Enhanced Segmentation Method for Iris Recognition

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Abstract— **Real-time Iris recognition systems are difficult to implement due to high processing time. Different steps of iris recognition process include segmentation, normalization and template creation and matching. Iris segmentation is the most time taking step in every iris processing application. Most iris processing implementations today employ low resolution iris image capture to keep the segmentation time within limits. This paper presents an enhanced iris segmentation method that allows iris recognition systems to be implemented in real-time applications. Reduced iris segmentation time further allows high resolution iris images to be used thereby enhancing recognition accuracy.**

Keywords- iris recognition; segmentation; real-time

I. INTRODUCTION

A biometric system provides identification of an individual based on a unique biometric feature or characteristic of an individual. Different biometric features include human speech, fingerprint, iris, retina, face etc. In terms of accuracy, face, fingerprint and iris based systems are considered to be most effective. Since fingerprint of an individual changes over time (over the age of an individual) and face recognition systems require large database area and high matching time they are considered infeasible for high accuracy, large size recognition applications. Iris textures possess high degree of randomness and complexity which is the key to uniqueness. Iris texture of an individual remains stable through life (age invariant) and can be encoded in small memory. These features (high degree of randomness, unchanging characteristics over time, small database size, low template matching time) make Iris based recognition the most accurate and reliable biometric identification available. Fig. 1 shows an eye image along with iris region (shown between the two concentric circles).

Figure 1: Eye Image

However iris systems are complex and costly due to the following reasons. Iris is a small moving target (1 cm) to acquire from (1 m) distance. It is located behind a curved, wet, reflecting surface with the curvature of the cornea causing wide-angle reflections obscured by lashes, lenses, reflecting eye glasses etc. Typically iris regions are partially occluded by eyelids, often drooping. Iris regions deform non-elastically as pupil changes size.

Different steps of the Iris recognition process are eye image acquisition (with near infrared illumination to capture the texture of the iris to be different from pupil region), segmentation (localize the iris region within the captured eye image), normalization (to obtain unwrapped annular iris region from Cartesian to polar form), template creation (feature extraction from iris texture information) and matching. The accuracy of the system and subsequent steps depend heavily on the quality of the segmentation process. Most of the previous works concentrated on improving the accuracy of segmentation with little regard to segmentation time. Table – 1 shows the execution times of various iris processing steps on a 300 MHz embedded processor (from [4]). We see that iris segmentation is the time consuming step that limits real-time acquisition and computation of iris template from "on-the-run" acquired eye images.

TABLE-1
Typical execution times of various Iris processing steps on a 300MHz processor

Operation	Execution Time
Accessing Image Focus	15ms
Localizing the eye and Iris Region (Segmentation)	90ms
Iris normalization	5ms
Binary Template Creation	7ms
Template Matching	10us

A. Previous Works

Most commercial iris recognition systems use patented algorithms developed by Daugman [1]-[3], and these algorithms are able to produce good recognition rates. These algorithms use the integro-differential operator to detect the pupil and iris boundaries. Wildes [5] elaborated the Hough transform based operator to determine the contours corresponding to the iris-pupil and iris-sclera edges. Many other researchers relied on these two techniques for locating the iris and extracting it from the others eye parts. In order to increase the pupil accuracy segmentation Kheirolahy [6] have used the optimized color mapping to make the pupil region clear and easy to segment and they have achieved 98%

accuracy by applying optimized color mapping. Their method worked well on most of the eye models. Next, Kallel [7] increased the localization of the iris by applying a morphological cleaning technique before integro-differential operator, the transform algorithm or the multi scale edge detector approach. Young Nam [8] recouped the drawback in Canny algorithm by adding an enhancement depending on dynamic threshold of edge detection algorithm. Further, Dey [9] have proposed a scaling, to reduce the search space, and power transform to assist for image thresholding and they have had almost 100% accuracy by applying their methods on CASIA iris database. Arvacheh [10] proposed active contour model to enhance pupil boundary detection. Jarjes [11] identified the pupil boundary by circle fitting. The angular integral projection function was used to detect points. Then, the precise contour is detected using active contour model initialized on the pupil circle. Badit [12] determined the pupil by finding a point in the pupil and then center is obtained using centroid of the pupil region. Circular boundary of the pupil is divided into specified number of points. These points are repositioned with respect to the maximum gradient and then joined together to obtained exact boundary of the pupil while Ying Chun [13] localized the pupil by combined techniques such as edge extraction and geometrical features to conform the coarse eye region by gray integration projection region combination.

Most of the previous work concentrated on improving the accuracy of the segmentation process with little regard to segmentation time. The previous algorithms are computationally complex and require high processing time. Hence these algorithms are not suitable for real-time processing of iris images. This paper considers reducing the segmentation time with almost no loss in accuracy. In the proposed segmentation approach, pupil and iris boundaries are approximated by circles. It initially attempts to locate pupil circle using edge detection on thresholded image and a modified and improved Hough transform. It then detects outer boundary with its center within a small window of pupil center and its perimeter outside the pupil circle within some range, using the robust circular integro-differential operator.

Section–II describes methodology of iris recognition system and Section-III describes the proposed iris segmentation algorithm. This algorithm has been tested on CASIA 2.0 database and the experimental results are presented in Section-IV. Section–V finally concludes the paper.

II. Methodology

The block diagram of the iris recognition process in shown in Fig. 2. The first step of the process is image acquisition. To capture the rich details of iris patterns, an imaging system should resolve a minimum of 70 pixels in iris radius (typical 100-140 pixels). Monochrome CCD cameras (480 x 640) have been used because near infrared (NIR) illumination in the 700nm –900nm band was required for imaging to be invisible to humans. In NIR wavelength, even darkly pigmented irises reveal rich and complex features. Wide-angle camera is necessary for coarse localization of eyes in faces and to steer the optics of a narrow angle camera, which acquires higher resolution images of eyes. Most of the present commercial systems use low resolution images to limit the processing time. However with the proposed algorithm which results in reduced segmentation time, even high resolution images can be considered during image acquisition thereby further improving the accuracy of recognition process.

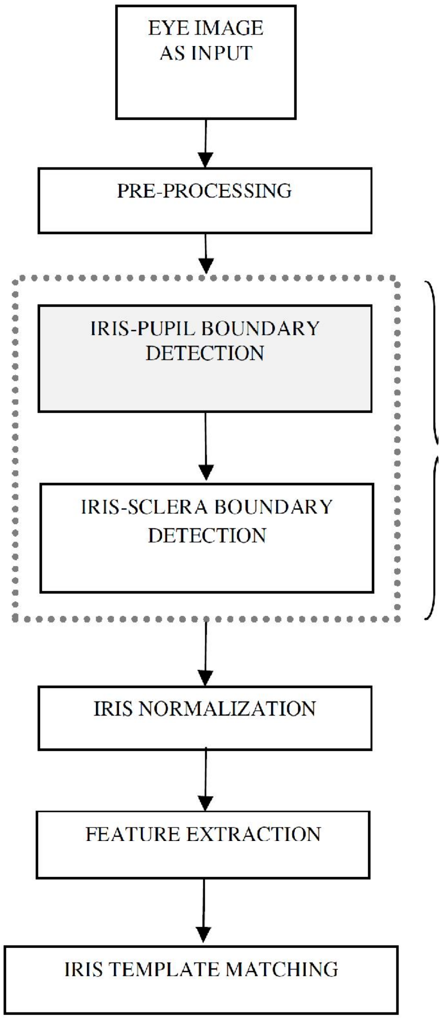


Figure 2: Different Steps of a typical Iris Recognition System

The second step is the iris segmentation. First, it is necessary to localize precisely the inner and outer boundaries of the iris, and to detect and exclude eyelids if they intrude. These detection operations are accomplished by an integro-differential operator [2]-[3], which behaves as a circular edge detector, blurred at a scale set by σ, that searches iteratively for a maximum contour integral derivative at successively finer scales through the three parameter space of center coordinates and radius (x_0, y_0, r).

$$\max_{x_0,y_0,r} G_\sigma(r) * \frac{\partial}{\partial r} \oint_{x_0,y_0,r} \frac{I(x,y)}{2\pi r} ds \tag{1}$$

This operation while achieving good accuracy in iris isolation is computationally quite complex since the search space involved (over x_0, y_0, r).) is very high. The next section proposes the enhanced segmentation algorithm that results in good accuracy and low processing time.

III. Proposed Segmentation Method

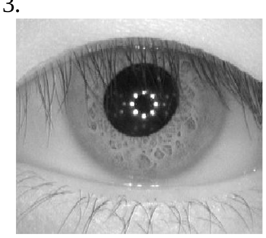
The proposed segmentation method is applied in two stages.

A. Inner Boundary localization

Pupil of the eye can be modeled as a dark circular region within the iris assuming it to be circular. An eye image I is scaled down and thresholded to obtain a binary image I_t to filter out pupil pixels. It reduces the search space for pupil boundary (iris inner boundary) only to the dark pixels in the image. But several types of noise pixels like eyelashes, eyebrows, shadow or specular reflection on the pupil pose severe problems. Hence specular reflection inside the pupil region and other dark spots caused by eyelashes are removed to give the binary image I_{tf}. Pixels at pupil boundary must be strong edge pixels; hence in order to obtain strong edge pixels, Sobel filters in vertical as well as horizontal direction are applied on I_{tf} giving the gradient images I_{gv} and I_{gh} respectively. The gradient magnitude image I_g is obtained as

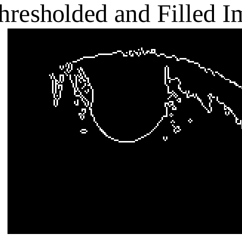
$$I_g = \sqrt{I_{gv}^2 + I_{gh}^2} \tag{2}$$

Finally, I_g is thresholded based on gradient magnitude to generate binary image I_{gb} having only strong edge pixels. Standard Hough transform is improved and used to detect the pupil boundary on only strong edge pixels represented as “White" in I_{gb}. Time complexity of this improved Hough transform is greatly reduced due to reduction of search space. The algorithm outputs the required parameters (circle center coordinates c_{xp}, c_{yp}) and radius r_p . Steps of pupil segmentation are shown in Fig. 3.

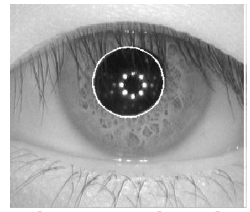


a)Original eye image

b)Thresholded and Filled Image



c)Result of Sobel Edge detection

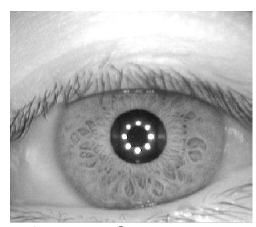


d)Segmented Pupil

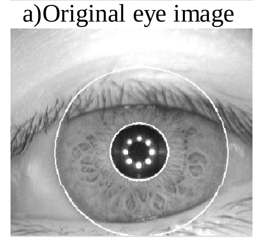
Figure 3: Illustration of Pupil detection

B. Outer Boundary Localization

The results of the inner boundary localization are used to guide the detection of outer boundary. The contrast across outer iris boundary is less compared to the inner boundary. Edge detection faces edge-strength thresholding problems. To tackle this problem, the robust circular integro-differential operator [7] is used in a modified manner. In order to localize iris outer boundary, original image I is first smoothened using 2-D radial Gaussian filter to remove stray noise to give I_s. Iris center and pupil center are not necessarily concentric, but are usually close. Using a 15×15 window around the pupil center, we apply the integro-differential operator over a sector instead of the whole circle. These sectors are chosen because in these sectors of the iris, occlusion is empirically found to be less compared to other areas of iris, thus facilitating correct localization. Intensity values along sector arcs of different radius are summed up. The center coordinates c_{xi}, c_{yi} and iris radius r_i to estimated to be those values that maximize this sum. Iris images after outer boundary localization are shown in Fig. 4



a)Original eye image



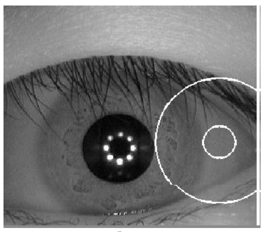
b) Inner boundary and outer boundary

Figure 4: Illustration of Outer Boundary detection

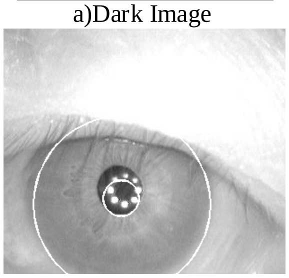
IV. Experimental Results

In order to analyze the proposed iris segmentation algorithm, we have considered the 400 images of 100 different subjects from CASIA 2 database. The accuracy of detection was found to be 99%. By adjusting the scale parameter and sector size of integro differential operator the accuracy could be increased to 99.5%. Out of 400 images, 9 images resulted in segmentation errors while segmentation for the other images was correct.

These 9 images are found to be too bright/dark. During the image acquisition process, if the captured images could be discarded based on intensity distribution being classified as too dark or too bright then the accuracy of segmentation process could be further improved. Examples of images for which segmentation failed can be seen in Fig. 5. Binary conversion Threshold and angular range are found to be the dominant parameters affecting the accuracy of segmentation. The segmentation time calculated for various segmentation methods is shown in Table-2. These results were obtained by running the different segmentation algorithms in MATLAB on a 2GHz Core2Duo processor based computing system.



a)Dark Image



b) Bright image

Figure 5: Some Segmentation Errors

TABLE-2
Computation Time for Iris segmentation

Segmentation Method	**Total Average Computational time for inner and outer boundary detection**
Integrodifferential operator [2]	5.08sec
Hough transform [5]	8.47sec
Multiscale Edge detection [7]	7.39sec
Proposed Two stage segmentation Method	0.9 – 1.03 sec

V. CONCLUSIONS

This paper considered the design of low complexity segmentation algorithm that results in reduced segmentation time without scarifying accuracy. The algorithm proceeds in the two stages viz. inner and outer boundary detection. Further adaptive optimization of the various parameters based on input image statistics further improves the segmentation accuracy. The segmentation time is typically reduced by a factor of 5. This work can be further extended by making it more robust against images with all kinds of nonidealities.

REFERENCES

[1] J. Daugman "Probing the uniqueness and randomness of Iris codes". Proceedings of the IEEE. Vol 94 No.11, November 2006. Pp. 1927-1935

[2] J. Daugman, "How Iris Recognition Works", IEEE Transactions on Circuits and Systems for Video Technology (CSVT), vol. 14, no. 1, 2004, pp. 21 -30

[3] J. Daugman, "High confidence visual recognition of persons by a test of statistical independence", IEEE Trans. on Pattern Analysis and Machine Intelligence, vol. 15, no. 11, 1993, pp. 1148-1161.

[4] S. Mahboubeh. Ellipse gamma spectrum iris recognition based on average square shrinking segmentation and trapezium normalization. A Ph.D. Thesis. Universiti Technologi Malaysia; 2011

[5] R. P. Wildes. Iris Recognition: An Emerging Biometric Technology. Proc. of the IEEE, 85(9):1348–1363, Sep 1997

[6] Kheirolahy, R.; Ebrahimnezhad, H.; Sedaaghi, M.H., "Robust pupil boundary detection by optimized color mapping for iris recognition," Computer Conference, 2009. CSICC 2009. 14th International CSI, vol., no., pp.170-175, 20-21 Oct. 2009.

[7] Kallel, I.K.; Masmoudi, D.S.; Derbel, N., "Fast pupil location for better iris detection," Systems, Signals and Devices, 2009. SSD '09. 6th International Multi-Conference on, vol., no., pp.1-6, 23-26 March 2009.

[8] Mi Young Nam; Phill Kyu Rhee; Chan Suk Lee, "A real time pupil location system using multiple illuminations clustering under varying environment," Consumer Electronics, 2009. ICCE'09. Digest of Technical Papers International Conference on, vol., no., pp.1-2, 10-14 Jan.2009

[9] Dey, S.; Samanta, D.; , "An Efficient Approach for Pupil Detection in Iris Images," Advanced Computing and Communications, 2007. ADCOM 2007. International Conference on, vol., no., pp.382-389, 18-21,Dec.,2007

[10] Arvacheh, E.M.; Tizhoosh, H.R.; , "IRIS Segmentation:Detecting Pupil, Limbus and Eyelids," Image Processing, 2006 IEEE International Conference on , vol., no., pp.2453-2456, 8-11 Oct. 2006.

[11] Jarjes, A.A.; Kuanquan Wang; Mohammed, G.J.; , "Iris localization: Detecting accurate pupil contour and localizing limbus boundary," Informatics in Control, Automation and Robotics (CAR), 2010 2nd International Asia Conference on , vol.1, no., pp.349-352, 6-7 March 2010.

[12] Basit, A.; Javed, M.Y.; Masood, S.; , "Non-circular pupillocalization in iris images," Emerging Technologies, 2008. ICET 2008. 4th International Conference on , vol., no., pp.228-231, 18-19 Oct. 2008.

[13] Ying-Chun Guo; Zheng-Xin Hou; Ming Yu; , "Automatic localization of pupils in color human images," Machine Learning and Cybernetics, 2004. Proceedings of 2004 International Conference on , vol.7, no., pp. 4067- 4070 vol.7, 26-29 Aug. 2004.