

# Study and Development of Iris Segmentation and Normalisation Techniques

Anshu Parashar, Yogita Gulati

**Abstract** - There have been several implementations of security systems using biometric, especially for identification and verification cases. The term "biometrics" is derived from the Greek words *bio* (life) and *metric* (to measure). In other words, *bio* means living creature and *metrics* means the ability to measure an object quantitatively. An example of pattern used in biometric is the iris pattern in human eye. The iris pattern has been proved unique for each person. The iris recognition system consists of an automatic segmentation system that is 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 was then normalized into a rectangular block with constant dimensions to account for imaging inconsistencies. Finally, the phase data from 1D Log-Gabor filters were extracted and quantized to four levels to encode the unique pattern of the iris into a bit-wise biometric template using Daugman's rubber-sheet model. The Hamming distance was employed for classification of iris templates, and two templates were found to match if a test of statistical independence was failed.

**Index Terms** - Segmentation, Histogram equalization, Hough Transform, Normalization.

## I. INTRODUCTION

The rapid developments in the field of Information Technology & WWW, causing human beings frequently confront with various kinds of unauthorized access. Also with the enlargement of mankind's activity range, the significance for person's status identity is becoming more and more important. So many different techniques for person's status identity have been proposed for this practical task. Conventional methods for status identity check like password and identification card are not always reliable, because these methods can be easily forgotten, stolen or forged. A wide variety of biometrics have been developed for

this challenge. Examples include automatic retinal vasculature scan, iris recognition, fingerprints matching, hand shape identification, handwritten signature verification, and voice recognition systems. Since 1987, when L. Flom and A. Safir [12] concluded about the stability of iris morphology and estimated the probability for the existence of two similar irises at 1 in  $10^{72}$ , the use of iris based biometric systems has been increasing. Iris is commonly recognized as one of the most reliable, unique and noninvasive biometric measures: it has a random morphogenesis and, apparently, no genetic penetrance. A biometric system provides automatic identification of a human being based on some unique physical or behavioral feature of the individual. Iris recognition is regarded as the most reliable and accurate biometric identification system being used in modern era. Most commercial iris recognition systems use patented algorithms developed by Daugman [1, 2], and these algorithms are able to produce perfect recognition rates. However, published results have usually been produced under favourable conditions, and there have been no independent trials of the technology.

## II. OVERVIEW

The system, as shown in Figure 1, is implemented in MATLAB.

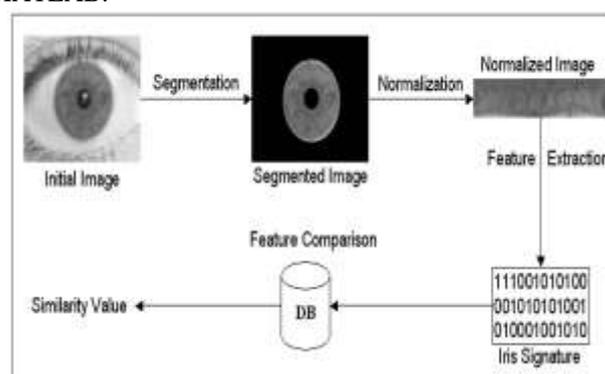


Fig.1. Typical stages of iris recognition.

A general iris recognition system is composed of four steps. Firstly an image containing the eye is captured then the original image containing iris is preprocessed to extract the iris. Thirdly iris features are extracted from the segmented image and is encoded in the form of an iris template and finally decision regarding acceptance or rejection of the subject is made by means of matching.

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### III. EARLIER WORKS

Daugman [1, 2] proposed an integro-differential operator for localizing iris regions along with removing the possible eyelid noises. From the publications, we cannot judge whether pupil and eyelash noises are considered in his method. Wildes [4] processed iris segmentation through simple filtering and histogram operations. Eyelid edges were detected when edge detectors were processed with horizontal and then modeled as parabolas. No direction preferences lead to the pupil boundary. Eyelash and pupil noises were not considered in his method. Boles and Boashah [5], Lim et al. [6] and Noh et al. [7] mainly focused on the iris image representation and feature matching, and did not introduce the information about segmentation. Tisse et al. [8] proposed a segmentation method based on integro-differential operators with a Hough Transform. This reduced the computation time and excluded potential centers outside of the eye image. Eyelashes and pupil noises were also not considered in his method. Ma et. al. [9] processed iris segmentation by simple filtering, edge detection and Hough Transform. In Masek's segmentation algorithm [11], the two circular boundaries of the iris are localized in the same way. The Canny edge detector is used to generate the edge map. Then after doing a circular Hough transform, the maximum value in the Hough space corresponds to the center and the radius of the circle.

### IV. PROPOSED APPROACH

For every iris recognition system, accuracy of the system is highly dependent on accurate iris segmentation. Better the iris is localized, better will be the performance of the system. Our basic experimentation of the *Daugman's* mathematical algorithms for iris processing, is derived from the information found in the open literature, led us to suggest a few possible improvements. For justification of these concepts, we implemented in *MATLAB*. Afterwards we tested individually the performances of the different processing blocks previously identified as follows: (1) locating iris in the image, (2) Cartesian to polar reference transform, (3) local features extraction, and encoding (4) matching.

#### A. Segmentation

Segmentation is a process of finding the most useful portion of the iris image for further processing. It is done by localizing pupil and iris boundaries, eyelashes and eyelids. In case there is no proper segmentation, next stages of iris recognition will suffer and false data will be generated as template which in turn affects the recognition rates. To speed iris segmentation, the iris has been roughly localized by a simple combination of Gaussian filtering, canny edge detection, and Hough transform. Hough Transform is used to deduce the radius and center of the pupil and iris circles. Canny edge detection operator [15] is used to detect the edges in the iris image which is the best edge detection operator available in *MATLAB*.

#### • Hough Transform

Considering the obtained edge points as  $(x_j, y_j), j = 1, 2, 3, \dots, n$ , a Hough transform can be written as:

$$H(x_c, y_c, r) = \sum_{j=1}^n h(x_j, y_j, x_c, y_c, r) \quad (1)$$

where

$$h(x_j, y_j, x_c, y_c, r) = \begin{cases} 1 & \text{if } g(x_j, y_j, x_c, y_c, r) = 0 \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

The limbus and pupil are both modeled as circles and the parametric function  $g$  is defined as:

$$g(x_j, y_j, x_c, y_c, r) = (x_j - x_c)^2 + (y_j - y_c)^2 - r^2 \quad (3)$$

Assuming a circle with the center  $(x_c, y_c)$  and radius  $r$  the edge points that are located over the circle result in a zero value of the function. The value of  $g$  is then transformed to 1 by the  $h$  function, which represents the local pattern of the contour. The local patterns are then used in a voting procedure using the Hough transform,  $H$ , in order to locate the proper pupil and limbus boundaries. In order to detect limbus, only vertical edge information is used. The upper and lower parts, which have the horizontal edge information, are usually covered by the two eyelids. The horizontal edge information is used for detecting the upper and lower eyelids, which are modeled as parabolic arcs. We implemented this method in *MATLAB*® by first employing canny edge detection to generate an edge map.

#### B. Normalization

The localized iris is then normalized to a rectangular block with a fixed size radius being in correspondence to the width of the block and angular displacement  $\theta$  being in correspondence with the length of the block as shown in fig. 2.

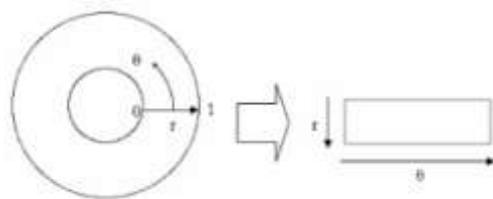


Fig. 2: Daugman's rubber sheet model.

Formally, the rubber sheet is a linear model that assigns to each pixel of the iris, regardless its size and pupillary dilation, a pair of real coordinates  $(r, \theta)$ , where  $r$  is on the unit interval  $[0, 1]$  and  $\theta$  is an angle in range  $[0, 2\pi]$ . The remapping of the iris image  $I(x, y)$  from raw Cartesian coordinates  $(x, y)$  to the dimensionless non concentric polar coordinate system  $(r, \theta)$  can be represented as:

$$I(x(r, \theta), y(r, \theta)) \rightarrow I(r, \theta) \quad (4)$$

where  $x(r, \theta)$  and  $y(r, \theta)$  are defined as linear combinations of both the set of pupillary boundary points  $(x_p(\theta), y_p(\theta))$  and the set of limbus boundary points along the outer perimeter of the iris  $(x_s(\theta), y_s(\theta))$  bordering the sclera:

$$\begin{aligned} x(r, \theta) &= (1-r) * x_p(\theta) + r * x_s(\theta) \\ y(r, \theta) &= (1-r) * y_p(\theta) + r * y_s(\theta) \end{aligned} \quad (5)$$

where  $I(x, y)$  is the iris region image,  $(x, y)$  are the original cartesian coordinates,  $(r, \theta)$  are the corresponding normalized polar coordinates, and  $(x_p, y_p)$  and  $(x_s, y_s)$  are the coordinates of the pupil and iris boundaries along the  $\theta$  direction.

### C. Feature Extraction and Encoding

Feature Extraction is a process to extract the information from the iris image. These features can not be used for reconstruction of images. But these values are used in classification. Gabor filters are used for the purpose. Gabor filters give rotation – invariant system for feature extraction. In our experiments, we employed a Gabor filter with isotropic 2D Gaussian for rotation invariant classification. Gabor filter's frequency domain equation is as follows:

$$\begin{aligned} G(x, y) &= g(x, y) \exp(-2\pi j(u.x + v.y)) \\ g(x, y) &= -\exp(x^2 + y^2 / 2\sigma^2).j = \sqrt{-1} \end{aligned} \quad (6)$$

The complex function  $G(x, y)$  can be split into two parts, even and odd filters.  $G_e(x, y)$  and  $G_o(x, y)$ , which are also known as symmetric and anti-symmetric filters respectively. The spatial Gabor filter is given in eq. 4.

$$\begin{aligned} G_e(x, y) &= g(x, y) \cos(2\pi f(x \cos \theta + y \sin \theta)) \\ G_o(x, y) &= g(x, y) \sin(2\pi f(x \cos \theta + y \sin \theta)) \end{aligned} \quad (7)$$

where  $G(x,y)$  is Gabor filter's kernel and  $g(x,y)$  is an isotropic 2D Gaussian function.

### D. Matching

Matching is performed using Hamming distance measure defined in eq. 5.

$$HD = \frac{1}{N} \sum_{j=1}^N X_j \oplus Y_j \quad (8)$$

The result is the no. of bits that are different between the binary codes  $X_j$  and  $Y_j$ . If the hamming distance between two images is 0, provided that there have not been any noise patterns in the image while it was segmented and normalized, the two images are from same subject and same eye. However, it is the ideal case and even in most perfect conditions, it is not the case. Hamming distance in practical conditions, i.e. considering some amount of noise is also available while acquiring the image, varies in the range (0,1]. It is measured against a pre defined threshold value which says if the calculated hamming distance is greater than the threshold this means the two images are not from the same subject else the images are from the same subject.

## V. EXPERIMENTS AND RESULTS

In the experiments, we implemented the method described by Daugman[13] which is composed of four main stages. In the segmentation we implemented the integro-differential operator that searches for both iris and pupil borders. Feature

extraction was accomplished through the use of two dimensional Gabor filters followed by a binarization process. Finally, feature comparison was made through the Hamming distance. A data set of grayscale iris digital images provided by the Chinese Academy of Sciences (CASIA) is used for testing. The CASIA [14] version 1 database consists of 756 gray scale images coming out of 108 distinct classes and 7 images of each eye. We carried out our experiments in MATLAB 7.8 (R2009a). Elapsed time for the iris preprocessing (segmentation and normalization) followed by feature extraction and encoding and hamming distance matching is 133.7 seconds with an average hamming distance 0.3486. Results of segmentation and normalization process are shown in fig. 3.

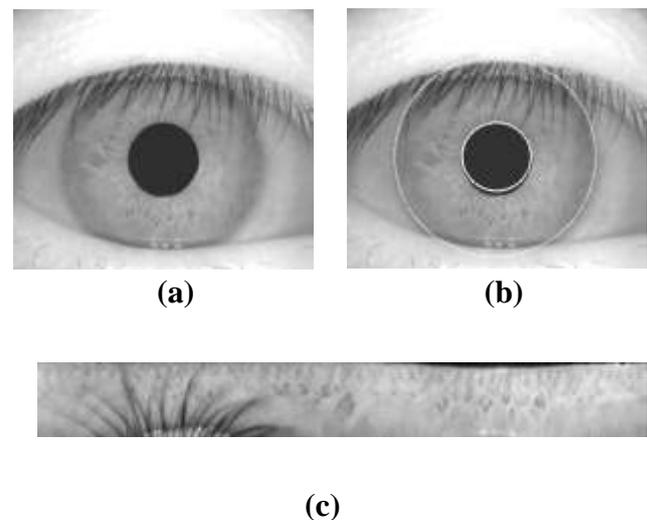


Fig. 3. (a) Original Iris Image, (b) Segmented Iris Image, (c) Normalized Iris Image

Results in the form of graph between frequency and Hamming distance are shown for both genuine and imposters separately as well as combined. Curve between FAR and FRR is also shown. Example results are here shown which are performed on a subset of 105 images of CASIA database from 15 different subjects.

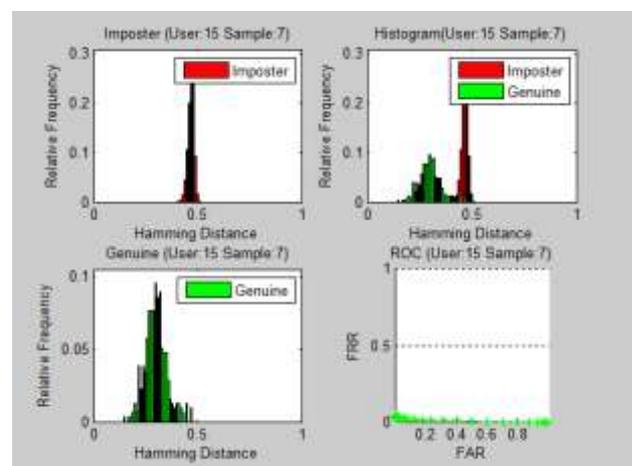


Fig. 4. (a) Hamming Distance vs. Relative Frequency for imposter, for genuine, for both imposter and genuine combined, and FAR vs. FRR

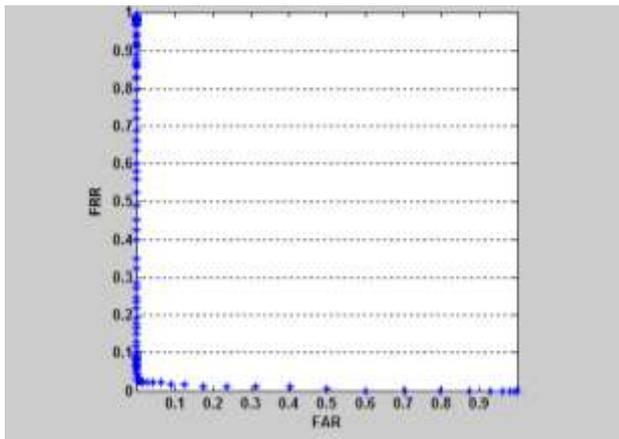


Fig. 4. (b) FAR vs. FRR (shown separately)

## VI. CONCLUSION

Accuracy of the results depends upon how effective segmentation and normalization is done in preprocessing stage of iris recognition. Various researchers have contributed significant amount of research for developing a constraint free iris recognition system and a lots of research is currently going on this direction. Basic need of iris recognition is valid input iris image which can be preprocessed accurately and efficiently so that normalization and other later stage functionalities discussed above can be implemented and handled with effectiveness. Eyelashes removal and other noise diminishing methods are not considered which shows there is some scope of development available in proposed approach too. Angular deflection also affects the recognition performance of the system which is not considered in the proposed work and can be taken as a future scope of the work.

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