Iris Recognition System using Biometric Template Matching Technology

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ABSTRACT- The world today is making rapid progress in its quest to realize the dream of a creating a user friendly, customer caring ambience. With every new dream comes the nightmare of a security of the system lapse which may allow the misuse of the system. A major success in trying to bridge the advent of a security lapse is the use of biometrics. Biometric technologies such as fingerprint, facial recognition, and iris recognition are deployed for verification and/or identification in applications such as access control, border management, and Identification systems. The work presented in this paper developing an 'open-source' iris recognition system in order to verify both the uniqueness of the human iris and also its performance as a biometric. The system performed with perfect recognition on a set of 40 eye images. The recognition scheme presented here is more reliable and accurate biometric technology.

Index Terms—*Degrees-of-freedom (DOF), Hamming distance (HD), Iridium Technologies (IRT), JPEG (Joint Photographique Experts Group), Personal Identification Number (PIN).*

1. INTRODUCTION

A biometric system provides automatic identification of an individual based on a unique feature or characteristic possessed by individual. The iris is an externally visible, yet protected organ whose unique epigenetic pattern remains stable throughout adult life. These characteristics make it very attractive for use as a biometric for identifying individuals.

The human iris is rich in features which can be used to quantitatively and distinguish one eye from another. The iris contains many collagenous fibers, contraction furrows, coronas, crypts, color, serpentine vasculature, striations, freckles, rifts, and pits. Measuring the patterns of these features and their spatial relationships to each other provides other quantifiable parameters useful to the identification process.

Statistical analyses of iris indicate that the IRT process uses 240 DOF (Degree Of Freedom), or independent measures of variation to distinguish one iris from another. The availability of these many degrees of freedom allows iris recognition to identify persons with an accuracy that is greater than other biometric systems.

When a person wishes to be identified by an iris recognition system, their eye is first photographed, and then a template is created for their iris region. This biometric template contains an objective mathematical representation of the unique information stored in the iris, and allows comparisons to be made between templates. This template is then compared with the other templates stored in a database until either a matching template is found and the person is identified, or no match is found and the person remains unidentified.

2. BASIS OF IRIS RECOGNITION SYSTEM

The iris is a thin circular diaphragm, which lies between the cornea and the lens of the human eye. A front-on view of the iris is shown in Fig. 1.

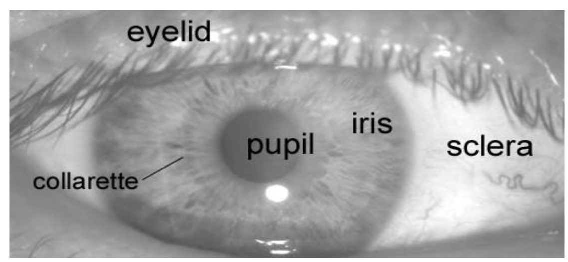

Fig1. front-on view of the iris

Image processing techniques are employed to extract the unique iris pattern from a digitized image of the eye, and encode it into a biometric template, which is stored in a database. The steps in processing is shown in Fig. 2

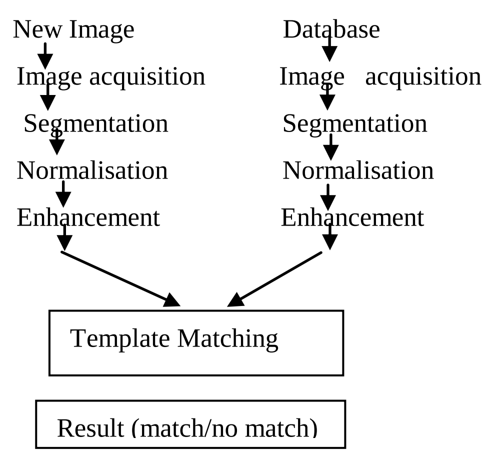

Fig. 2 Processing steps

3. IMAGE ACQUISITION

Image is acquired with following parameters taken into consideration:

- Brightness of surroundings
- Head tilt and distance

Database is composed of 200 images collected from 40 persons in two distinct sessions.

Session 1:

The enrollment noise factors is minimized in the first image capture session,

Session 2:

The second session changed the capture location in order to introduce natural luminosity factor. This enabled the appearance of heterogeneous images with respect to reflections, contrast, luminosity and focus problems.

All images from both sessions are classified with respect to three parameters [1]Focus [2] Reflections and [3] Visible Iris, in a three value scale 'Good', 'Average' and 'Bad'. As shown in Table 1.

Table 1. Classification of Image

Parameters	Focus	Reflection	Visible iris
Good	73.83%	58.87%	36.73%
Average	17.53%	36.78%	47.83%
Bad	8.63%	4.34%	15.44%

4. SEGMENTATION AND BOUNDARY DETECTION

The iris region shown in Fig.1, approximated by two circles one for the iris/sclera boundary and another (interior to the first) for the iris/pupil boundary. Segmentation and boundary detection is implemented in two stages. The first stage is to isolate the actual iris region in a digital eye image. The eyelids and eyelashes normally occlude the upper and lower parts of the iris region. Also, specular reflections can occur within the iris region which may corrupt the iris pattern. Hence second stage of segmentation technique is required to isolate eyelids and exclude these artifacts as well as locate the circular iris region.

An automatic segmentation algorithm based on the Hough Transform is used for creating templates. 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, present in an image. Circular Hough Transform is used for detecting the iris and pupil boundaries and linear Hough Transform is used to isolate eyelids.

4.1 Detection of iris and pupil boundaries

This involves first employing canny edge detection, to generate an edge map. From the edge map, votes are cast in Hough space for the parameters of circles passing through each edge point. These parameters are the centre coordinates x_c and y_c , and the radius r, which are able to define any circle according to the equation no.1

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

A maximum point in the Hough space is corresponds to the radius and centre coordinates of the circle, best defined by the edge points. Gradient is biased in the vertical direction for the outer iris/sclera boundary. Vertical and horizontal gradient is weighted equally for the inner iris/pupil boundary.

4.2Data Base

The range of radius values to search for is set manually, depending on the database used. For the database, values of the iris radius range from 90 to 150 pixels, while the pupil radius ranges from 28 to 75 pixels. In order to make the circle detection process more efficient and accurate, the Hough Transform for the iris/sclera boundary is performed first, then the Hough Transform for the iris/pupil boundary is performed within the iris region, instead of the whole eye region, since the pupil is always within the iris region. After the completion of this process, six parameters, (the radius, and x and y centre coordinates for both circles) are stored in the database.

4.2 Isolation of eyelids

Eyelids are isolated by first fitting a line to the upper and lower eyelid using the linear Hough Transform. A second horizontal line is then drawn, which intersects with the first line at the iris edge that is closest to the pupil. This process is illustrated in Figure 3 and is done for both the top and bottom eyelids. The second horizontal line allows maximum isolation of eyelid regions. Canny edge detection is used to create an edge map, and only horizontal gradient information is taken.

The linear Hough Transform is implemented by using the MATLAB™ Radon Transform, which is a form of the Hough Transform. If the maximum in Hough space is lower than a set threshold, then no line is fitted, since this corresponds to non-occluding eyelids. Also, the lines are restricted to lie exterior to the pupil region, and interior to the iris region. As shown in Fig. 3

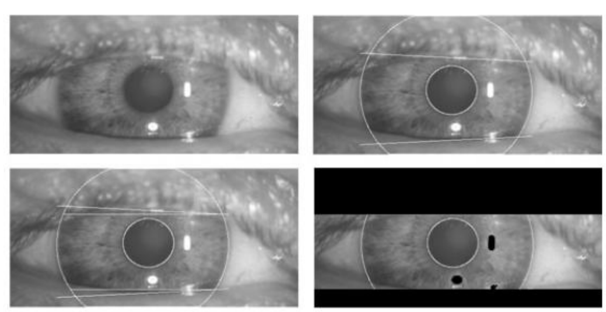

Fig .3 Stages of segmentation with eye image

In Fig. 3 Stages of segmentation are shown with eye image 'pi201b' from the LEI database Top left (original eye image), Top right (two circles overlaid for iris and pupil boundaries and two lines for top and bottom eyelid), Bottom left (horizontal lines are drawn for each eyelid from the lowest/highest point of the fitted line), Bottom right (probable eyelid and specular reflection are isolated as black areas).

5. NORMALIZATION OF EXTRACTED IRIS

Once the iris region is successfully segmented from an eye image, the next stage is to normalize the iris region in rectangular block so that it has fixed dimensions in order to allow comparisons. The normalization process produces 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.

5.1 Implementation of normalize pattern

For normalization of iris regions a technique based on Daugman's rubber sheet model is employed. The centre of the pupil is considered as the reference point, and radial vectors pass through the iris region, as shown in Figure 3. A number of data points are selected along each radial line and this is defined as the radial resolution. The number of radial lines going around the iris region is defined as the angular resolution. Since the pupil can be non-concentric to the iris, a remapping formula is needed to rescale points depending on the angle around the circle. Remapping formula is given by eq.2

$$r' = \sqrt{\alpha\beta} \pm \sqrt{\alpha\beta^2 - \alpha - r_I^{\,2}}$$

$$\text{with} \qquad \text{-----}(2)$$

$$\alpha = O_x^2 + O_y^2$$

$$\beta = \cos\left(\pi - \arctan\left(\frac{O_y}{O_x}\right) - \theta\right)$$

Where displacement of the centre of the pupil relative to the centre of the iris is given by o_x , o_y , and ***r'*** is the distance between the edge of the pupil and edge of the iris at an angle, θ around the region, and r_I is the radius of the iris. The remapping formula first gives the radius of the iris region 'doughnut' as a function of the angle *θ*.

A constant number of points are chosen along each radial line, so that a constant number of radial data points are taken, irrespective of how narrow or wide the radius is at a particular angle. The normalized pattern is created by backtracking to find the Cartesian coordinates of data points from the radial and angular position in the normalized pattern. From the 'doughnut' iris region, normalization produces a 2D array with horizontal dimensions of angular resolution and vertical dimensions of radial resolution.

Another 2D array is created for marking reflections, eyelashes, and eyelids detected in the segmentation stage. In order to prevent non-iris region data from corrupting the normalized representation, data points which occur along the pupil border or the iris border is discarded.

5.2 Feature encoding implementation

In order to provide accurate recognition of individuals, the most discriminating information present in an iris pattern is extracted. Only the significant features of the iris are encoded so that comparisons between templates can be made. Feature encoding is implemented by convolving the normalized iris pattern with 1D Log-Gabor wavelets.

6. TEMPLATE MATCHING TECHNIQUES

For Template matching, the Hamming distance is chosen as a metric for recognition, since bit-wise comparisons is necessary.

6.1 Hamming distance

The Hamming distance gives a measure of how many bits are the same between two bit patterns. Using the Hamming distance of two bit patterns, a decision can be made as to whether the two patterns were generated from different irises or from the same one. In comparing the bit patterns *X* and *Y*, the Hamming distance, *HD*, is defined by eq.3. HD is the sum of disagreeing bits (sum of the exclusive-OR between *X* and *Y*) over *N*. where N is the total number of bits in the bit pattern.

$$HD = \frac{1}{N}\sum_{j-1}^{N} Xj\,(XOR)\,Yj \qquad \text{------} \qquad (3)$$

Since an individual iris region contains features with high degrees of freedom, each iris region will produce a bit-pattern which is independent to that produced by another iris, on the other hand, two iris codes produced from the same iris will be highly correlated.

If two bits patterns are completely independent, such as iris templates generated from different irises, the Hamming distance between the two patterns should equal to **0.5.** This occurs because independence implies the two bit patterns will be totally random, so there is 0.5 chance of setting any bit to 1, and vice versa. Therefore, half of the bits will agree and half will disagree between the two patterns. If two patterns are derived from the same iris, the Hamming distance between them will be close to **0.0**, since they are highly correlated and the bits should agree between the two iris codes.

VI.2 Template Matching Algorithm

The Hamming distance is the matching metric employed by Daugman, and calculation of the Hamming distance is taken with bits that are generated from the actual iris region and this modifies Hamming distance formula as per eq. 4

$$\mathbf{HD} = \frac{1}{N - \sum_{k-1}^{N} Xn_k\,(\mathrm{OR})\,Yn_k} \sum_{j-1}^{k} X_j\,(\mathrm{XOR})\,Y_j\,(\mathrm{AND})\,Xn'_j\,(\mathrm{AND})\,Yn'_j$$

------- (4)

Where *Xj* and *Yj* are the two bit-wise templates to compare, *Xn* and *Yn* are the corresponding noise masks for *Xj* and *Yj*, and *N* is the number of bits represented by each template. In order to account for rotational inconsistencies, when the Hamming distance of two templates is calculated, one template is shifted left and right bit-wise and a number of Hamming distance values are calculated from successive shifts. The shifting process for one shift is illustrated in Figure 4.

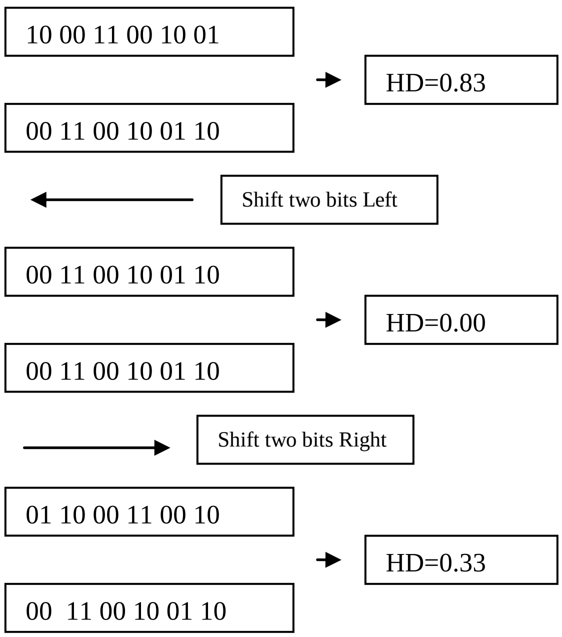

Fig. 4 Shifting Process.

As shown in Fig. 4 one shift is defined as one shift left, and one shift right of a reference template. In this example one filter is used to encode the templates, so only two bits are moved during a shift. The lowest Hamming distance, in this case zero, is used since this corresponds to the best match between the two templates.

7. SIMULATION RESULTS

Hamming distance is calculated with Hough and with compressed template size (Windows Bitmap format, and JPEG format). Results is shown in table 2

Tab. 2 Hamming distance calculated with different Template

Template	Hough	Bitmap	Jpeg
Time(sec)	87.27	**52.65**	55.51
Size(Kb)	240	98.9	**57.7**
Hamming Distance	**0.4082**	0.5164	0.4166

As shown in table 2 Accuracy decreases if Template Size decreases.

7.1 Scaling

One more factor considered while image processing of the iris is to consider the amount of scaling factor multiplied to the inner and outer radii. A normal optimum factor is of 0.4 but by changing the factor to other value shows a significant loss in accuracy as shown in Tab.3

Tab.3 effect of scaling on Accuracy

Scaling (n)	0.3	0.4	0.5
Hamming Distance	0.1947	**0.2808**	0.3915

8. CONCLUSION

This paper presented the complete iris recognition system consists of an automatic segmentation system based on the Hough Transform, and is able to localize the circular iris and pupil region, occluding eyelids and eyelashes, and reflections. The extracted iris region is then normalized into a rectangular block with constant dimensions to account for imaging inconsistencies. The Hamming distance is employed for classification of iris templates, and two templates were found to match if a test of statistical independence was failed. The system performed with perfect recognition on a set of 40 eye images.

The system presented in this paper is able to perform accurately, however there are still a number of issues which need to be addressed. First of all, the automatic segmentation was not perfect, since it could not successfully segment the iris regions for all of the eye images in the two databases. In order to improve the automatic segmentation algorithm, a more elaborate eyelid and eyelash detection system could be implemented.

An improvement could also be made in the speed of the system. The most computation intensive stages include performing the Hough Transform, and calculating Hamming distance values between templates to search®for a match. Since the system is implemented in MATLAB , which is an interpreted language, speed benefits could be made by implementing computationally intensive parts in C or C++.

9.REFERENCES

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