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Iris Recognition for Human Identification

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Abstract— Iris recognition is a part of biometric identification which offers a new solution for personal identification, authentication and security by analyzing the random pattern of the iris. The iris recognition system automatically recognizes the identity of a person from a new eye image by comparing it to the human iris patterns stored in an iris template database. The iris template database is created using three steps the first step is segmentation. Hough transform is used to segment the iris region from the eye image of the CASIA database. The noise due to eyelid occlusions, reflections is eliminated in the segmentation stage. The next step is normalization. A technique based on Daugman's rubber sheet model was employed on the iris for creating a dimensionally consistent representation of the iris region. The last step is feature encoding. The normalized iris was convolved with 1D Log-Gabor filters then the phase data from 1D Log-Gabor filters was extracted and quantized to four levels to encode the unique pattern of the iris in to a bit-wise biometric template. At last Template of the new eye image will be compared with the iris template database using hamming distance.

Keywords— Feature Extraction; Feature Matching; Biometric Identification; Iris Recognition.

I. INTRODUCTION

The human iris begins to form in the third month of gestation and the structure is complete by the eight month, even though the color and pigmentation continue to build through the first year of birth. After that, the structure of the iris remains stable throughout a person's life. It is composed of several layers which gives its unique appearance. This uniqueness is visually apparent when looking at its rich and small details seen in high resolution camera images under proper focus and illumination. The iris is the ring-shape structure that encircles the pupil, the dark centered portion of the eye, and stretches radially to the sclera, the white portion of the eye see Fig. 1.1

The possibility that the iris of the eye might be used as a kind of optical fingerprint for personal identification was suggested originally by ophthalmologists [1], [2], [3], who noted from clinical experience that every iris had a highly detailed and unique texture, which remained unchanged in clinical photographs spanning decades (contrary to the occult diagnostic claims of "iridology"). The difference even exists between identical twins and between the left and right eye of the same eye [4].the only characteristics that is dependent on genetics is the pigmentation of the iris which determines its color.

The iris recognition system automatically recognizes the identity of a person from a new eye image by comparing it to the human iris patterns stored in an iris template database.

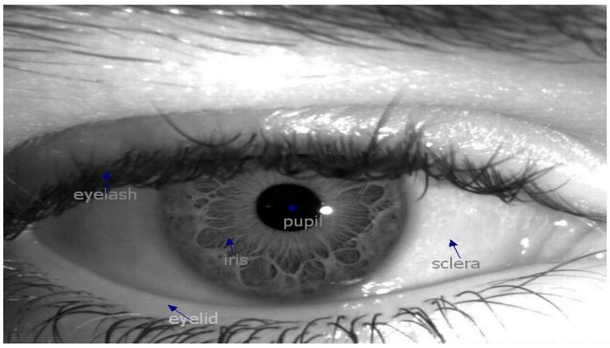

Fig. 1.1 Front view of human eye

The iris template database is created using three steps see Fig. 1.2. The first step is segmentation. The iris boundaries are modeled as two circles which are not concentric. The inner circle is the papillary boundary between the pupil and the iris where as the outer circle is the limbic boundary between the iris and the sclera. The noise due to eyelid occlusions, reflections is eliminated in the segmentation stage. The next step is normalization of the segmented iris for creating a dimensionally consistent representation of the iris region. The last step is feature encoding. The normalized iris was convolved with filters then the phase data from filters was extracted and quantized to four levels to encode the unique pattern of the iris in to a bit-wise biometric template. Template of the new eye image will be compared with the iris template database and decision will be made.

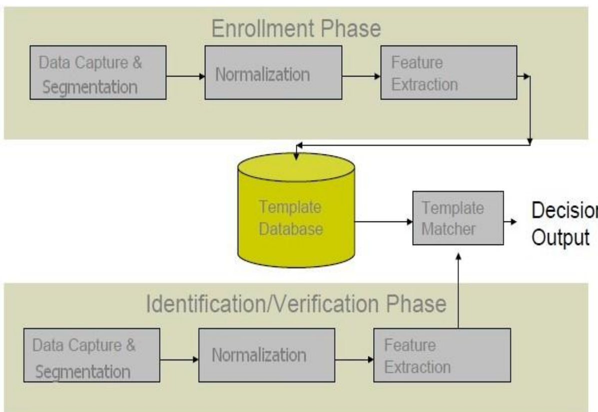

Fig. 1.2 basic process of iris recognition system

II. SEGMENTATION

The main objective here is to remove any non-useful information, namely the pupil-iris boundary and the part outside the iris (sclera, eyelids, and skin), eyelid occlusion. R. Wildes used Hough transforms to detect the iris contour. Daugman proposed an integro-differential operator to find both the pupil and the iris contour. The segmentation stage is critical to the success of an iris recognition system, since data that is falsely represented as iris pattern data will corrupt the biometric templates generated, resulting in poor recognition rates.

The proposed algorithm is based on the fact that there is some obvious difference in the intensity around each boundary, so we need an edge detection algorithm. Locating the iris is not a trivial task since its intensity is close to that of the sclera and is often obscured by eyelashes and eyelids. However the pupil, due to its regular size and uniform dark shade, is relatively easy to locate. The success of segmentation depends on the imaging quality of eye images. Persons with darkly pigmented irises will present very low contrast between the pupil and iris region if imaged under natural light, making segmentation more difficult.

A. Hough transform

Any object can be described by mathematical functions that define the boundaries of that object. The Hough transform is a technique used in digital image processing to isolate features of a particular shape within an image [5]. This technique finds objects with a particular shape within a certain class of shapes. It uses parameters that describe any shape, creates a mesh of those parameters and then follows a voting procedure to cast votes in the mesh cells in some accumulator space. In most of the cases Hough Transform requires some kind of edge detection of the objects prior to performing transform. Due to various kinds of noises in the image, the detected edges may not be in a perfect shape. Hough Transform performs shape detection by grouping these edge points using a voting procedure in an accumulator space.

Circular Hough Transform uses the parameterized equation of circle for this purpose the equation of circle can be written as:

$$(x-a)^2 + (y-b)^2 = r^2 \tag{2.1}$$

Circular Hough Transformer (CHT) is used to detect the inner and outer boundaries of the iris. First the eye image is edge detected in the vertical then Based on CHT algorithm for every edge a circle is drawn at last the maximum in the Hough space will be chosen when the maximum in the Hough space is chosen we find the circle parameters i.e. the center coordinates and the radius of the iris.

The P position in Fig. 2.1 is getting the majority of votes so it will be the maximum.

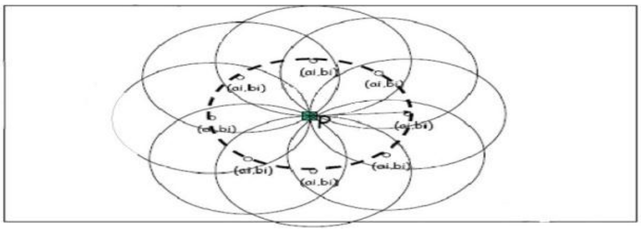

Fig. 2.1 accumulator hough space

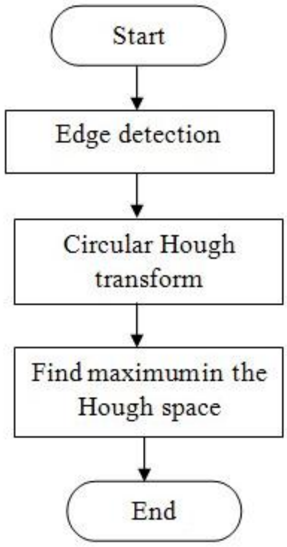

Fig. 2.2 flowchart of localization of outer iris boundary

To improve the segmentation of pupil the brightness of the image was calculated. If the brightness was less than threshold Histogram equalization was applied to the previously detected iris if not the iris-pupil boundary is bright enough so histogram equalization is not necessary.

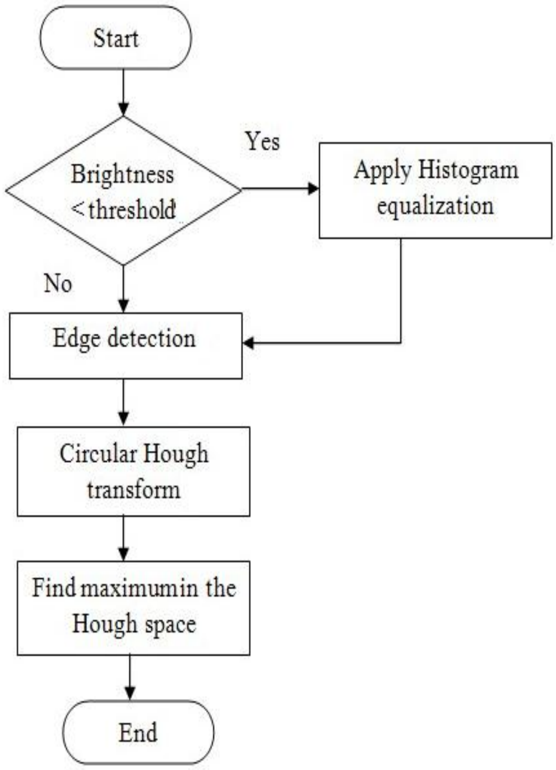

Fig. 2.3 flowchart of localization of inner iris boundary

The last stage in segmentation is detecting noises like eyelid occlusion and reflection. Linear Hough Transform (LHT) is used to detect the eyelid occlusion.

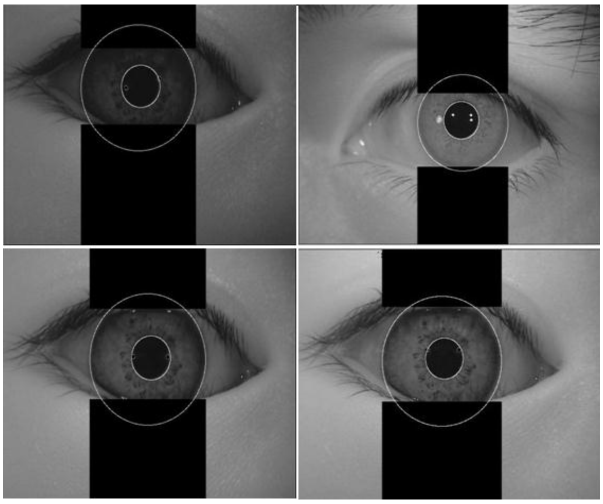

Fig. 2.4 Segmentation of various eye images

III. NORMALIZATION

The main objective of normalization is to map the segmented iris image in to a fixed reference or coordinate system. It is required to extract fixed number of features from the iris region regardless its spatial resolution. Two images of the same iris might be very different as a result of the size of the image Due to the distance between the eye and the capturing device and the camera optical magnification factor, size of the pupil due to the illumination and orientation of the iris. As described in [6], the invariance to all of these factors can be achieved through the translation of the captured data into a double dimensionless polar coordinate system. :

A. *Daugman's rubber sheet model*

The Cartesian to polar reference transform suggested by Daugman [7] authorizes equivalent rectangular representation of the zone of interest as shown in Fig. 3.1. In this way it is possible to compensate the stretching of the iris texture as the pupil changes in size, and unfold the frequency information contained in the circular texture in order to facilitate next feature extraction.

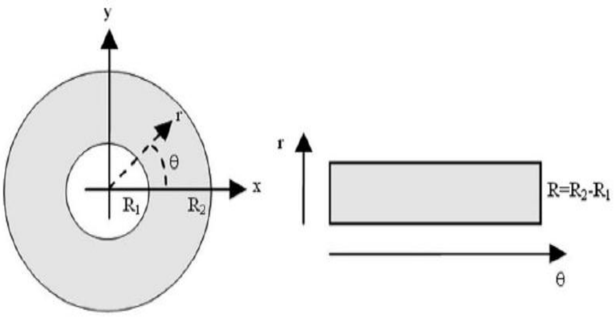

Fig. 3.1 Daugman's rubber sheet model

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

This is given by

$$\boldsymbol{r} = \sqrt{\boldsymbol{\alpha}}\boldsymbol{\beta} \pm \sqrt{\boldsymbol{\alpha}\boldsymbol{\beta}^2 - \boldsymbol{\alpha} - r_I{}^2} \qquad (3.1)$$

With $\alpha = (ox)^2 + (\mathrm{oy})^2$

$$\beta = \cos(\pi - \tan^{-1}(\frac{\mathrm{oy}}{ox})) - \theta)$$

Where displacement of the centre of the pupil relative to the centre of the iris is given by ox, oy, and r is the distance between the edge of the pupil and edge of the iris at an angle, θ around the region, and $\boldsymbol{r_I}$ is the radius of the iris.

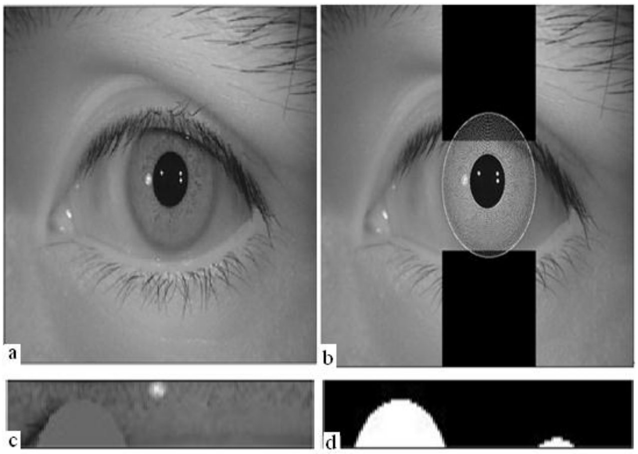

Fig. 3.2 **a**) an eye image (S2001L03 from the CASIA- iris-lamp database) **b**) corresponding 20 pixels by 240 pixels data points of normalization **c**) corresponding polar representation **d**) corresponding noise.

IV. ENCODING

After being able to localize the iris and normalize the iris it is time to extract the most discriminating feature in its pattern so that a comparison between templates can be done. The iris pattern provides two types of information: The amplitude information and the phase information. As shown by Oppenheim and Lim, and because of the dependence of the amplitude information on many extraneous factors, only phase information is used to generate the iris code [8]. Wavelets can be used to decompose the data in the iris region into components that appear at different resolutions, allowing therefore features that occur at the same position and resolution to be matched up.

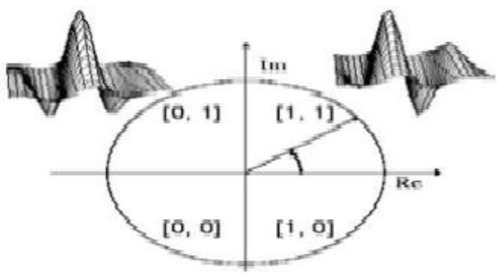

Fig. 4.1 Encoding phase information

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A. Log-gabor filter

Gabor filters are a traditional choice for obtaining localized frequency information. They offer the best simultaneous localization of spatial and frequency information. However they have two main limitations. The maximum bandwidth of a Gabor filter is limited to approximately one octave and Gabor filters are not optimal if one is seeking broad spectral information with maximal spatial localization.

An alternative to the Gabor function is the Log-Gabor function proposed by Field. Log-Gabor filters can be constructed with arbitrary bandwidth and the bandwidth can be optimized to produce a filter with minimal spatial extent. The frequency response of a Log-Gabor filter is given as;

$$G(f) = e^{-(\log(f/f_o))^2 / 2(\log(\sigma/f_o))^2} \quad (4.1)$$

Where f_o represents the centre frequency, and σ gives the bandwidth of the filter.

V. MATCHING

The hamming distance algorithm employed also incorporates noise masking, so that only significant bits are used in calculating the hamming distance between two iris templates. Now when taking the hamming distance, only those bits in the iris pattern that corresponds to '0' bits in noise masks of both iris patterns will be used in the calculation. The hamming distance will be calculated using only the bits generated from the true iris region, and the hamming distance formula is given as

$$a = \left(\frac{1}{N-\sum_{k=1}^{N} Xnk(OR)Ynk}\right) \quad (5.1)$$

$$b = \sum_{j=1}^{N} x_j \,(XOR)\, y_j \,(AND) Xn'_j (AND)\, yn'_j \quad (5.2)$$

$$HD = a \times b \quad (5.3)$$

Where x_j and y_j are the two bit-wise templates to compare, Xn'_j and yn'_j are the corresponding noise masks for x_j andy_j,N is the number of bits represented by each template and HD is the hamming distance. 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 number of bits moved during each shift is given by two times the number of filters used, since each filter will generate two bits of information from one pixel of the normalized region. From the calculated hamming distance values, only the lowest is taken, since this corresponds to the best match between two templates.

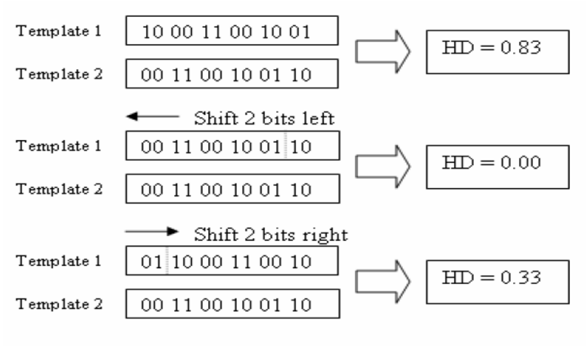

Fig. 5.1 An illustration of the matching process

VI. RESULT

The 100 hamming distance of the same iris capture in different time and condition from CASIA-Iris-Twins database was calculated.their mean, standard deviation and histogram distribution can be seen in Fig. 6.1

Mean = 0.2791
Standard deviation = 0.0839

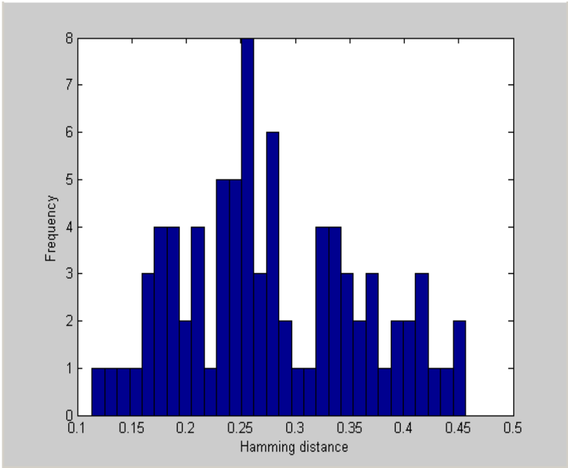

Fig. 6.1 intra-class Hamming distance distribution of CASIA-Iris-Twins database

100 hamming distance of different iris from CASIA-Iris-Twins database was calculated.their mean, standard deviation and histogram distribution can be seen in Fig. 6.2

Mean = 0.4649
Standard deviation = 0.0171

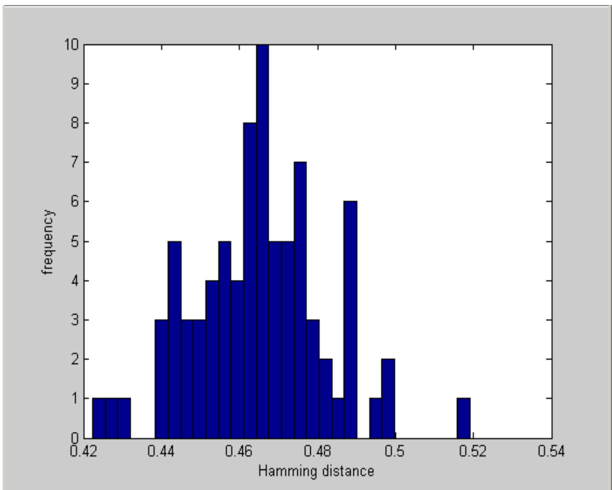

Fig. 6.2 inter-class Hamming distance distribution of CASIA-Iris-Twins database

Distribution of 100 hamming distance of the same iris capture in different time and condition from CASIA-Iris- Twins database and 100 hamming distance of different iris from CASIA-Iris-Twins database can be seen in Fig. 6.3 notice the separation in hamming distance of 0.4 that shows not all but most of the hamming distance from different iris is above 0.4 and the hamming distance from same iris is less than 0.4.

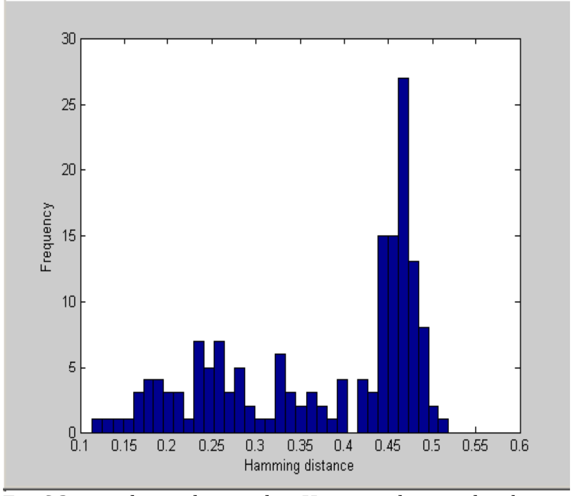

Fig. 6.3 inter-class and intra- class Hamming distance distribution of CASIA-Iris-Twins database

TABLE I. FALSE ACCEPTANCE AND REJECTION RATE FOR VARIOUS HAMMING DISTANCE VALUES

HAMMING DISTANCE	FALSE ACCEPTATION RATE (FAR) (%)	FALSE REJECTION RATE (FRR) (%)
0.1	0.000	100.000
0.15	0.000	96.296
0.2	0.00	80.247
025	0.000	60.494
0.3	0.000	37.037
0.35	0.000	22.222
0.4	0.000	11.111
0.45	19.753	1.234
0.5	98.765	0.000

VII. CONCLUSION

The aim of this project was to implement methods used for iris recognition and to test those methods on a database of iris provided by the Chinese Academy of Sciences Institute of Automation (CASIA) using matlab .the system had 4 sub systems these are segmentation, normalization, feature encoding and matching .the segmentation was implemented using hough transformer to segment the iris from the eye image and its performance was tested on 100 eye image from CASIA database and it gives 84% success.

Normalization was done using Daugman's rubber sheet model to create dimensionally consistent representation of the iris region and it was tested on images of CASIA-Iris-Lamp it gives excellent result.

The normalized image was encoded using 1D-log Gabor filter and hamming distance was used for matching .hamming distance had to be carefully decide so as to use the iris recognition system with acceptable FAR and FRR. With hamming distance of 0.4 it gives 0% of FAR and 11.11% of FRR.

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