Iris Localization Using Segmentation & Hough Transform Method

Mr. Shaikh. I. J ,Mr. Shaikh .A .H.A.R

Abstract— A biometric system provides automatic identification of an individual based on a unique feature or characteristic possessed by the individual. Iris recognition is regarded as the most reliable and accurate biometric identification system available. In Iris recognition the system captures an image of an individual's eye, the iris in the image is then meant for the further segmentation and normalization for extracting its feature. Segmentation is used for the localization of the correct iris region in the particular portion of an eye and it should be done accurately and correctly to remove the eyelids, eyelashes, reflection and pupil noises present in iris region. In this paper, we are using simple Canny Edge Detection scheme and Circular Hough Transform, to detect the iris' boundaries in the eye's image .Iris images are selected from the CASIA Database. The segmented iris region was normalized to minimize the dimensional inconsistencies between iris regions by using Daugman's Rubber Sheet Model.

Index Terms— Daughman's Algorithm, Daugman's Rubber Sheet Model, Iris Recognition, segmentation, Canny Edge Detection , Hough Transform

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1 INTRODUCTION

The purpose of 'Iris Recognition' a biometrical based technology for personal identification and verification, is to recognize a person from his/her iris prints. In fact, iris patterns are characterized by high level of stability and distinctiveness. Each individual has a unique iris (see Figure 1) the difference even exists between identical twins and between the left and right eye of the same person. [1]
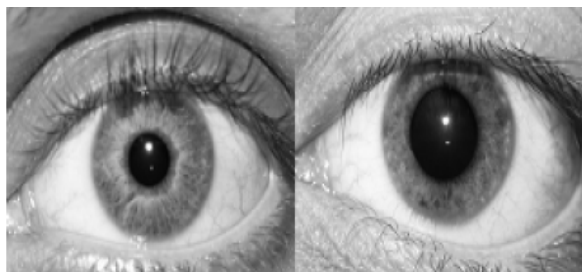

Figure 1: Distinctiveness of human iris

2. Iris Recognition Process

Following are the steps for Iris Recognition[2]

Step 1: Image acquisition, the first phase, is one of

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- Mr. I.J .Shaikh   is currently pursuing masters degree program in electronic & Telecommunication engineering in Solapur University, India .
  E-mail: shaikhimran76@yahoo.com
- Mr.A.H.A.R is currently pursuing masters degree program in electric engineering in solapur University, I ndia .
  E-mail: .abdulhakimshaikh@yahoo.com

the major challenges of automated iris recognition since we need to capture a high-quality image of the iris.

Step 2: Iris localization takes place to detect the edge of the iris as well as that of the pupil; thus extracting the iris region
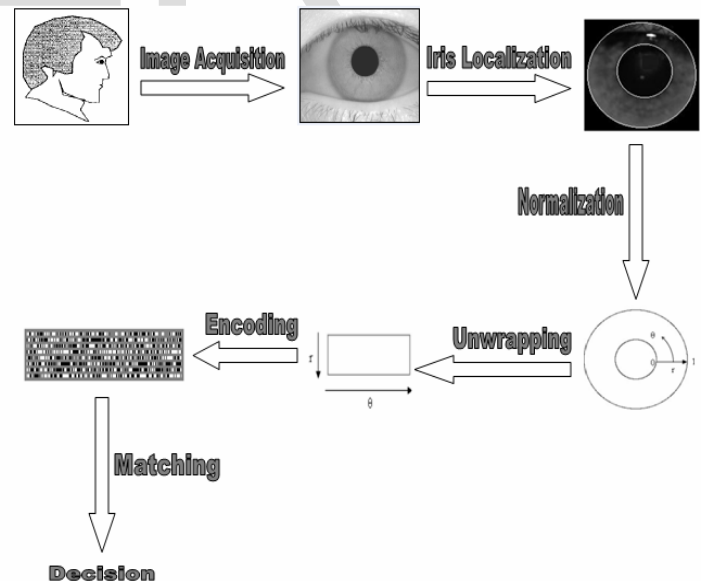

Figure 2.1. Iris Recognition Process

Step 3: Normalization is used to be able to transform the iris region to have fixed dimensions, and hence removing the dimensional

inconsistencies between eye images due to the stretching of the iris caused by the pupil dilation from varying levels of illumination.

Step 4: The normalized iris region is unwrapped into a rectangular region.

Step 5: Finally, it is time to extract the most discriminating feature in the iris pattern so that a comparison between templates can be done. Therefore, the obtained iris region is encoded using wavelets to construct the iris code. As a result, a decision can be made in matching step.

In paper we are concentrating only on step 2 i.e. Iris localization with the help of segmentation and Hough transform. For localization of iris in eye image the first step is segmentation and then after that we are using Hough transform for iris part finding.

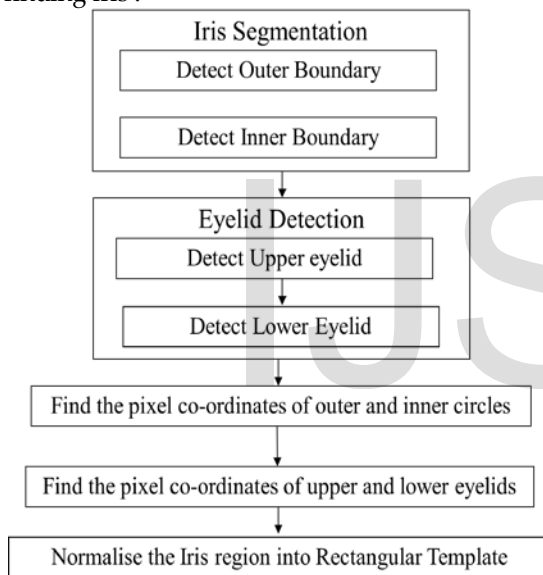Following are the steps that we are following for finding iris .

Figure 2.2. Steps In Iris Segmentation & Hough

Transform Process

3. Image Segmentation

The main objective here is to remove non useful information, namely the pupil segment and the part outside the iris (sclera, eyelids, skin). [2].The eyelids and eyelashes normally occlude the upper and lower parts of the iris region. The success of segmentation depends on the imaging quality of eye images. The segmentation step detects the boundaries of iris region. The segmented region is then converted into template in the normalization step. In segmentation, firstly edges from the input eye image are detected using the edge detector step.

Stages in Segmentation
➢ Edge detection.

➢ Finding a circle.
➢ Eyelid detection

3.1 Edge Detection.

Edges characterize object boundaries and are therefore a problem of fundamental importance in image processing [4]. Edges in images are areas with strong intensity contrast i.e. a jump in intensity from one pixel to the next.

In segmentation process to detect the iris boundary, it is necessary to create an edge map. The Canny edge detection principle is used to generate an edge map. The canny edge detector first smoothens the image to eliminate noise. It then finds the image gradient to highlight regions with high spatial derivatives. The algorithm then tracks along these regions and suppresses any pixel that is not at the maximum (nonmaxima suppression). The nonmaxima array is now further reduced by hysteresis. Hysteresis is used to track along the remaining pixels that have not been suppressed. Hysteresis uses two thresholds, if the magnitude is below lower threshold, it is set to zero. If the magnitude is above higher threshold, it is treated as edge. And if the magnitude is between the two thresholds, then it is set to zero unless there is a path from this pixel to a pixel with a value above lower threshold.

The Canny edge detection algorithm consists of following steps:
• Smooth the image with a Gaussian filter,
• Compute the gradient of image.
• Apply nonmaxima suppression to the gradient image,
• Use double thresholding algorithm to detect and link edges.

In order to make circle detection process more efficient and accurate, the Hough transform for the iris/sclera boundary was performed first, then the Hough transform for the iris/pupil boundary was performed within the iris region, instead of the whole eye region, since the pupil is always within the iris region.

3.1.1 Smoothing:

The smoothing of image is done to suppress the noise. Noise is associated with high frequency, the noise suppression means suppression of high frequencies. The input eye image is firstly smoothened using a Gaussian Filter.

Let I [i, j] denote the image, G [i, j, σ] be a Gaussian smoothing operator. Gaussian smoothing operator is a 2D convolution operator which is used to blur images and remove noise and is given by 2D Gaussian equation:

$$G(i, j) = \frac{1}{2\pi\sigma^2} \exp\left\{-\frac{i^2 + j^2}{2\sigma^2}\right\}$$

where σ is the standard deviation i.e. spread of the Gaussian and controls the degree of smoothing. A σ decides degree of smoothing means, increase in σ will make the gap between different level of edges larger and decrease in σ will make the gap between different level of edges smaller. The result of convolution of image I [i, j] with G [i, j,σ] gives an array of smoothed data as;

$$S [i, j] = I [i, j] * G [i , j,\sigma]$$

3.1.2 Gradient Calculation:

The Motivation of gradient operators is to detect changes in image function. Change in pixel value corresponds to large gradient value. Gradient operators are based on local derivatives of image function. So, derivatives are larger at locations where image function undergoes rapid change. Gradient operators have effect of suppressing only the low frequencies in Fourier transform domain.
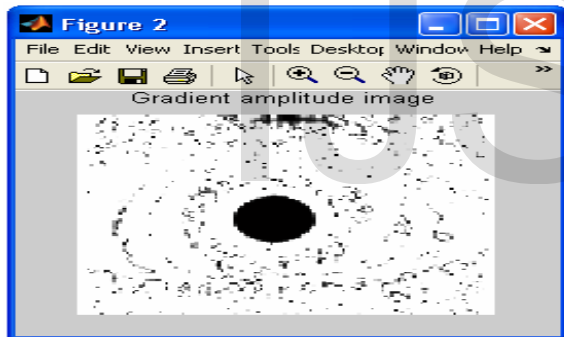

. Figure 3.1 The gradient amplitude image while
finding outer and inner boundary of iris.

Firstly, the gradient of the smoothed array S [i , j] is used to produce the x and y partial derivatives P [i, j] and Q [i , j] respectively. The magnitude and orientation of the gradient can be computed as,

$$M [i, j] = (P [i, j] 2 + Q [i, j] 2)$$

$$\theta [i, j] = \tan^{-1} (Q [i, j] / P [i, j])$$

3.2.3 Nonmaxima Suppression:

In this approach, an edge point is defined to be a point whose strength is locally maximum in the direction of the gradient. This means that zero value is assigned everywhere except the local maxima points.

At the local maxima points the value is preserved and all other values are marked as zeros. This process, which results in one pixel wide ridges, is called as non-maxima suppression. Below figure shows image after Non Maxima suppression.
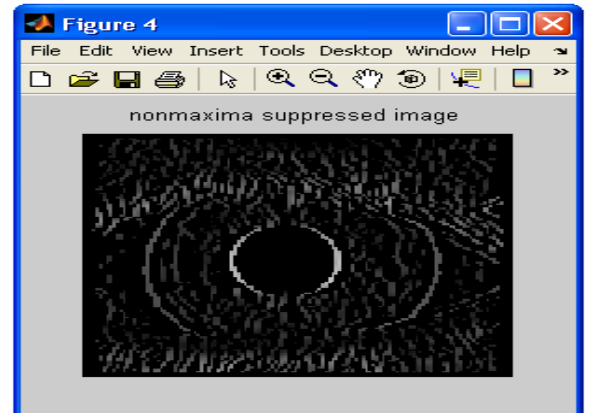

Figure 3.2. shows image after Non Maxima

suppression

3.2.4 Hysteresis Thresholding:

In spite of smoothing performed as a first step in edge detection, the nonmaxima suppressed magnitude image N [i, j] will contain many false edge fragments caused by noise and fine texture. The contrast of the false edge fragments is small. These false edge fragments in the nonmaxima suppressed image should be reduced.
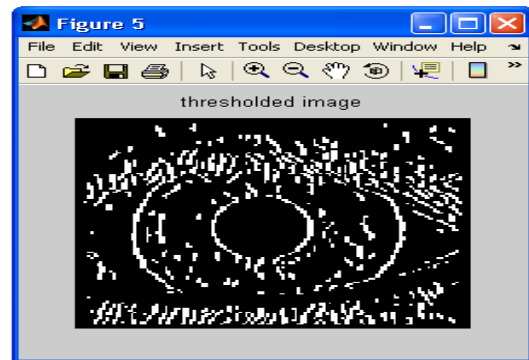

Figure 3.3 Thresholded image showing outer and

inner boundary of iris.

One typical procedure is to apply a threshold to nonmaxima suppressed magnitude image N [i, j]. The threshold T is decided such that a prominent edge map is created. All values below threshold are set to zero. After application of threshold to the non maxima suppressed magnitude image, an

array E [i, j] containing the edges detected in the image I [i, j] is obtained.

3.2 Finding a Circle (Hough Transform).

In above step after finding the edge map of input eye image by canny edge detector, next step is to find radius and centre co-ordinates of the outer and inner circular boundary of iris region. Here the radius and centre co-ordinates of both the circles are to be found. The Hough transform is used to determine parameters of simple geometric objects, such as lines, ellipses and circles, present in an image. The circular Hough transform is employed to find out the radius and centre coordinates of the circular boundary of pupil and iris outer boundary.

Firstly, an edge map is generated by using the canny edge detector. 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 and y, and the radius r, which are able to define any circle according to the equation,

$$x2 + y2 - r2 = 0 \ ....(5.3.1.)$$

Both circular boundaries of iris are localized in the same way.

3.3 Eyelids and Eyelashes Detection

The eyelashes and Eyelids do not contain any useful information. The segmented image obtained so far contains redundant information which is not required and acts like noise. So, this redundant information has to be eliminated and processed further.

Firstly edges are detected using the canny edge detector and then horizontal lines are detected. Eyelids are isolated by first fitting a line to the upper and lower eyelid using the linear Hough transform. Fig. 5.6 shows results of eyelid detection.
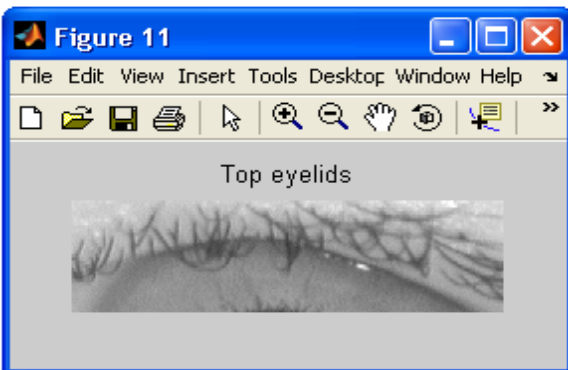

Figure 3.4 Upper eyelids
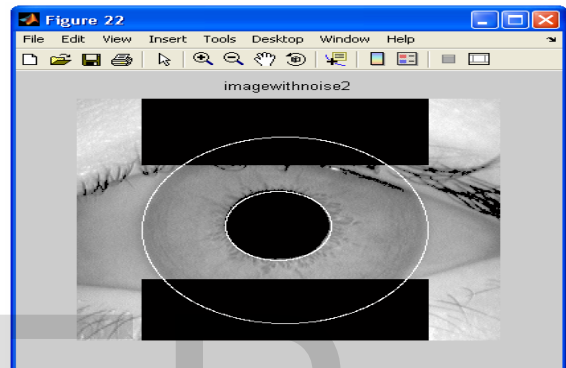

Figure 3.5 Lower eyelids
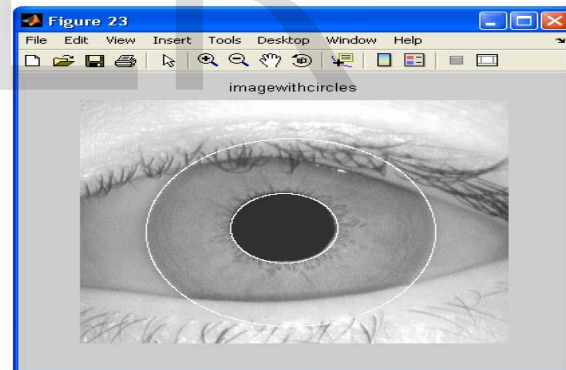

Figure 3.6. segmented iris with the noise mask

Figure 3.7 Segmented iris showing both circles.

4. Iris 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 images of iris taken at different time or in different place have many differences, even though images are taken from the same person, because elastic deformations of the pupil will affect the size of iris,. The dimensional inconsistencies between eye images are mainly due to the stretching of the iris

caused by pupil dilation from varying levels of illumination.

For the purpose of achieving more accurate recognition results, it is necessary to compensate for such deformation. To compensate the difference and improve the precision of matching, iris normalization is necessary. In the normalization process the iris region is converted from rectangular co-ordinate system (*x*, *y*) to polar coordinate system (*r*, *θ*). The respective polar co-ordinates are given by,

$$r = \sqrt{x^2 + y^2} \qquad \text{and} \qquad \theta = \tan^{-1}(y/x)$$ ...

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.

The rubber sheet model takes into account pupil dilation and size inconsistencies in order to produce a normalized representation with constant dimensions. The homogenous rubber sheet model remaps points 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] as shown in fig.5.8
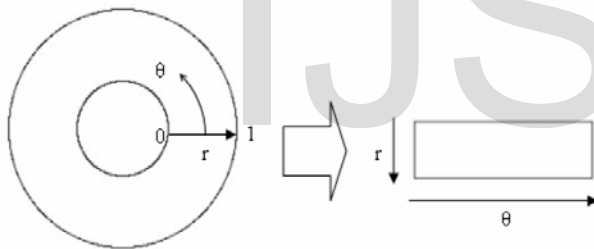

Figure 4.1 Rubber sheet model

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. While mapping iris region into polar co-ordinate system, the centre of the pupil was considered as the reference point, and radial vectors pass through the iris region, as shown in Figure. 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.

After detecting eyelids and eyelashes, a mask based on the eyelids and eyelashes is used to cover the noisy area and extract the iris without noise. Image processing of the eye region is computationally expensive as the area of interest is

of doughnut shape and grabbing the pixels in this region requires repeated rectangular to polar conversion. The template generated after normalization is shown in Figure

This is the template generated using rectangular to polar co-ordinate conversion. These kinds of templates are generated for each individual and are stored in the database.
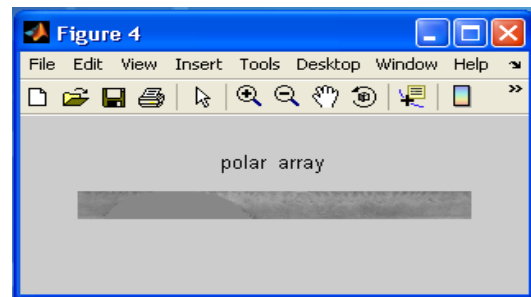

Figure 4.2. Template generated after normalization.

5. CONCLUSION

The iris is an ideal biometric feature for human identification. In this paper we are using simple segmentation & Hough Transform method to detect iris part in eye image. Here we have shown that in segmentation process with the help of simple canny Edge Detector how effectively we can detect outer & inner boundary as well as we can detect Upper & lower eyelid .

Than after by using simple circular Hough transform how we can detect Iris boundary. Experimental results have illustrated that how effectively we can perform this task . But one point to remember here is that effectiveness of Iris localization by this method i.e. segmentation & circular Hough transform will totally depend on quality of input image.

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