Iris Pattern Segmentation using Automatic Segmentation and Window Technique

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Abstract: **A Biometric system is an automatic identification of an individual based on a unique feature or characteristic. Iris recognition has great advantage such as variability, stability and security. In this paper, use the two methods for iris segmentation -An automatic segmentation method and Window method. Window method is a novel approach which comprises two steps first finds pupils' center and then two radial coefficients because sometime pupil is not perfect circle. The second step extract the information of the pupil center and find edges on a one-dimensional imaginary line to each side of the pupil. Localization of iris image is required before iris matching. By experiments we conclude that automatic segmentation algorithm gives 84% accuracy while window technique gives 99% accurate result for Pupil boundary and 79 % for iris edge detections in presence of high degree of eyelashes and eyelids covering the iris region.**

Keywords-Circular Hough Transform; Iris localization; Normalization; rubber sheet mode; Iris basis matrix.

I. INTRODUCTION

Biometric refers to the identification & verification of human identity based on certain physiological trait of a person. The commonly used biometric feature includes speech fingerprint, face, handwriting, hand geometry etc, in these methods iris recognition is regarded as a high accuracy verification technology, so that many country have idea of adopting iris recognition to improve safety of their key departments. The iris is the pigmented colored part of the eye behind the eyelids and in front of lens. It is the only internal organ of the body which is normally externally visible. These visible patterns are unique to individuals and it has been found that the probability of finding similar pattern is almost 'ZERO'. Iris recognition system includes certain steps i.e. iris collection, preprocessing, segmentation, normalization, feature extraction and pattern matching. In this paper, we are focused on segmentation of iris pattern.

Several researchers have introduced various methods for iris finding and localization. John Daugman [1] has proposed very first practical and robust methodologies, providing the base work of many functioning systems. He used integro differential operator to find both the iris inner and outer boundaries contour. Shamsi [4] also use integro differential operator for iris segmentation. Wildes [7], Kong and Zhang [2] and Ma et al. [8] proposed a circular Hough transform method with gradient-based binary edge map construction. Narote et. al [3] has proposed modification circular Hough transform to determine an automated threshold for binarization based on histogram. Bodade and talbar [5] presents a novel approach of accurate iris segmentation using two images captured at two different intensities. Yahya and Nordin [6] & Fitzgibbon et al. [9], proposed a new method based on Direct least squares fitting of ellipse to detect the inner boundary of iris. This method uses Ellipse fitting instead of circle fitting of iris shape. The ellipse fitting is required for real iris images. This method combines several advantages:

• It is ellipse-specific, so that even bad data will always return an ellipse.

• It can be solved naturally by a generalized eigen system.

• It is extremely robust, efficient, and easy to implement.

II. SEGMENTATION TECHNIQUES:

In this paper, we are discussed two approaches for iris segmentation. First, Hough transform based method is used for iris localization and rubber sheet modal is for normalization. And second, a novel approach window technique in which finds the center of the pupil and two radial coefficients due to elliptical shape of pupil. Then extract the information of the pupil center and tries to find edges on a one-dimensional imaginary line to each side of the pupil.

A. *Image Acquisition*

First step of iris recognition system is captured iris region of the human eye image. Eye iris is very small and black object so it must be captured at a short distant about 4cm to 13 cm under a good illumination environment. The objective iris image may have undesired portion of eyes like sclera, eyelid, pupil, the area of this is also a dependent parameters on eye to camera distance & angle of camera. To improve the quality of iris images preprocessing steps are required. In this paper, we have used CASIA database for experiments. Image acquisition is the basic step of iris recognition system and after that iris segmentation is done.

III. AUTOMATIC SEGMENTATION TECHNIQUE

This method evolved the following steps-

A. Iris Localization

To detect the iris image, which is an annular portion between the pupil (inner boundary) and the sclera (outer boundary) localization is required. Pupil is the black circular part surrounded by iris tissues. Outer radius of the iris Pattern can be detected with the help of the center of the pupil. The process of localization requires detection of the inner boundaries (limiting part between iris and pupil) & outer boundary (limiting edge of iris & sclera)

Firstly convert the iris image into grey scale image to remove the illumination effect. In this paper circular Hough transform is employed for detecting the iris and Pupil boundaries. Hough transform perform better when image muddled with artifacts like shadows and noise. This transform first, find the intensity image gradient in the given image at all the locations by convolving with the Sobel filters. Sobel filter are used 3*3 Kernels to calculate the gradient (intensity variation) of image in vertical direction G_{ver} and horizontal direction G_{hor}. The Sobel filter kernels are:

$$C_{ver} = \{-1\ -2\ -1; 0\ 0\ 0;\ 1\ 2\ 1\} \quad (1)$$

$$C_{hor} = \{-1\ 0\ 1; -2\ 0\ 2;\ -1\ 0\ 1\} \quad (2)$$

The absolute value of gradient images along horizontal and vertical direction is by following equation;

$$G_{abs} = G_{ver} + G_{hor} \quad (3)$$

Where G_{ver} is the convolution of the image with C_{ver} and G_{hor} is the convolution of the image with $C_{hor.}$ The edge map of absolute gradient is obtained using canny edge detection. Center of the edge image is determined with the following equation:

$$x_c = x - r*\cos(\theta) \quad (4)$$

$$y_c = y - r*\sin(\theta) \quad (5)$$

Where x,y are the coordinates at pixel P and r is the possible range of radius values, θ(theta) ranges $[0;\pi]$.

A maximum point in the Hough space will correspond of the radius r and center coordinates x_c & y_c of the circle. If using all gradient data, Hough transform is performs firstly for iris/ sclera boundary then apply for iris/pupil boundary. After the completion, the radius, x-y center coordinates for both circles are obtained. The image eyelid and eyelashes are integral part of captured image which affect the effective information of iris, to filter out the undesired part (eyelid, eyelashes, sclera) we use the linear Hough transform. To isolate the eyelid first fitting a line to the upper and lower eyelid with linear Hough transforms. A second horizontal line is drawn, which intersects with the first line at the iris edge that is closest to the pupil. For horizontal gradient information canny edge detector is used & only horizontal component information is taken.

B. Normalization

Between eye images have dimensional inconsistencies due to stretching of the iris caused by pupil dilation from varying level of illumination. Normalization process rectifies those inconsistencies which are produce due to head tilt, imaging distance, rotation of the camera etc. Normalization process will produce iris images, which have same constant dimensions for obtain the two different snap of one iris image under different conditions should same. In normalization we convert the circular iris region into rectangular region. To normalize the iris region Daugman's rubber sheet model is used. Here, we remap 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].

In normalization process, changed the coordinate system by unwrapping the iris and all the point within the iris boundary are mapped into their polar equivalent. Pupil's centre is taken as referral point, and radial vectors pass through the iris region. 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.

IV. WINDOW TECHNIQUE

A. Pupillary boundary

In this paper, CASIA database eye image is used for the experiment. To find the pupil, we first need to apply a linear threshold in the image, Where, *I* is the original image and *g* is the threshold image. If intensity of Pixels greater than the empirical value of 70 (in a 0 to 256 scale) are dark pixels, therefore converted to 1 (black). Pixels intensity is smaller than or equal to 70 are assigned to 0 (white). Next, we apply Freeman's chain code to find regions of 8-connected pixels that are assigned with value equal 1. There is also a possible to see that eyelashes also satisfy the threshold condition, but its area is smaller than the pupil area. Using this knowledge, we can cycle through all regions.

Finally, we apply the chain code algorithm in order to retrieve the only region in the image (i.e. the pupil). From this region, it is trivial to obtain its central moments. Finding the edges of the pupil involves the creation of two imaginary orthogonal lines passing through the centroid of the region. The binarized pupil boundaries are defined by the first pixel with intensity zero; from the center to the extremities. It is very efficient and reliable method.

B. Iris edge detection

In this step of iris segmentation, finding the contour of the iris. The first problem comes from the anatomy of the eye and the fact that every person is different. Sometimes the eyelid may occlude part of the iris and not perfect circle may be assumed in this case. Other times due to variation in gaze direction the iris center will not match the pupil center, and we will have to deal with strips of iris of different width around the pupil.

We are considering that areas of the iris at the right and left of the pupil are the ones that most often present visible for data extraction. The areas above and below the pupil have unique information, but there is a possibility that they are totally or partially occluded by eyelash or eyelid. A technique adopted for iris detection which use the information from pupillary boundary section to trace a horizontal imaginary line that crosses the whole image passing through the center of the pupil. We analyze that the signal composed by pixel intensity from the center of the image towards the border and try to detect abrupt increases of intensity level. Although the edge between the iris disk and the sclera are smooth and it has greater intensity than iris pixels. We intensify this difference applying a linear contrast filter. There is possibility of sudden rise in intensity because some pixels inside the iris disk are very bright. So, detection of iris edge at that point gets fail. To prevent that from happening, we take the intensity average of small windows and then detect when the sudden rises occur from these intervals.

The following steps taken to detect the edges of the iris image I(x,y).

- With papillary boundary algorithm,

  find the center (x_{cp},y_{cp}) of the pupil and the pupil radius r_x and then apply a linear contrast filter on image I(x,y): $G(x, y) = I(x, y).\alpha$
- Create vector V=$\{v_1,v_2,\ldots,v_w\}$ that holds pixel intensities of the imaginary row passing through the center of the pupil (r_x), with w being the width of contrasted image G(x,y).
- Create vector R=$\{r_{xcp+\,rx\,r},\ r_{xcp+\,rx\,+\,1},\ldots,r_w\}$ from the row that passes through the center of the pupil (y_{cp}) in contrasted iris image G(x,y). Vector R formed by the elements of the y_{cp} line that start at the right fringe of the pupil $(x_{cp}+rx)$ and go all the way to the width (w) of the image. Experiences shown that adding a small margin to the fringe of the pupil provides good results as it covers for small errors of the "findpupil" algorithm.
- Similar as described above, create vector L=$\{l_{xcp-rx},l_{xcp-rx-1},\ldots,r_1\}$ from row (y_{cp}) of G(x,y). This time we are forming vector L which contains elements of pupil center line starting at the left fringe of the pupil and ending at the first element of that line.
- For each side of the pupil (vector R for the right side and vector L for the left side):
  - Calculate the average window vector A=$\{a_1,\ldots,a_n\}$ where n=|L| or n=|R|. Vector A is subdivided in i windows of size w_s. For all window $i_1^{\ n/ws}$, elements $a_{i.ws-ws}\ldots a_{i.ws}$ will contain the average of that

window. We found through experiments that a window size *ws=15* provides satisfactory results for the CASIA Iris database.

- Identify the edge point given side of the iris (vector L or R) as the first increase of values in A_j ($1 \le j \le n$) that exceeds a set threshold *t*. In our experiments, a value of *t* equal to 10 has shown to identify the correct location of the iris edge. The advantage of this algorithm is performance. For an image of size *m.n*, the complexity is O(*m.n*) for the contrast operation and O(*m*) for edge finding, total complexity of O(*m.n*). The reader must be warned though that algorithm efficiency and reliability highly depends on carefully chosen threshold (*t*) and window size (*ws*). Other modifications to the algorithm may also help improve the overall accuracy of the algorithm for instance adding margins to the sides of the pupil.

Fast computation comes with a price, and the algorithm is very sensitive to local intensity variation (or lack of).

C. Feature extraction

So far we have performed the segmentation of the iris in two steps to reduce the size of vector pattern and to isolate only information that distinguishes individuals, namely the iris patterns. Reduced size of iris pattern is required because the CASIA Iris Database provides images that are 320x280 i.e. 89,600 pixels. This dimension is too high for today's computing power, and even though we had such capacity, and it also not gives the satisfactory results.

D. Forming iris basis: overall Strategy

Iris Basis is our first attempt to reduce the dimension of the eye image and focused only one part of the eye that effectively identify the desired part. Also, we are restricted to map only those areas of iris which has less influence of eyelashes and eyelids. Assuming that intra-class rotation of iris is practically void, we propose an approach, reduce the size of the iris image and extract pixels of either side of the pupil The overall strategy is as follows: given image, desired number of Iris Basis rows and columns,

- Retrieve pupil center, radius and iris endpoints.
- Calculate height of pupil (2 times radius) and space between rows (*s*) as pupil height divided by desired number of Iris Basis rows.
- Calculate index of the first target row as center of pupil – vertical pupil radius, assuming that first row is at the top of the image.
- For each side of the pupil, find baseline width as iris edge of current side – pupil edge of current side.

And for all baselines, starting at the top of the pupil, ending at the bottom of the pupil and spaced by *s*, perform the following steps-

- Calculate, using the equation of the circle, the (x,y) location of pixel that resides in the intersection of current baseline and circle centered at pupil center with radius equal to pupil horizontal radius .
- Map pixels that are under the baseline to vector B with number of elements equal to half of desired number of columns. Use an average mask of 3x3 pixels to calculate pixel intensity.
- Append vector B to Iris Basis matrix of respective side of the iris
- Merge the two halves of Iris Basis matrices side by side into one final Iris Basis matrix.

This is an attempt to avoid eyelashes and eyelids. The final result of classification will depend only on texture features are in samples. This algorithm considers only those features to the sides of the pupil.

V. EXPERIMENTAL RESULT

The iris images in our experiment are from Chinese Academy of Science Institute of Automation database (CASIA data base) [10]. The resolution of each image is 320x280 pixels, 256 grey scale. There are 108 datasets from 108 users each dataset has 7 iris images.

First method uses the Circular Hough transform for iris localization. An automatic segmentation algorithm is presented, which would localize the iris region from an eye image and isolate eyelid, eyelash and reflection area. Then normalization is performed to eliminate the inconsistencies between iris regions. Figure (1-5) shows the result for automatic segmentation technique.

Second method is window technique, which re-samples iris images into 40x40 pixels of 1601 pattern vector, is used for segmentation. Later Technique involves two steps; first is pupil detection algorithm which gives 99 % accuracy but its iris detection algorithm gives 79 % accuracy in case of high degree of eyelash overlapping and eyelids covering part of the iris or the sclera was not as white as expected. Figure (6-9) shows the segmentation results for window technique.

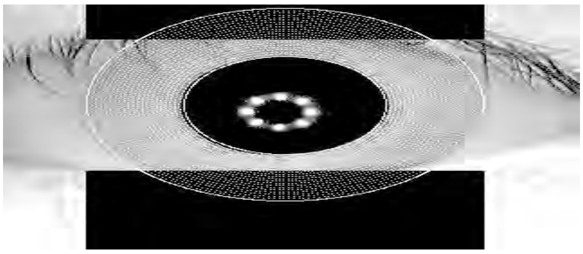

Fig.1. Eye- Iris Segmentation

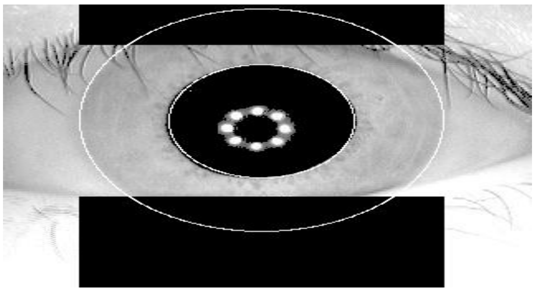

Fig.2 Upper and lower eyelid detection

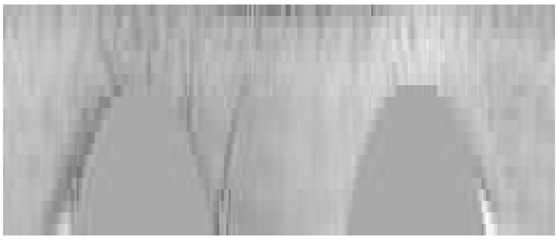

Fig 3. Normalised eye image

Fig 4. Polar noise model

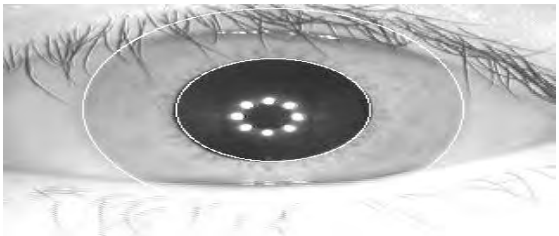

Fig 5. Segmented iris

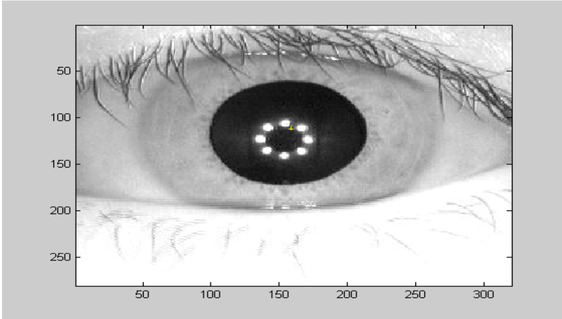

Fig 6. Pupil finder(Find the pupil center)

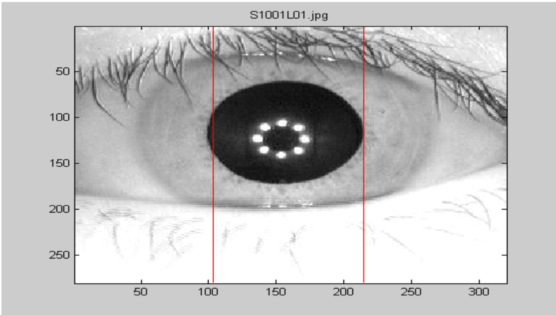

Fig 7. Cycles through all images of the database and gives the final count of segmentation successes or failures.

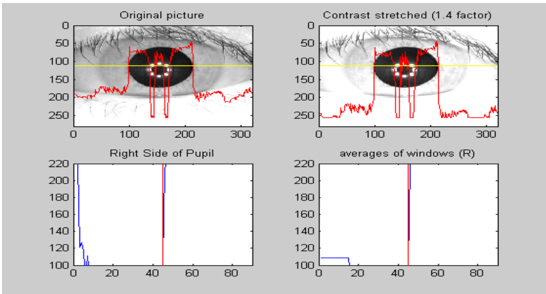

Fig 8. Iris finders (perform image segmentation and finds the edge points of the iris at the horizontal line that crosses the center of the pupil)

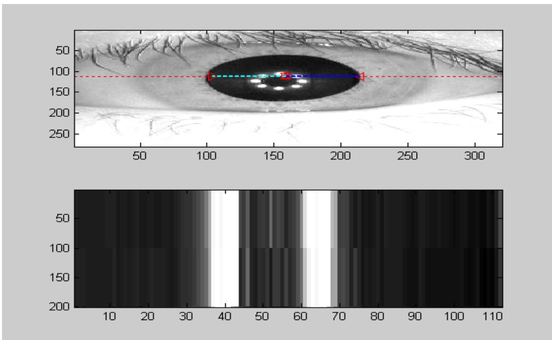

Fig 9. Iris basis construction & visualization

VI. CONCLUSION

In this paper, we have used two techniques for iris image segmentation; Automatic segmentation algorithm and window technique. Automatic segmentation technique based on assumption that iris are always circular in shape. Window technique extracts the areas of the iris at the right and left of the pupil are the ones that most often visible for data extraction. The areas above and below the pupil have unique information, but there is a possibility that they are totally or partially occluded by eyelash or eyelid. So, this method is unaffected by shape of the iris. The proposed window technique involves two steps for matching i.e. pupil detection and iris detection. Improvement in iris detection algorithm will provide the improved overall performance of the window technique.

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