Iris Recognition using Secant Lines Segments Histogram

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Abstract

Biometrics is a method for recognizing based on physiological and behavioral characteristics. Iris recognition is one of the robust biometric technologies used for authentication applications. An iris recognition system is composed of segmentation, normalization, feature extraction and matching. The performance of iris recognition system depends on the selection of iris features. Most commercial iris recognition systems used patented algorithms developed by Daugman's Gabor filter for feature extraction. These methods have large computation. To overcome this problem, a new effective method, Secant Lines Segments Histogram, is proposed for extracting features of iris. In this paper, Hough Transform is applied for localizing the iris region. The segmented iris is normalized using Daugman's Rubber Sheet Model. For extracting iris features, Secant Lines Segments Histogram is used. The two iris feature vectors are matched using Euclidean Distance. The proposed iris recognition system reduces the computation and time load for extracting features of the iris.

Keywords: *Daugman's Gabor Filter, Secant Lines Segments Histogram*

1. Introduction

In the present world with the advancing technologies, the necessity of security increases. With the development of information technology and the increasing need for security, intelligent personal identification has become a very important topic. Traditional methods for personal identification are based on token (a physical key, ID card) or knowledge (a secret password, PIN) [1]. These methods suffer from various problems. For example, ID cards may be forged or lost, and passwords may be forgotten or guessed. Biometric solutions address these fundamental problems because an individual' biometric data is unique and cannot be transferred. Biometric systems provide reliable recognition schemes to determine or confirm the individual identity. Biometrics has capability to distinguish between authorized user and an imposter. An advantage of using biometric authentication is that it cannot be lost or forgotten, as the person has to be physically present during at the point of identification process. The commonly used biometric features include speech, fingerprint, face, iris, voice, hand geometry, retinal identification, and body odor identification. Compared with other biometrics, iris recognition is more reliable and accurate for authentication process due to these various characteristics such as unique, universal, stable, etc. Iris recognition is most accurate and reliable biometric identification system available in the current scenario [2].

Applications such as passenger control in airports, access control in restricted areas, border control, database access and financial services are some of the examples where the iris recognition technology has been applied for more reliable identification and verification.

2. Related Works

The concept of iris recognition was first proposed by Dr. Frank Burch in1939. It was first implemented in 1990 when Dr. John Daugman created the algorithms for it. Plenty of works are done on iris recognition system by many researchers. Most of the cases, authors claimed the better performance of speed in capturing images and recognition over the existing systems available at that time. To gather the knowledge, the following selective works have been considered.

Daouk et al., [3] have described a novel technique for iris recognition. In this technique, a fusion mechanism that amalgamates both, a Canny edge detection scheme and a circular Hough transform are used, to detect the iris' boundaries in the eye's digital image. And then the Haar wavelet is used in order to extract the deterministic patterns in a person's iris in the form of a feature vector. The quantized vectors are compared using the Hamming Distance operator to determine the similarity of them.

P. Verma et al. [4] used Daugman's algorithm segmentation method for iris recognition. Iris images are selected from the CASIA Database, then the iris and pupil boundary are detected from rest of the eye image, removing the noises. The segmented iris region was normalized to minimize the dimensional inconsistencies between iris regions by using Daugman's Rubber Sheet Model. Then for the features of the iris were encoded by convolving the normalized iris region with 1D Log-Gabor filters and phase quantizing the output in order to produce a bit-wise biometric template. The Hamming distance was chosen as a matching metric, which gave them measure of how many bits disagreed between the templates of the iris.

3. Proposed Iris Recognition System

Iris recognition is a method by which the system recognizes a person by their unique identical feature found in the eye. The proposed iris recognition approach is divided into five modules: image acquisition, segmentation, normalization, and feature extraction and matching.

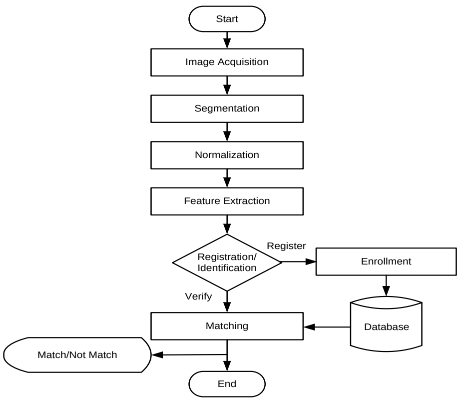

Figure 1. Flow Chart of Iris Recognition System

3.1. Image Acquisition

In order to get a fast and effective iris recognition system, an image is acquired from CASIA database to minimize the requirement of user cooperation. The Chinese Academy of Sciences - Institute of Automation (CASIA) eye image database contains 756 grayscale eye images with 108 unique eyes or classes and 7 different images of each unique eye [5]. Images from each class are taken from two sessions with one month interval between sessions. The images were captured especially for iris recognition research using specialized digital optics developed by the National Laboratory of Pattern Recognition, China. The eye images are mainly from persons of Asian descent, whose eyes are characterized by irises that are densely pigmented, and with dark eyelashes. Due to specialized imaging conditions using near infra-red light, features in the iris region are highly visible and there is good contrast between pupil, iris and sclera regions. The main reason of choosing gray iris image can provide enough information to identify different individuals.

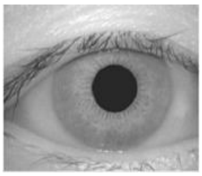

Figure 2. Original Eye Image

3.2. Iris Localization

The important step of iris recognition system is to isolate the actual iris region from the captured digital eye. The iris region can be approximated by two circles, one for the iris/sclera boundary and another for interior of the iris/pupil boundary [6]. The Hough transform is applied on these images after canny edge detection to identify the circles of desired radii (i.e. those corresponding to pupil and iris boundary) and then is marked on the image. The circular Hough transform can be employed to deduce the radius and center coordinates of the pupil and iris regions. Firstly, an edge map is generated by calculating the first derivatives of intensity values in an eye image and then threshold the result. 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.

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

A maximum point in the Hough space will correspond to the radius and center coordinates of the circle best defined by the edge points. However, the eyelids and eyelashes normally obstruct the upper and lower parts of the iris region. Therefore, Eyelids are isolated by first fitting a line to the upper and lower eyelids by using Linear Hough Transform. For isolating eyelashes, a simple thresholding technique was used because eyelashes are quite dark with the lowest intensity values when compared with the rest of the eye image. For the eyelids and eyelashes detection process, the coordinates of any of these noise areas are marked using the MATLAB® NaN type, so that intensity values at these points are not misrepresented as iris region data.

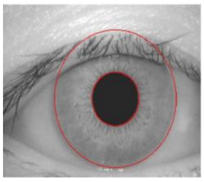

Figure 3. Segmented Iris Region

3.3. Normalization

Once the iris region is successfully segmented from an eye image, the next stage is to transform the iris region so that it has fixed dimensions in order to allow comparisons. The dimensional inconsistencies between eye images are mainly due to the stretching of the iris caused by pupil dilation from varying levels of illumination. Other sources of inconsistency include, varying imaging distance, rotation of the camera, head tilt, and rotation of the eye within the eye socket. 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. Therefore, the segmented iris region is normalized using Daugman's Rubber Sheet Model to transform the iris texture from Cartesian to Polar coordinates [7].

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].

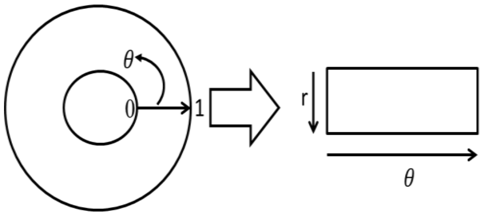

Figure 5. Daugman's Rubber Sheet Model

The remapping of the iris region from (x,y) Cartesian coordinates to the normalized non-concentric polar representation is modeled as:

$$I(x(r,\theta), y(r,\theta)) \longrightarrow I(r,\theta) \qquad (2)$$

with

$$x(r,\theta) = (1-r)x_p(\theta) + rx_i(\theta)$$
$$y(r,\theta) = (1-r)y_p(\theta) + ry_i(\theta)$$

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 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 modeled as a flexible rubber sheet anchored at the iris boundary with the pupil center as the reference point.

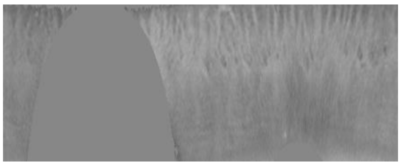

Figure 4. Normalized Iris Region

3.4. Image Enhancement

Image quality is very important factor in the performance of an iris recognition system. When the higher quality images are not available the iris recognition can be compromised by using the low quality images such as those acquired in a non-invasive, non-cooperative environment, e.g. iris images obtained at a distance and on the move. These images characterized by abundant degrading factors such as low resolution, lighting and contrast, extensive specular reflections, eyelid occlusion and presence of contact lenses, etc.

The normalized iris image still has low contrast and may have non-uniform illumination caused by the position of light sources. Histogram equalization is a technique that generates a gray map which changes the histogram of an image and redistributing all pixels values to be as close as possible to a user-specified desired histogram. It allows for areas of lower local contrast to gain a higher contrast [8].

Histogram equalization automatically determines a transformation function seeking to produce an output image with a uniform Histogram. This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. Histogram equalization automatically determines a transformation function seeking to produce an output image with a uniform Histogram.

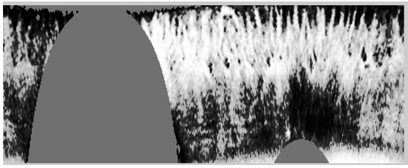

Figure 6. Enhanced Normalized Iris Texture

3.5. Feature Extraction

The most important step in iris recognition is the ability of extracting some unique attributes from iris, which help to generate a specific code for each individual. Feature extraction identifies the most prominent features for classification. The most discriminating information present in the iris texture can be extracted using secant lines segments algorithm.

3.5.1. Secant Lines Segments Histogram

Most commercial iris recognition systems used patented algorithms of Gabor filter for extracting features of iris. However, it has large computation and time load because, in patented algorithm of Gabor filter method, all pixels in iris texture are convolved to extract features of iris texture. To overcome this problem, secant lines segments histogram feature extraction method is proposed.

The procedure of proposed feature extraction method of accurate iris recognition system is followed as:

Step 1: Load the normalized iris image.

Step2: Convert the normalized image to binary image.

Step3: Set the secant lines on the normalized iris texture such as 10 lines, 20lines, 30 lines and 50 lines.

Step4: Generate histogram of same interval of length of iris texture between black and white along the secant lines.

In this proposed feature extraction approach, the normalized input image is gray scale image. This gray scale iris image is converted into binary iris image. Converting binary image can provide information present in iris texture clearly for extracting iris features.

Then, the secant lines are set horizontally such as 10 lines, 20 lines, 30 lines, 40 lines and 50 lines. Generally, the more the secant lines, the better the recognition rate. This proposed iris recognition approach is tested using different numbers of secant lines to evaluate the best accurate recognition rate and the less run time of its system.

Finally, the same interval of length of iris features along a secant line are counted between black and white such as 1-10 pixels length, 11-20 pixels length,…,151-160 pixels length. Therefore, 1-10 pixels length of iris feature contains from one pixel length of iris feature to ten pixels length of feature of iris. For each secant line, there are 16 bins in a histogram. If 10 secant lines are set, secant lines segments histogram has 160 bins. So, in a secant lines segment histogram, the number of bins depend on setting of the number secant lines on iris texture.

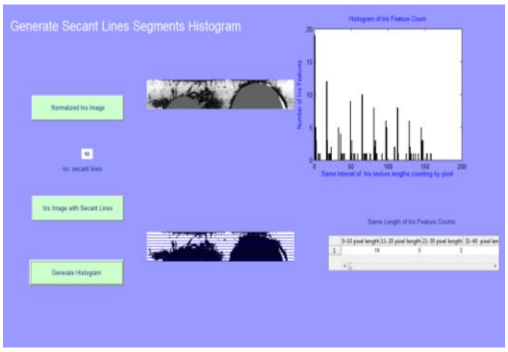

Figure 7. Feature Extraction Using Secant Lines Segments Histogram

3.6. Matching

Once the histogram generated from feature extraction stage will need a corresponding matching metric, which gives a measure of similarity between two iris templates. This metric should give one range of values when comparing templates generated from the same eye and another range of values when comparing templates created from different irises. These two cases should give distinct and separate values so that a decision can be made with high confidence as to whether two templates are from the same iris or from two different irises.

Euclidean distance is used to match the two iris feature vectors in iris recognition system [9]. Euclidean distance between two points in p-dimensional space is a geometrically shortest distance on the straight line passing through both the points. For a distance between two p-dimensional features x = (x_1, x_2,…, x_p) and y_1= (y_1,y_2,…,y_p) the Euclidean metric is defined as:

$$d(x,y) = \left[\sum_{i=1}^{p} (x_i - y_i)^2 \right]^{1/2} \quad (3)$$

4. Performance Evaluation

The performance of the iris recognition system as a whole is examined. Tests are carried out to find the best threshold, so that the false accept rate and false reject rate are minimized, and to confirm that iris recognition can perform accurately as a biometric for recognition of individuals.

The performance of the proposed iris recognition approach could be measured by recognition rate and time complexity. Recognition performance has many measurement standards. In this proposed iris recognition approach, the performance of recognition rate can be measured by the following equation.

Recognition Rate = 100-(FAR+FRR) (4)

Recognition rate or accuracy can be defined by two error rates, false acceptance rate and false rejection rate that can be used in order to test the system accuracy: FRR and FAR.

FRR: FAR is the probability that an enrolled person is not identified by the system, and it occurs only when comparing multiple versions of the iris image from the same human subject.

$$(\%)FRR = \frac{\text{No.of incidents of false rejections}}{\text{Total No.of samples}} * 100\% \quad (5)$$

FAR: FAR is the probability that an imposter is identified as an enrolled person, and it occurs only when comparing the iris image of different classes from different human subjects.

$$(\%)FAR = \frac{\text{No.of incidents of false acceptances}}{\text{Total No.of samples}} * 100\% \quad (6)$$

In addition, True Acceptance Rate (TAR) is also important in an iris recognition system. The true accept rate is a statistic used to measure biometric performance when performing the verification task. It is the percentage of times a system (correctly) verifies a true claim of identity. True Acceptance occurs when the system says that an unknown sample matches a particular person in the database and the match is correct.

$$(\%TAR) = \frac{\text{Number of accidents of True Acceptances}}{(\text{Number of accidents of True Acceptances} + \text{Number of accidents of Flase Rejections})} * 100 \quad (7)$$

The main objective of an iris recognition system is to achieve the best recognition rate and true accept rate. In this iris recognition system, CASIA database is used for acquisition. From this database, 700 grayscale images of 100 images of different person or classes are tested to evaluate the performance of iris recognition system.

The proposed feature extraction method is tested using different number of secant lines such as 10 lines, 20 lines, 30 lines, 40 lines and 50 lines to evaluate the best accurate recognition rate. The more the secant lines, the better the recognition rate.

Table (1) shows the results of false acceptance rate, false rejection rate, recognition rate and true acceptance rate using 50 secant lines with different thresholds that are the values of Euclidean distance in matching of iris features vectors.

According to Table (1), when the threshold value is decreased, the false acceptance rate is decreased and the false rejection rate is increased. But, although false rejection rate is increased, it is a little impact on the recognition rate because this increased false rejection rate is very low. In addition, true accept rate is also important in the iris recognition system. In this analysis, 7 different thresholds (Th.) are used such as “<90”, “<82”, “<81”, “<80”, “<78”, “< 76” and “<70”. From Table (1), the threshold value “<80” is chosen as a best threshold to get the appropriate recognition rate of 81.28% and true accept rate of 79.43%.

Table 1. FAR, FRR, Recognition Rate and True Accept Rate with Different Thresholds Using 50 Secant Lines

Th.	FAR (%)	FRR (%)	Recognition Rate (%)	True Accept Rate (%)
<90	31.28	0.09	68.63	90.57
<82	20.88	0.18	78.95	82.29
<81	19.70	0.20	80.11	80.29
<80	18.51	0.21	81.28	79.43
<78	16.30	0.24	83.46	76.43
<76	14.18	0.27	85.55	72.71
<70	8.42	0.36	91.22	63.71

5. Comparison of Secant Lines Segments Histogram and 1 D Log Gabor Filter

Most commercial iris recognition systems used patented algorithms of Gabor filter for extracting feature of iris. The 1D log Gabor filter is one of patented algorithms of Gabor filter feature extraction method. Figure (8) compares the recognition rate and true accept rate of iris recognition systems in which 1 D log Gabor Filter and secant lines segments histogram are used. According to figure (8) secant lines segments histogram feature extraction method provides more recognition rate than 1D Log Gabor Filter.

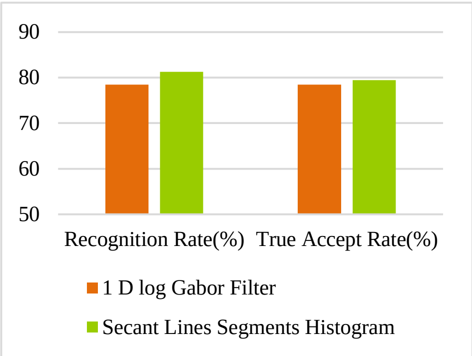

Figure 8. Comparison of Recognition Rate and True Accept Rate of 1D Log Gabor Filter and Secant Lines Segments Histogram

Time complexity is an important factor in the iris recognition system. Figure (9) shows time complexity of 1D Log Gabor Filter and Secant Lines Segments Histogram. However, it has large computation and time load because all pixels in iris texture are convolved to extract features of iris texture.

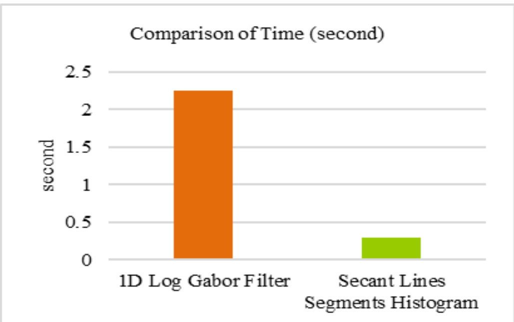

Figure 9: Comparison of Run Time of 1 D Log Gabor Filter and Secant Lines Segments Histogram

To overcome this problem, secant lines segments histogram feature extraction method using 50 secant lines is proposed. In the proposed feature extraction method, the same distance of iris textures are counted along secant line as a histogram. So, the proposed feature extraction method reduces the computation and time load for extracting features of iris texture.

6. Conclusion

This paper has presented an iris recognition system for security, which is tested using CASIA database, a database of digitized gray scale eye images, in order to get accurate and efficiency rate. In order to get accurate recognition, a new and effective feature extraction method, secant lines segments histogram is used for extracting iris features. The proposed feature extraction method provides different irises feature counts for different irises. Secant lines segments histogram feature extraction method provides more recognition rate than 1D Log Gabor Filter. Moreover, the proposed iris recognition approach reduces the computation and time load for extracting features of iris texture than 1D Log Gabor Filter.

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