested on large image sets involving more than 200 subject. In this study, we achieved good performance using a proposed system as presented in this paper. However, it is not really objective for comparison due to different conditions of data.

4. Conclusion

Here we have presented a new and effective approach for iris recognition which operates using the combination of several algorithms to produce good performance. The algorithm approach is tested for CASIA irises databases. All recognition rates are more than 95%. Therefore, the proposed iris recognition algorithm has demonstrated to be promising for iris recognition and is suitable for identification process. In future work, we will improve the processing method for iris segmentation to reduce the influence from light, eyelid, and eyelash. Furthermore, features selection will be employed to further improve the performance of the system.

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The conclusion should contains problem, objectives, method, results, conclusion, and future works if available.

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Declarations

Author contribution

All authors contributed equally as the main contributor of this paper. All authors read and approved the final paper.

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