Segmentation Approach for a Noisy Iris Images Based on Block Statistical Parameters

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Abstract: The Iris localization plays a big role in the performance of an iris recognition system. This is due to the dependent of the next steps up on it, and the incorrect segmentation might lead to inexact normalization and improper feature extraction from less discriminatory parts (eyelids, eyelashes, pupil, etc.) so the execution of system will diminish. An effective method for locating the iris of the eye is suggested in this paper. At first a mixture of gamma transform and contrast enhancing mechanisms are used to guarantee a precise renovation of eye image to become an iris area easy to isolate. The next step is relayed on calculating the statistical image parameters (i.e., the mean and standard deviation) which are employed as a feature to detect outer iris boundary. The integro-differential operational technique is used with further pre-processing processes to detect the inner boundaries of iris. The noisy iris UBIRIS.v1 dataset was used in the experiment. Thee conducted results indicated that the proposed technique has a good performance, which is improved accuracy of iris localization step for noisy dataset.

Keywords: Biometrics, Statistical parameters, Iris segmentation, Noisy environments, Iris recognition Integro-differential operator (IDO)

1. INTRODUCTION
Biometrics is a technique that uses physiological or behavioral features to authenticate a person's identity [1] to identify individuals. Biometrics is used instantly based upon different physiological characteristics, including fingerprints, face, movement, iris, ear, and sound. Due to its unique nature and its fixed patter throughout the life of the individual the human iris pattern can be used as an ideal biometrical feature [2], [3]. An iris offers high precision in applications relating to personal identification. These applications represent secure access to the ATM machines bank accounts, border controls at national borders, safe access to condominium buildings, passport controls etc. [4]. In spite of there is a fact that iris patterns may provide high confidence for safe identification and personal
authentication but still many challenges ahead of researchers. One of the key issues of iris recognition research is to achieve distinct features of the iris that may maintain its stability to the users concerned on a large scale and under different interference conditions, such as lighting differences, aging, as well as eyelids and eyelashes effecting.

2. RELATED WORKS

The most common current methods of iris localization are boundary-based. These approaches at first find the region of pupil as the internal border of the iris, and then discovery the eyelid and limb regions, isolating the iris from it. The Hough transform (HT) [4] and combined Daugman’s integro differential operator (IDO) are these kinds of approaches [5].

Wildes approach used HT which is discovered the circular by voting on the edge-map within a certain range of radius. HT-based detection methods are also used [6],[7]. The integro-differential operator for Daugman, looks for the maximum variance in the pixel's value on circular contours ds with changing the radius r and center (x0, y0) over the whole of the image domain. The $G_{\sigma}$ is a smoothing function and the symbol * indicates the convolution. The advanced method was developed in 2012 [8]

$$\max_{(r,x_0,y_0)} = \left| G_{\sigma}(r) \ast \frac{\partial}{\partial r} \int_{(x_0,y_0)} l(x,y) \frac{1}{2\pi r} \, ds \right|$$

Despite its high efficiency, when the iris input is noisy, the Daugman operator does not always locate the iris precisely. The noise represented by a reflection image, or not fully eye opened. Jeong et al. [9] in 2010 proposed a technique that aims to decrease error rate in a non-cooperative environment. In combination with AdaBoost, this technique was used to detect pupil and iris borders by two circular edge detectors and this method estimates true eyelid and eyelash boundaries. It is also there are other ways to reduce noise before iris boundaries detection for increasing the accurateness of localization [10].

All these localization methods require high-quality images and an ultimate environment of imaging; consequently, those approaches get less precise or can result with higher error rates in non-ideal situations.

Other methods consist of pixel-based localization approaches. These approaches depend upon defining the border between iris and other pixels in the neighborhood by means of a particular color texture and lighting gradient. Depending on the distinction features an iris designation is made for the identification of iris and non-iris pixels. Khan et al. Khan et al., in 2011 [11] suggested a way to localize iris. They used the two-dimensional profile lines between the iris and the sclera and measured the gradient pixels by pixels in which the iris limit is the most important change. Ashwaq and Duaa, [12] proposed an approach for localizing iris area by using mixture of image processing techniques. The formal features of the iris, like the noise region in several areas of the eye image, are kept in mind (i.e., specular reflections, focus and small visible iris part). The iris occurred and as the iris borders became clear as the boundary area of these two boundaries. However, the overall performance of the iris localization methods is reduced by various constraints such as dark skin, eyelashes, and hair or where the true boundaries of the iris are not detected.

On the other hand, the external iris boundaries appear to be non-circular and non-elliptical in non-zero images such as iris images off-axis. Furthermore, the region of iris localization is not effective since eyelashes and eyelids are incompletely blurred. It is notice that important to use a non-circular method to iris segmentation for overcoming these encounters. For this reason, the active contour is a perfect candidate [13].

Nevertheless, the presence of vulnerabilities in previous active contour models does not make them effective to segment the iris. For example, the active snake contour [14], is sensitized to the initial curve and cannot discover non-axial objects. Though the difficulties related with snake active contour have been mitigated by Xu and Prince [15] in the Active Gradient Vector Flow (GVF), the GVF contour continues to have minimum energy points and stop at the incorrect edges. The standard snake and GVF
versions are also built to shrink to the target mark. Therefore, if the primary mask is within the target object the contour reduces and disappears [16].

To address these issues concerning the existing approaches, we propose an approach to localize the iris of the eye where a mixture of gamma transform and contrast enhancement mechanisms are employed to ensure an accurate translation of eye image to become an iris area easy to isolate. The next step is relayed on calculating the image’s statistical parameters which are employed as a feature to detect outer iris border. The rest of this article is structured accordingly. The proposed system is described in detail in Section 2. Section 3 discusses the experimental results and discussion. Section 4 includes the conclusions.

3. PROPOSED System

The localization of iris from the eye image is a significant stage in iris recognition system; it goals to allocate of iris borders accurately. Iris of human is a part between the pupil region and the white sclera region which are represented the inner circle and outer circle respectively as depicted in Figure (1).

![Figure 1. Human eye anatomy [17].](image)

The main steps of the iris segmentation are:
1. Segmentation of pupil which is a technique to detect of the internal border of the pupil region.
2. Segmentation of iris which is a technique to detect of the outside border of the iris region.

3.1. PUPIL SEGMENTATION

Daugmans integro differential operator (IDO) [4] is one of the primary strategies of iris segmentation, however it struggles to locate the iris center's rough location in noisy environments. A pupil segmentation algorithm is proposed to address this issue. First, many image enhancement techniques, such as contrast stretching and histogram equalization were used to improve the input image before applying the Daugman’s operator. Second, the pupil circle is localized using the IDO. By applying the IDO without preprocessing enhancement techniques it is negatively detect pupil boundary which is affected of a noise such as small visible pupil region with light reflections. To eliminate difficulties on the pupil detection, algorithm (1) is applied to the image before applying the Daugman’s operator. it was suggested that the areas of light affected will filled by the average pixel intensity in the area around it. Daugman’s operator is performed on the eye image processed after algorithm (1) is applied.

Algorithm 1: Pupil Segmentation

Input:
- I \(\text{the input eye image}\)

Output:
- Xc, Yc, Rp \(\text{Center of pupil with its radius}\)

Step1: Convert RGB input eye image to gray
Step2: An image I is input to Gamma transform to get gamma image G using the following equation:

\[
G = ((I / 255) ^ {\alpha} \times 255
\]

Where, \(G\) is gamma image, \(I\) is the input image. The value of \(\alpha=0.8\) is selected in this step.
Step3: Clean image to remove small details using smoothing filter with 3×3 window.
Step4: Convert to binary with threshold equal to 0.35.
Step5: Cut boundary from four direction left, right, top and bottom with ratio 30% of image dimensions.
Step6: Collect reflex pixels region coordinates
Step7: The light reflex area is filled with the mean of pixels intensities from the neighboring to it.
Step8: Adjust the eye image after filling the light affected region by using Histogram equalization.
Step9: Gamma transform is performed on the I image with α=4 using equation 2.
Step10: Establish the pupil’s center (Xc, Yc) and hence its radius Rb was using IDO.

Figure 2 shows the output for each step in pupil localization method.

![Figure 2. Proposed pupil localization steps](image)

3.2. IRIS SEGMENTATION

In this paper an approach is introduced to localize the iris of the eye, it relays on calculating image statistical parameters of eye image. To detect iris pixels, the mean m and standard deviation st values of the 5 × 5 mask are calculated. Next, compare the st and m values for each window with the predefined thresholds. An IrisReg binary image is created where the detection iris pixel is set to zero otherwise it is set to one. If m of the selected window greater than a predefined threshold T1 and st value is greater than threshold T2 the point of the center is considered as iris point and set the IrisReg to zero otherwise it is considered as non-iris point and set to one. Algorithm (2) lists the steps of proposed iris localization.

Algorithm 2: Iris Segmentation
Input:
  I, // Input color image
  W, H, // width and height
Output:
  IrisReg // Iris Region
  Xi, Yi, Ri; // center coordinates of iris // and its radius
Step1: Convert RGB color image I to gray g.
Step2: Gamma transform is performed to g image using equation (3). The value of α = 0.18 is chose to map all UBIRS database images.
Step3: Contrast stretching is performed on the gamma G image.
Step4: Cut boundary from four directions left, right, top and bottom with ratio 20% of image dimensions.
Step5: Isolate the iris pixels depend on mean and standard deviation
    let bk = 5 (i.e., window size 5×5)
    For i = 1 to W-bk
        For j = 1 to H-bk
            For k = 1 to bk
                For l = 1 to bk
                    block (k, l) = G (i+k, j+l)
                EndFor l
            EndFor k
        EndFor j
    EndFor i
    Find the mean of block m
    Find the standard deviation of block st
    If m > T1 or st > T2
        S(i,j) = 0;
    Else
        S(i,j) = 255;
    EndIf
    EndFor j
    EndFor i
Step6: Convert the resulted image IrisReg to binary
Step7: Complement binary image
Step8: Perform the region filling to fill light reflex in the iris region
Step9: Rotate the resulted image S 180° then put the rotated image in S1
Step10: Add the two image S and S1 before and after rotation
    IrisReg = S + S1
Step11: Collect the coordinates of the resulted region
    Let x = 1; y = 1;
    Let SX = 0; SY = 0;
    For i = 1 to W-bk
        For j = 1 to H-bk
            If IrisReg (i,j) = 1
                SX = SX + i;
                SY = SY + j;
                Increment x
                Increment y
            Endif
        EndFor j
    EndFor i
    Xi = SX/(x-1);
    Yi = SY/(y-1);
Step12: Compute the radius R by scanning horizontally from center
    Let Ri = 0
    For i = Xi to W-bk
        If IrisReg (i, Y) = 1
            Ri = Ri + 1;
        Else
            .
Figure 3 depicts how step 5 succeeded to isolate the pixels of iris region depend on mean and standard deviation of each block of image.

Figure 3. Details of step 5 of algorithm 2

Figure 4 shows the resulted image after performed step 6-10 of algorithm 2 for iris segmentation. In this figure the effect of step rotation and addition which are represented by step 8 and 10 in algorithm 2.

Figure 4. The resulted image after performed step 6-10 of algorithm 2.

Figure 5 shows another example to depict the output image for each step in proposed iris localization method.
4. EXPERIMENTAL RESULTS AND DISCUSSIONS

The experiment of the suggested iris localization method is tested on an iris image dataset, UBIRIS.v1 [19]. This dataset consists of a set of iris of visible wavelength taken from close range through user collaboration. The UBIRIS.V1 consists of 1877 iris images and the size of each image is reduced to 200 × 150. Figure 6 shows samples of UBIRIS dataset.

Figure 5. Iris segmentation steps.

Figure 6. Samples of UBIRIS dataset.
Figure 7 and Figure 8 show samples of accurately pupil and iris segmentation respectively after applying proposed system.

![Figure 7](image1.png)

**Figure 7.** Samples of accurate pupil localization

![Figure 8](image2.png)

**Figure 8.** Samples of accurate iris localization

Table 1 depicts the results of pupil and iris localization after applying the proposed method on the UBIRIS dataset.

| No. of Stage | Stage name               | No. of images | Accuracy  |
|--------------|--------------------------|---------------|-----------|
| 1            | Segmentation of pupil region | 1877          | 98.55 %   |
| 2            | Segmentation of iris region    | 1877          | 97.84 %   |

From Table 2 it is noticed that the proposed method has accuracy 98.19 which is good result compared with previous method for noisy environment. The methods based on HT or IDO have some difficulties to find true edge due to the noise which are added to eye images. The suggested method is developing the Daugman's method to accurately localize pupil area by performing some preprocessing enhancement techniques to eliminate the affected noise of the eye image.
Table 3 shows the time required for iris localization to one image using three methods. As we see the proposed method speed up iris localizing compared with other methods.

| Method                | Time in Sec. |
|-----------------------|--------------|
| Daugman’s operator    | 1.7          |
| Masek method          | 0.4          |
| Proposed method       | 0.18         |

Table 2. Segmentation accuracy results of UBIiris dataset

| Method                    | Parameters                                      | Accuracy  |
|---------------------------|-------------------------------------------------|-----------|
| Daugman [4]               | -                                               | 93.53%    |
| Wildes [5]                | Thresholds of Hysteresis: Hi=50, Low=44,        | 89.12%    |
|                           | Dimension of Gaussian Kernel =5                  |           |
| Masek [19]                | Dimension of Gaussian Kernel =5,                | 87.12%    |
|                           | Kovesi Parameters=(40,35)                        |           |
| Liam and Chekima [20]     | Threshold: 140                                  | 47.90%    |
| Ashwaq and Duaa [12]      | The threshold for inner boundary= 71.5          | 97.3%     |
|                           | The threshold for outer boundary= 153            |           |
| Proposed method           | α for inner boundary= 0.5                        | 98.19     |
|                           | α for outer boundary= 0.18                       |           |
|                           | T1=0.3, T2= 0.05                                 |           |

**5. CONCLUSIONS**

In this article, we present an approach for iris segmentation. The IDO is one of the dominant iris segmentation techniques which is employed for pupil localization after some enhancement techniques is used to eliminate the various types of noise. The developed enhancement process makes the pupil region brightness close to be bi-modal and have distribution for purpose of segmentation. The proposed of outer boundary method relays on calculating statistical parameters for image. The statistical parameters values for each window are compared with Predefined thresholds. This method is robust in light and larger reflection areas because the noise detection is based on these statistical parameters for determining the iris region.

**REFERENCES**

[1] S. Prabhakar, S. Pankanti, A. K. Jain. 2003. Biometric Recognition: Security and Privacy Concerns. In Proceedings of the IEEE Security & Privacy: 33-42.
[2] K. Delac and M. Grgic. 2004, A Survey of Biometric Recognition Methods. In Proceedings of the 46th International Symposium Electronics in Marine (Elmar’04):184-193.
[3] Y. Chen, M. Adjouadi, C. Han et al. 2010: A Highly Accurate and Computationally Efficient Approach for Unconstrained Iris Segmentation. Image and Vision Computing, 28(2): 261-269.
[4] Daugman, J. G.1993. High confidence visual recognition of persons by a test of statistical independence. IEEE Trans. Pattern Anal. Mach. Intal., 15(11): 1148-1161.
[5] Wildes R. 1997. Iris Recognition, an Emerging Biometric Technology. Proceedings of the IEEE, 85(9).
[6] Tisse C, Martin, L. Torres, Robert M. 2002. Person Identification Technique Using Human Iris Recognition. International Conference on Vision Interface, Canada.

[7] Daugman J. 1994. Biometric Personal Identification System Based On Iris Analysis. United States Patent, Patent Number: 5, 291, 560, 1994.

[8] Uhl, A., Wild, P. 2012. Weighted Adaptive Hough and Ellipsopolar Transforms for Real-Time Iris Segmentation. In Proceedings of the 5th IEEE International Conference on Biometrics, New Delhi, India: 283-290.

[9] Jeong, D.S., Hwang, J.W., Kang, B.J., Park, K.R., Won, C.S., Park, D.-K.; Kim, J. 2010. A New Iris Segmentation Method for Non-Ideal Iris Images. Image Vis. Compute: 254-260.

[10] Tan, T., He, Z. Sun, Z. 2010. Efficient and Robust Segmentation of Noisy Iris Images for Non-Cooperative Iris Recognition. Image Vis. Compute: 223-230.

[11] Khan, T.M., Khan, M.A., Malik, S.A., Khan, S.A., Bashir, T., Dar, A.H. 2011. Automatic Localization of Pupil Using Eccentricity and Iris Using Gradient Based Method. Opt. Lasers Eng.:177–187.

[12] Ashwaq T. Hashim, Duaa A. Noori. 2016. An Approach of Noisy Color Iris Segmentation Based on Hybrid Image Processing Techniques. Cyberworlds (CW) International Conference.

[13] M. Haidekker. 2011. Deformable Models and Active Contours. Wiley-IEEE Press: 173-210.

[14] M. Kass, A. Witkin, and D. Terzopoulos. 1998. Snakes: Active Contour Models. International Journal of Computer Vision, 1(4): 321-331.

[15] C. Xu and J. L. Prince. 1998. Snakes, Shapes, and Gradient Vector Flow. IEEE Trans. Image Process, 7(3): 359-369.

[16] L. D. Cohen and I. Cohen. 1993. Finite-Element Methods For Active Contour Models And Balloons For 2-D And 3-D Images. IEEE Trans. Pattern Anal. Mach. Intell., 15(11): 1131-1147.

[17] SARIN, A. 2014. Iris Biometric System Using a Hybrid Approach. In Computer Science & Information Technology-CSCP, India.

[18] H. Proenc,a and L. A, Alexandre. 2005. Ubiris: A Noisy Iris Image Database. In Proceedings of the International Conference on Image Analysis and Processing: 970-977.

[19] L. Masek. 2003. Recognition of Human Iris Patterns for Biometric Identification. B.Sc. thesis. The School of Computer Science and Software Engineering. The University of Western Australia.

[20] L. Liam, A. Chekima, L. Fan, and J. dargham. 2002. Iris Recognition Using Self-Organizing Neural Network. In IEEE, 2002 Student Conference on Research and Developing Systems: 169-172, Malaysia.