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Performance Analysis of Iris Recognition System- A Review

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Abstract

In this Review paper, it is summarize and compare the methods of automatic identification of iris recognition used in different stages. In particular, Iris image acquisition, Segmentation, Normalization, Feature encoding and matching steps are studied and compared. In Segmentation and Normalization stage, iris image is converted into standard format with contrast manipulation; noise reduction by filtering process and transformation. From the rest of the acquired image segmentation process delimits that iris image. In segmentation, the number of resources which required describing large set of data should be selected and simplified.

Keywords- Iris recognition system, Segmentation, Feature extraction, Matching algorithm.

Introduction

Iris Recognition

Iris recognition is a highly effective and efficient identification technology which is regarded as a reliable and tremendously accurate biometric system. Iris is the annular portion between the dark pupil and the white sclera which provides many interlacing minute characteristics. Iris has a rich uniqueness of differences in anatomical texture information which is essentially stable over a person's life. The personal identification systems are noninvasive to their users based on iris recognition system. Iris recognition system consists of four stages such as iris acquisition, segmentation, normalization, feature extraction and matching which leading to a decision.

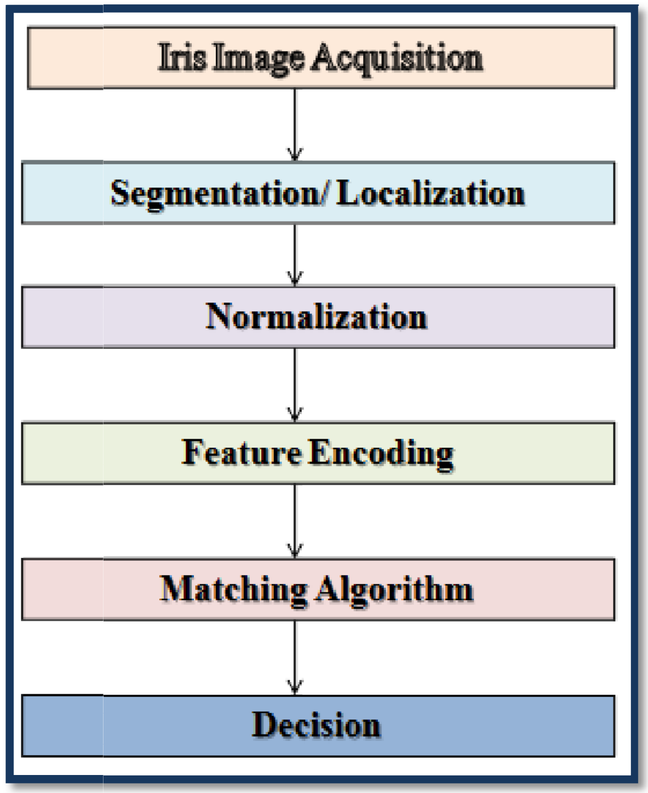

Figure 1. Iris Recognition Systems

Iris recognition is an automated identification method that uses mathematical *Pattern Recognition* techniques on the unique features of an individual's eyes to provide an unmatched identification technology. In iris recognition system, accuracy is most considerable one. Because accuracy of iris recognition system depends on reduce the false acceptance rate and increase the false rejection rate. The following five main reasons to answer why iris recognition is more important.

- Its error rate is very low.
- Iris is a permanent biometric.
- User acceptability is reasonable.
- Real time biometric verification.
- Less susceptible to spoofing.

Iris Image Acquisition

The acquisition stage obtains the images of an eye. Iris images are generally acquired in near infra red illumination. The variation of distance between the eye and the camera from 4-50 cm. For extracting good texture with the intensity level Iris diameter typically should be between 100-200 pixels. The Chinese Academy of Sciences (CASIA) iris image database collected 756 iris images from 108 eyes over two sessions with noise free and perfect imaging conditions. UBIRIS database collected 1877 images from 241 persons over two sessions. LEI database is a small database of 120 grayscale images with noise. UPOL database having the localization work which includes images from the internal part of the eye.

Table 1. An overview of Iris image acquisition cameras

Acquisition Cameras	Remarks
NIR camera[40].	The maximum operational distance is 60 cm with near infrared illuminator. The typical resolution 640×480 used for iris identification with commercial availability.
High Resolution camera[6].	The visual light illuminator operated in maximum distance 5 cm with typical resolution 6144×4096. It is used for iris pattern analysis and it has challenges against intrusive capture and short operational distance
Telescope type camera[19].	The maximum operational distance of telescope type camera is 3 m with near infra red illuminator. It is used in iris surveillance and more challenges against eye safety.

Segmentation/Localization

The Iris is located in between the pupil and sclera. The darker part of the eye is pupil. Iris localization technique is locate and isolates the iris region. The spatial extent in the eye image segments the iris by isolating it from other structures such as the sclera, pupil, eyelid and eyelashes. The Canny operator used to obtain the accurate parameters of the pupil and limbus and the Hough transform obtain the center of the pupil.

Table 2. An overview of Segmentation Algorithm

Methods	Remarks
Coarse to fine strategy and integro-differential operator[9].	In the coarse stage technique, from the rescaled image finds outer iris boundary as circles using integro-differential operator in order to improve localization time.
Canny edge detector with Hough transform and Homocentric circle algorithm[16].	Normal line algorithm is created for finding center and inner edge by means of canny edges. To find outer edge by Homocentric circle algorithm which improve localization speed.
Bisection method and Histogram equalization[35].	The Bisection method used to find inner boundary and eyelid position is used to find the outer boundary. To find out the correlate boundary by Histogram equalization and statistical information. When iris image is blurred, it is difficult to locate the boundary between the iris and the sclera.
Graph cuts[28].	Non-ideal images has been developed using graph cuts for a robust segmentation approach with pixel label error rate 5.9%.
Moments and clustering	Small windows of the image as texture features by using the

algorithm[27].	moments then applying a clustering algorithm to segment the image with 98.02% good dataset and 97.88% noisy dataset.
Modified Hough transform[14].	Modification to Hough transform for circle to restrict votes for center location based on direction of edges. The detected portion of iris is divided into four parts for eyelid detection. The eyelid in each of these windows is detected and results are connected together.
Phase congruency analysis[25].	It detects edge points and fit ellipses to the detected edge points.
Geometric active contours[30].	From eyelashes apply opening operators to suppress interference and the pupil and limbic boundaries approximate elliptical boundaries. Geometric active contours refine the detected boundary to a narrow band over the estimated boundary.
Active contour method[31].	In non-ideal iris images, a level set style active contour method for finding the pupil and iris boundaries.
Starburst method[32].	Smoothing and gradient detection preprocess the image and find a pupil location as a starting point for the starburst method. Then set the darkest 5% of the image to black and other pixels to white.
Two level Hierarchical approach and active contour approach[38].	First, find an approximate initial pupil boundary, modeled as an ellipse with five parameters in order to improve the speed of active contour segmentation. With the maximum intensity change, the parameters are varied in a search for a boundary. Active contour approach refined the approximate iris boundaries.
Parabolic integro-differential operator[25].	A method for eyelid detection in visible light images uses a parabolic integro-differential operator for iris localization. Then compare lower pixel error rate and algorithm involving the IDO using detected edge pixels.
Iris BEE algorithm[26].	The two eye detection rate in the videos was 97.7%. The segmentation rate was 81.5% and the matching rate was 56.1% which is used for segmentation and feature extraction.
Lighter computation algorithm[7].	Lighter computation algorithm dividing the image in a rectangular grid and estimating the average intensity in each cell. The pre-location of the pupil can be finding the cell with smallest luminance. The smallest grey levels based on the pupil region having the pixels.
Dilation and compression operations[2].	Once the pupil is found, in order to find the pupil and iris boundaries as ellipses the standard deviation is computed in both vertical and horizontal direction.
Clustering algorithm and moments[22].	A method of texture based segmentation which applies a clustering algorithm to segment the image which uses the moments of small windows of the characteristic feature image.
Canny edge detection and Hough transform[37].	Before applying Canny edge detection and Hough transform estimates the center of the pupil with certain threshold of a

	grey level.
Active contour models[1].	Active contour models which use texture analysis and nested cuts are used to find the elliptical iris shape on off-angle images.
Rotation and scaling transform[13].	An ellipse used to fit the pupil boundary and then applies these transform the image off angle and turn it into a circumference.
Phase consistency[12].	It used to obtain edge information and find noise boundaries and occlusion regions in order to improve the detection of eyelid and eyelashes occlusion and specular reflections.
Hough Linear Transform[18].	To perform the detection of eyelashes based on the Hough Linear transform. By applying noise masks created through a threshold of the grey level histogram used to detect eyelids.

Normalization

After locating the iris, the locating iris image cannot carry on the code immediately and firstly should carry on the calibration. To unwrap the segmented region using Daugman's rubber-sheet model, mapping points from the Cartesian coordinate system of the original image into a normalized polar region. The normalization process have the same constant dimensions will produce iris regions. At the same spatial location two photograph of the similar iris under different conditions will have characteristic features.

The angular resolution, which determines how many sample points selected around the iris circumference. Along any given rays the radial resolution, which specifies how many points sampled between the pupil and limbic boundaries. Band averaging is another technique to initially create a larger normalized image. When generating the iris code, then average neighboring rows to create a smaller image is used.

Feature Encoding

From the preprocessing step, with the normalized iris image proper iris features can be extracted. In the feature encoding process, the template is generated which also need a corresponding match metric gives a measure of similarity between two iris templates. During the feature extraction step the uniqueness of the characteristics extracted that will determine the reliability of the recognition.

A set of features will be assigned to each iris pattern obtained which allows the computation of a similarity measure between two iris patterns. When the patterns are generated by the same eye the similarity value must be within predefined range to make a reliable decision about the identity of an iris pattern known as interclass comparisons. When patterns created by different eyes are compared within different range known as interclass comparisons.

The meta-heuristic is a nature-inspired approach which is applied for finding solutions of difficult combinatorial optimization problems. The Evolutionary methods such as Tabu Search, Harmony Search, Genetic

Algorithm, Particle Swarm Optimization, K-Nearest Neighbor, Bee Colony Optimization and Ant Colony Optimization can be used to perform the feature selection which optimizes the measure of probability in image processing[41-68].

Table 3. An overview of feature encoding technique

Methods	Description
Gaussian filter[34].	The gradient vector of an iris image is convolved with a Gaussian filter which is used for texture representation, yielding a local orientation at each pixel from normalized iris image.
Dyadic wavelet transform[17].	Dyadic wavelet transform of a sequence of 1-D intensity signals around the inner part of the iris has been used to create a binary iris code which system achieves 0.07% of EER.
Modified Log Gabor Filter[19].	Gabor filter are not band pass filters but Log-Gabor filters are strictly band pass filters.
Discrete Cosine Transform[23].	DCT is used in feature extraction and is applied rotated at 45 degree from radial axis to rectangular patches.
Hilbert transform[4].	The texture analysis have done by computing the analytic image which is the sum of the original image signal and Hilbert transform of the original signal.
2D Wavelet Demodulation[5].	It provides the Correct Match rate is 100%.
1D Log-Gabor filter[6].	A typical 1D Log-Gabor iris biometric system on a digital signal processor (DSP), and shows the relative speed of software versus DSP implementation.
Ordinal features[33].	The representation of relative intensity relationship between regions of iris image filtered by multi-lobe differential filters using ordinal features.
2D Discrete Wavelet transform[36].	It is applied to overlapping 32×32 pixel blocks and achieves 0.66% EER on the data.
Wavelet coefficients based on a wedge let dictionary[29].	The wedge let is parameterized by a square region into two sections such as the distance of the segment from the center of the square and the angle of the segment.
Self Organizing Map[3].	A Self Organizing Map neural network to divide the binary image into nodes which compute Voronoi polygons from the topological graph of the image. It achieves 99.87% correct recognition on the iris data.
Indexing algorithm with multi resolution discrete cosine transform[20].	An indexing algorithm used to reduce the search time. Using a multi resolution Discrete Cosine Transform divide each unwrapped iris image into sub bands to create a histogram of transform coefficients for each sub band. To search for a match to a new image, the algorithm computes the key for the new image, retrieves all irises with matching keys from the database, and compares iris templates from the retrieved set.

Matching Algorithm

All of the feature extraction algorithms presented before give as a result a sequence of numbers or a pattern and it give no information about their relation with the templates stored in the database. After generate the iris code of the image, need to compare this template and see if any matching occurs. Once the features have been extracted, a pattern matching procedure is done, which can be divided into,

1. *Evaluation of the similarity* with the stored information, resulting in a similarity score.
2. *Recognition decision*: acceptance/rejection of the user.

In general, the recognition decision stage is based on a threshold that regulates the acceptance/rejection decision. The level of security that the application requires will make its value more or less strict, increasing the number of false rejections or the false acceptances accordingly.

Table 4. An overview of matching algorithms

Approach	Remarks
Pyramid technique[21].	Pyramid technique has been proposed in indexing hand geometry database to 8.86% of original size with 0% FRR.
B+ tree[8].	B+ tree provides an efficient indexing scheme for binary feature template.
Modified B+ tree[11].	For biometric database indexing the modified B+ tree projected to lower dimensional feature from the higher dimensional feature vector which used to index the database by forming B+ tree.
KD-Tree[10].	An efficient indexing technique is based on KD-tree with feature level fusion which uses the multi dimensional feature vector.
PCA and block based image statistics[24].	PCA uses the iris code while block based on features extracted from iris structure.

Summary and Conclusion

In this survey paper various performance analysis of iris recognition has been studied and compared with number of approaches used in iris recognition systems. This is used to focus on the future of developments of iris recognition systems. Iris recognition system described several methods and to discussed requirements and properties of techniques in iris recognition. This paper is used to give more information about iris segmentation and feature extraction. It is a milestone for analyzing all technologies relevant to iris recognition system. In this paper, various steps in automatic identification: i) Iris image acquisition ii) Segmentation iii) Normalization iv) Feature

Extraction and v) Matching Algorithm and their performance have been studied and compared.

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