Pupil Segmentation from IRIS Images using Modified Peak Detection Algorithm

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ABSTRACT
Iris segmentation is an important phase in iris recognition and identifies the accuracy of preprocessing. This paper proposes improved peak detection algorithm to locate the pupil accurately. The modified peak detection algorithm determines the optimal peak which helps for pupil localization. Thresholding is done based on the peak determined. Finally canny edge detector is applied on the binary threshold image to separate the pupil from the image. The proposed method was tested on CASIA and UBIRIS datasets and the results show that the proposed method segments the pupil from the given iris image. Subjective and objective evaluation proves the efficacy of the proposed method.

Keywords
Pupil Extraction, Iris Segmentation, Peak Detection.

1. INTRODUCTION
Iris recognition is gaining acceptance as a robust biometric for high security and large–scale applications [1][2][3]. A typical iris recognition system comprises of the steps extracting pre–processing (pupil boundary), extracting iris boundary, define the iris code and finally matching with some metric like Hamming distance. The challenging part in iris recognition is the occlusion of iris by eyelids or eyelashes. The early works focused on extracting good features for efficient recognition rather than on pre–processing.

Image thresholding is the most simple and trivial segmentation approach to separate the object from images, and more particularly gray level images [4]. Normally the good edge detection method is to have a very less error. The goal of segmentation is to prove that the segmentation techniques based on the peak detection algorithm provides a good segmentation result and improves the ability to apply the same technique to the any type of images [5]. Neeta Nain et. al, [6] proposed a dynamic peak detection algorithm for edge detection. Both these methods output the optimal threshold values which mean that multilevel thresholding is done on the image to get the binary equivalent.

The aim of our investigation is to correctly locate the pupil boundary from the iris image. It means finding the position of centre and radius of the pupil. In our approach, the pupil boundary is assumed as circular in shape. As a pre– processing step, the image is subjected to Gaussian filtering to minimize the detection of false edges, noise and other irrelevant details. The proposed peak detection algorithm is applied on pre–processed image to get the optimal threshold value. The peak detection algorithm described in Section 3 is a four stage process which yields the most optimal single threshold value through which the binary image is formed. The proposed method yields a single optimal threshold value compared to [5][6] herein multiple thresholds are obtained. The peak obtained is treated as optimal value because it segments the pupil from the iris image perfectly from the CASIA and UBIRIS datasets without any error. Edge detectors are applied on the binary image to segment the pupil from the iris image. Edge detection from matrix operations [8] is applied on the binary image in addition to classical canny edge detector [16] for comparison.

The rest of the paper is organized as follows. Section 2 describes brief review on pupil segmentation. In Section 3, the proposed method is described. The proposed method has been evaluated over all the iris images of CASIA and UBIRIS data sets and the results are presented in Section 4. Section 5 concludes the work.

2. RELATED WORKS

In Iris, the darkest region of eye is pupil and outer boundary of the darkest region is sclera. The pupil and sclera can be as rough circle.

Iris localization means to isolate the actual region in a digital iris image by detecting the inner and outer iris boundaries [9]. The most popular method for inner boundary detection is the Hough Transformation [10]. For pupil boundary, it is defined as

$$H(Xc, Yc, r) = \sum_{i=1}^{n} h(Xi, Yi, Xc, Yc, r)$$

where H (x_c , y_c , r) represents a circle through a point, the coordinates x_c , y_c , r define a circle equation as

$$X_c^2 + Y_c^2 - r^2 = 0$$

Most of the researches tried to improve upon Wildes et. al's idea of using edge detection and a Hough transform. Most of the work on pupil segmentation has been made based on the assumption that the pupil is the darkest region and presented good results on locating the iris. The major problem arises in these approaches when the method is tested on real images. In Tian et. al's method [11], they determine a threshold value and then finds all the pixels less than the threshold value for approximating the pupil center. Xu et. al[12] divides the image into a rectangular grid and used the minimum mean intensity level across the grid cells to generate a threshold for binarizing the image to get pupil region. Zaim et al. [13] determined the pupil region by using divide and conquer approach to detect connected regions of uniform intensity. Bonney et. al [14] proposed a method in which they determine the pupil by significant bit plane and applying morphological operations erosion and dilation. Cui et al. [15] decomposed the iris image using Haar wavelet before pupil localization. Modified Hough Transform was used to obtain the center and radius of pupil. Iris outer boundary was localized using an integral differential operator.

3. PROPOSED METHOD

The proposed method is considered as the pre–processing (or) a part of iris localization step because it deals in extracting the inner boundary of iris only. The proposed peak detection algorithm is described in 3.1. The block diagram of the proposed method is given in Figure 1.

3.1Peak Detection Algorithm

We propose a slightly modified peak finding algorithm to discover the most well-known peak which is later considered as the optimal threshold value for iris binarization. The steps involved are

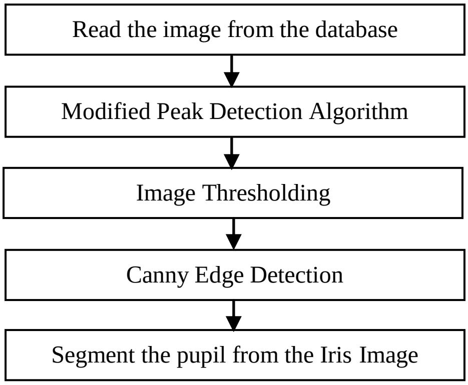

Fig 1: Block Diagram of the Proposed Method

1. Determine the frequencies of the image and place the gray level values that are related to their frequencies in a set. Each gray scale value is denoted as i and the corresponding frequency is denoted as f_i in a set S_0.

$$S_0 = \{(i, f_i)\}$$

2. Determine all the local maxima. In set S_1 contains the data that are corresponding to the frequency of local maxima in the histogram image.

$$S_1 = \{(i, f_i) \mid ((f_{i+1} < f_i) \;\&\; (f_i > f_{i+1}))\}$$

Where $(i, f_i) \in S_0$

3. Determine the set S_2, which are having frequency greater than or equal to maximum frequency (f max) in the set S_1.

$$f\,max = max\ (F)$$

$$S_2 = (i, f_i) \mid f_i > f\,max$$

Where $(i, f_i) \in S_1$

4. Reduce the number of peaks which are having close difference from set S_2. It can be done by checking the variation in set S_2. If the variation in S_2 is less than or equal to 15 and the minimum frequency element is equal to frequency of i is removed from S_2.

$$\begin{aligned}
&\text{if } (\min(f_i, f_j) == f_i) \\
&S_3 = S_2 - (i, f_i) \mid i > j, (i - j) \le 15 \\
&\text{elseif } (\min(f_i, f_j) == f_j) \\
&S_3 = S_2 - (j, f_j) \mid i > j, (i - j) \le 15 \\
&\text{End}
\end{aligned}$$

Where $(i, f_i), (j, f_j) \in S_2$ and f_i, f_j are frequencies corresponding to the i^{th} and j^{th} gray levels respectively.

5. Refine the set once again to get the most predominant peak value

$$S_4 = S_3 - (((i, f_i) \mid i > j, (i - j) < 10))$$

Where $(i, f_i) \in S_3$

3.2 Thersholding

Thresholding [7] is a process of partitioning an image into pixels based its gray level. The peak value obtained in the previous step is used for thresholding. Truncated interval thresholding is used which is defined as g(x, y) =

$$\begin{aligned}
&0 \quad, \text{if } 0 < i(x, y) \le T_1 \\
&255, \text{if } T_1 < i(x, y) \le T_2 \\
&0 \quad, \text{Otherwise}
\end{aligned}$$

In case of truncated interval thresholding, the very low intensity pixels (almost black) and very high intensity pixels (almost white) become zero (black) and the medium intensity pixels ranging from the threshold values T_1 and T_2 are highlighted to 255 (white). The procedure for choosing the values T_1 and T_2 is follows:

Based on the previous step, the peak is determined. If the highest peak is obtained for the intensity value 0 or 255, then the second highest peak is considered. Otherwise, to the peak value, one third of the intensity is subtracted to get the T_1 value and one third of it is added to get the T_2 value. This means that if we draw the lines from T_1 and T_2 to the highest peak, a triangle is formed. The peak value is the centroid of the triangle formed. The intensity values falling within the triangle are highlighted to 255 and the intensity values that fall outside the triangle are merged with background.

Special cases: If the triangle is formed outside the histogram i.e., $T_1 < 0$ or $T_2 > 255$, then the bounds are considered for the respective thresholds. This means that if one third of the intensity is subtracted from the peak and the value is less than zero then $T_1 = 0$. Similarly $T_2 = 255$.

3.3. Edge Detection

Edge detection is a process of detection of these discontinuities in an image [7]. The process of edge localization is complex in the case of intensity level images. We have used matrix operations based edge detector proposed by Janakiraman et. al [8] and Canny's edge detector for the analysis. Janakiraman et.al proposed an efficient method for determining the edge map of the image by doing rotation operations. The pixel in the given image is subjected to different types of rotation with different angles. Then the transformed image is subtracted from the original image to get the dominant pixels. They termed the pixels as dominant pixels since these pixels are invariant subject to rotations. Dominant pixels are subsequently enhanced and linked to get the final edge map.

4. EXPERIMENTAL RESULTS

The proposed method is tested on the CASIA and UBIRIS datasets. These two datasets are the general databases for iris image. The first version of CASIA databases have some disadvantages that are identifying the pupil region and fill the region with black pixels. Iris segmentation helps to improve their results. In Second version of CASIA databases overcome the disadvantages and reduce the noise.

The proposed method is implemented using Matlab 6.5 and the CPU used is Intel Core 2 Duo T7250 @ 2.00 GHz with 1 GB RAM. The experiment is carried out all the images of UBIRIS and CASIA. Results of some sample images are shown in Figures 2 and 3 respectively.

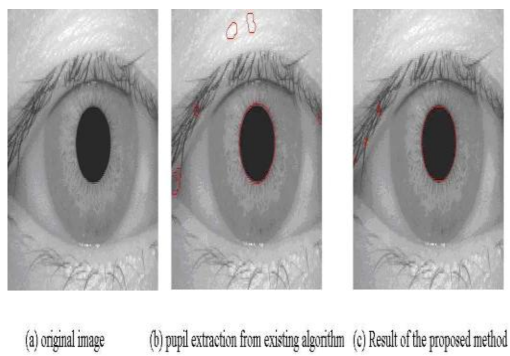

Fig.2: Result of sample images

In the Figure 2 .a is the original image of iris, 2.b is pupil extract from the existing algorithm and 2.c shows the result of proposed algorithm.

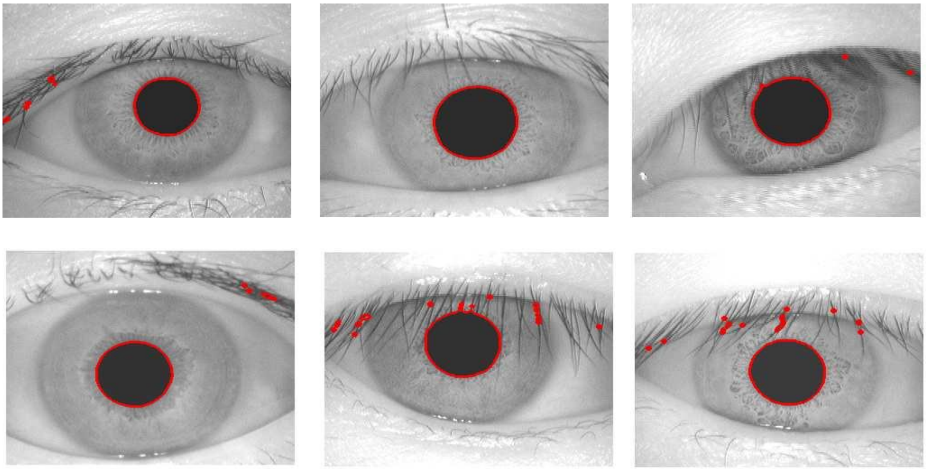

Fig.3: Results of the proposed method or some more sample images

5. FUTURE WORK

Based on the inner boundary, the outer boundary also should be localized for complete iris localization. From the results it is evident that the pupil has been identified correctly by the proposed method. In addition, in some images, there are some more small portions plotted red in color. These small components can be ignored in further processing.

6. CONCLUSION

In this paper, a novel method is proposed for pupil segmentation from the iris images. The novelty of the approach lies in improving the existing method and applied to iris images. The proposed method involves simple arithmetic operations without involvement of huge concepts like Hough transform etc and still locates the pupil with accuracy. The experimental results show the efficacy of the proposed method.

7. REFERENCES

[1] Jain A.K., Ross A. and Prabhakar S: An Introduction to Biometric Recognition, IEEE Transactions on Circuits and Systems for Video Tech.,Vol. 14 (2004), 4–20.

[2] Zhang D: Automated Biometrics: Technologies and Systems, Kluwer(2004).

[3] Luis–Gracia R.D., Alberola-Lopez C., Aghzout A. and Ruiz-Alzola: Biometric Identification Systems, Signal Processing, Vol. 83 (2003), 2539–2557.

[4] Peihua Li, Xiaomin Liu, Lijuan Xiao, Qi Song: Robust and accurate iris segmentation in very noisy iris images, Journal of Image and Vision Computing, Vol. 28 (2010), 246–253.

[5] Nakib A., Oulhadj H., Siarry P.: Image histogram thresholding based on multiobjective Optimization, Signal Processing Vol. 87 (2007), 2516–2534.

[6] Neeta Nain, Gaurav Jindal, Ashish Garg and Anshul Jain.: Dynamic Thresholding Based Edge Detection, Proceedings of the World Congress on Engineering, (2008).

[7] Gonzalez R.C., Woods R. Digital Image Processing, 3rd edition, University of MMM, Chicago Press, (2005).

[8] Janakiraman T.N. and Chandra Mouli P.V.S.S.R.: Color Image Edge

Detection using Pseudo-complement and Matrix Operations, Journal of World Academy of Science, Engineering and Technology, Vol 42 (2008), 435–439.

[9] Makram Nabti and Ahmed Bouridane: An efficient and fast iris recognition system based on a combined multiscale feature extraction technique, Pattern Recognition, Vol. 41 (2008), 868–879.

[10] Wildes R.P.: Iris recognition: an emerging biometrics technology, Proceedings, IEEE Vol. 85(9) (1997), 1348–1363.

[11] Qi–Chuan Tian, Quan Pan, Yong-Mei Cheng, Quan-Xue Gao: Fast algorithm and application of Hough transform in iris segmentation, International Conference on Machine Learning and Cybernetics, Vol.7 (2004), 3977–3980.

[12] GuangZhu Xu, ZaiFeng Zhang, YiDe Ma: Automatic Iris Segmentation based on local areas, International Conference on Pattern Recognition, (2006),505–508.

[13] Zaim A., Quweider M., Scargle J. Iglesias, Tang R.: A robust and accurate segmentation of iris images using optimal partitioning, ICPR '2006, 578-581.

[14] Bradford Bonney, Robert Ives, Delores Etter, Yingzi Du: Iris pattern extraction using bit planes and standard deviations,, 38th Asilomar Conference on Signals, Systems and Computers,2004, 582–586.

[15] Cui J., Wang Y., Tan T., Ma L. and Sun Z.: A Fast and Robust Iris Localization Method Based on Texture Segmentation, Proceedings of the SPIE, Vol. 5404, (2004), 401–408.

[16] Canny J.: A computational approach to edge detection, IEEE Transactions on Pattern Analysis and Machine Intelligence Vol. 8(6) (1986), 679–698.