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Segmentation Approach for a Noisy Iris Images Based on Hybrid Techniques

Hala J. Abdelwahed[a*], **Ashwaq T. Hashim**[b], **Ahmed M. Hasan**[c]

[a] Control and Systems Eng. Dept., University of Technology-Iraq, Baghdad, Iraq
Email: halaaleqabi@gmail.com

[b] Control and Systems Eng. Dept., University of Technology-Iraq, Baghdad, Iraq
Email: 60102@uotechnology.edu.iq

[c] Control and Systems Eng. Dept., University of Technology-Iraq, Baghdad, Iraq
Email: 60163@uotechnology.edu.iq
*Corresponding author.

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ABSTRACT

Iris recognition indicates the procedure of recognizing humans based on their both left and right iris patterns. Nowadays there is rapid progress in realizing an old dream of developing a user-friendly recognition system. Most of the new projects became a nightmare of security of the system. The prosperity of iris recognition aside from its attractive physical characteristics is led to developing an efficient feature extractor to attain the required objective of recognition. Fingerprint, facial, and iris biometric techniques are developed widely for identifying processing most boarded management points, access control, and military checkpoints. Hybridization between Daugman's Integro Differential Operator (IDO) with edge base methods was realized through taking the advantages of the good qualities of both methods so as to enhance the precision and reduce the required time. The proposed hybrid recognition system is very reliable and accurate. UBIRIS version 1 dataset was utilized in the conducted simulation which indicates the distinctions of the hybrid method in providing good performance and accuracy with reducing the time consuming of iris localization by approximately 99% compared with IDO and edge based methods.

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1. Introduction

A biometric recognition system of individuals is established on unique features of the individual. It makes use of many biological features such as fingerprints, iris, human speech, retina, face, etc. The recognition system of the face, fingerprints, and iris of the eye are considered to be more efficient in accuracy and reliability [1].

The human iris is regarded as a major biological feature, as it has always been uniquely unchanged in the progression of time. Moreover, the recognition procedure is noninvasive because the iris image is not being acquired and processed by physical affection [2]. Unrivaled accessibility and unchanged characteristics throughout a person's life are the reasons to dominate the iris in information security. Currently, Systems for Iris Recognition are widely used to identify individuals at airports, stations, immigration, mobile and computer access at research institutes, or in accessing database in control distributed systems [3].

Actually, iris localization is ordinarily the recognition's first step, identification and authentication systems and consequently may influence the performance directly. In this sense, how this initial phase affects the mentioned systems in a delightful (impotent) inquiry to be investigated. To achieve such an objective, the basic methods in the proposed iris localization are benchmarked here. The most common localization of iris involves boundary – based methods. These methods firstly detect the pupil as an iris inner boundary, therefore find the outer boundary of iris after estranging the eyelids and the limbic regions to separate the iris.

The boundary – based technique includes the integro differential operator (IDO) of Hough Transform (HT) and Daugman. HT discovers the circularity via edge-map voting inwards, the specified radius range identified as the Wildes strategy [4]. Moreover, HT-based on detection approaches are likewise utilized by [5-11]. Daugman's IDO [12] which is the first approach for iris biometrics was proposed.

Daugman's IDO is an approach that is utilized an integral derivative for finding the boundary, he used a circular iris and pupil region in addition to the upper and lower eye parties to locate the operator in this context. In 2012 Zhu Yu and cut in [13], proposed a method of removing the eyelashes by means of dual threshold method, which is beneficial compared to other approaches to iris location. Later, HT and least square methods obtain correctly the exact location. Radman et al. in [14] design a quick and trusted iris segmentation algorithm which is essential for building a strong iris recognition system for less restricted iris images. They worked to discover the exact location center of the pupil utilizing the circular Gabor filter. The iris and pupil circles are positioned with the IDO as the eye and the centers of the iris are in the tiny region around the tough place of the pupil. They are a live-wire technique to remove upper and lower eyelash. In 2016 [15], Ashwaq and Duaa introduced an approach to localize the iris region by using a hybrid image processing technique. In this approach, the forward attributes of the iris are taken into consideration such as Noise region found in different parts of the eye image (i.e. small visible iris parts, specular reflections, and focus). In 2019 [16], Ashwaq and Zina proposed an approach for the pupillary with limbic iris boundaries localization. They employed the powerful of arithmetic operations which are very simple and therefore very fast. Consequently, combined them with morphological operations to design fast and accurate algorithm but still, some failures to detect desired iris are adequate for the threshold value which is resulted due to the consecutive image addition.

The remainders of the paper are recognized as follows: Section 2 briefly introduces the Daugman's Integro Differentia Operator (IDO) section 3 discuss edge-base methodology. Section 4 describes the proposed system in details. Section 5 shows the experimental results and section 6 concludes the paper with a discussion.

2. HE INTEGRATED OPERATOR OF DAUGMAN'S (IDO)

The Daugman's integro-differential algorithm for iris recognition, Regarded as one of the best-known iris recognition algorithms. Daugman utilizes an integro-differential administrator for finding the round iris under study districts, and furthermore the curve of the upper and lower eyelids [12]. The intro-differential operations illustrated by Eq. (1)

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

Where I(x, y) is the concentration of the pixel in the iris image at coordinates (x, y).

r refers to the radius of varied circular regions at (x0, y0) coordinates. σ denotes standard deviation in Gaussian distribution. Gσ (r) refers to the used Gaussian filter of scale sigma (σ). (x0, y0) is the initial center coordinates of the specified iris.s refers to the contour of the circle specified by the parameters (r, x0, y0).

Iris is usually not located exactly where the features of the iris image are boisterous, regardless of its elevated expertise. That demand may be as a reflection, or the image does not completely open or the eyelashes hiding some portion of the iris area. Low-quality irises image caused indigent acknowledgment execution giving that customary handling of iris images achieved [2]. The Daugman

IDO and HT are the strong iris segmentation mechanisms, but they take a large part of the calculation time to locate iris center and eyelid boundaries in rough positions.

3. Edge-based methodology

This strategy relives the circular frames within the binary-edge map is anticipated for the points xj and yj, where j = 1, ... n, over the image gradient. The aim is to attain the triplet information that consists of two-dimensioned initial coordinates and ranges value which maximizes the expression H (xc, yc, r) in the Eq. (2) [5]:

$$H(X_c, y_c, r) = \sum_{i=1}^{n} h(x_j , y_j , x_c, y_c, r) \quad (2)$$

where $h(x_j , y_j , x_c, y_c, r) = 1$
when $(x_i - x_c)^2 + (y_i - y_c)^2 - r^2 = 0$.

It is mentioned obviously from experience that any techniques related to the edge-based detection are labeled to the incorrect edges. On the contrary, HT is computationally comprehensive through "pure force" so that apps in real time may not be useful. In addition to these approaches that are influenced by hairs, dark skin, and eyelashes. Iris boundary cannot be identified correctly if it implicates the extent of eyelids or skin, which decreases significantly the total performance of iris recognition.

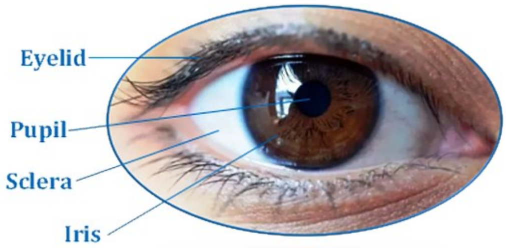

Figure 1: Eye image [3]

4. Proposed Method

Iris segmentation is an effective and vital step for implementing the iris recognition system. A small, dark circle inside the iris called the pupil, the size of this pupil altered depending on the intensity of the light. Moreover a white portion of the eyeball called sclera, the sclera is the white portion of the eye which surrounds the iris directly [2]. Sample of eye parts are shown in Figure 1. It is identified with the precise restriction of iris borders.

The use of Daugman's integro differential operator (IDO) and Edge-based techniques are restricted to work with high-quality images and under ideal imaging setting that is overcame the difficulties such as obstruction by eyelids, eyelashes, glass frames, hair, off-angle, presence of contact lenses, poor illumination, motion blur, lighting and specular reflections, partially eye image. Consequently, the techniques are not suitable for non-ideal and noisy images which may result in higher error rates. In order to overcome these limitations, then a hybrid method is proposed to locate the true boundary in unconstrained environments. The proposed hybrid iris localization consists of two main stages:

Stage1: Pupil border detection to allocate the inner border of the iris region.

Stage2: revealing the iris external border.

I. Detecting Pupil Boundary

Daugman's integro differential operator (IDO) currently is used for localization. However, this method shows poor results with noisy images. Various image enhancement techniques have been used in order to address these issues concerning the existing noisy images. Such techniques utilized like the contrast boosting with histogram equalization, to precise the input image before the Daugman's (IDO) operator starts.

These modifications applied to Daugman's operator in order to enhance its efficiency to avoid some drawbacks such as light reflections which have a negative effect on iris border detection and reduce the processing time required through reducing the number of pixels.

The proposed algorithm 1 is used to prevent the effect of light reflection on iris detection before using Daugman's operator. The operator is filling up the light influenced area by the rate of pixels' intensities from the nearby area. The operation of Daugman is conducted on the eye image obtained after the application of the algorithm 1.

Histogram equalization is one of the best techniques in enhancing the contrast of the images. This technique alter the intensity values of all pixels likewise the center pixel of the given image. Therefore, a new pixel was calculated to be considered as pixel's center and calculate the new radius for the iris' outer boundary.

Algorithm 1: Pupil localization

Perform an automatic localization of the pupil region from an eye image.

Input:

I \\ The input eye image

Output:

Xc, Yc, Rp \\ Center of the pupil with its \\radius

Step1: Convert RGB input eye image to gray

Step2: Gamma mapping operator is applied to the image *I* using the following equation:

$$G = ((I/255)^\wedge\alpha) \times 255 \qquad (3)$$

Where *G*: a gamma image, *I*: the input image, and α: the gamma factor. Values of α in the range 0-1 enhance the contrast of bright regions and when α > 1 then enhances contrast in dark regions. The value of α=0.9 is selected to make the eye image more dark and let the light reflex region more distinguished. This value is suitable for best results in this step.

Step3: Applying canny edge detection algorithm in order to create the edge map.

Step4: Convert to binary with a threshold equal to 0.35.

Step5: Cut boundary from four directions left, right, top and bottom with ratio 30% of image dimensions.

Step6: Collect reflex pixels region coordinates

Step7: Fulfill the area with brightness impacted by median pixel intensity from the surround region.

Step8: Adjust the eye image after filling the light affected region by using Histogram equalization.

Step9: Gamma mapping operator is applied to the image *I* with α=4 using eq. (3). This value is selected to make the eye image more whiting and let the pupil region more distinguished. It is suitable to get good result

Step10: Establish the pupil's center R_b and hence its radius using Daugman's integro-differential operator. Figure 2 shows the steps of proposed pupil localization.

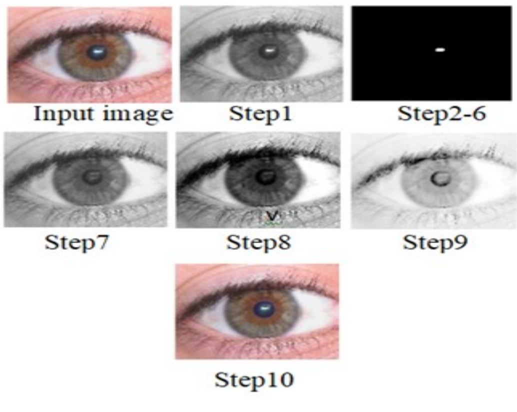

Figure 2: Steps of proposed pupil localization

II. Detecting Iris Boundary

This stage automatically segments the iris from the eye image. And it included consecutive steps as listed in the algorithm 2.

Algorithm 2: Iris localization

Perform an automatic localization of the iris region from an eye image.

Input:
I \\ The input eye image
X_c, Y_c \\ Center of pupil
Output:
X_i, Y_i, R_i \\ Center coordinates with radius \\for the detected iris boundary
Step1: Convert RGB input eye image *I* to gray
Step2: Enhance the gray image using filtering and contrast adjustment methods using eq. (3) with α=2.5. This value is chosen by test to clarify the iris region and then become easy to localize.
Step3: Perform the edge detection operation using Canny operator to achieve edge map
Step4: Utilizing the edge map, Hough transform was implemented for perceiving circles in the image
Step5: Compute the center coordinates X_i and Y_i of a circle and its radius R_i, as shown in Figure 3.

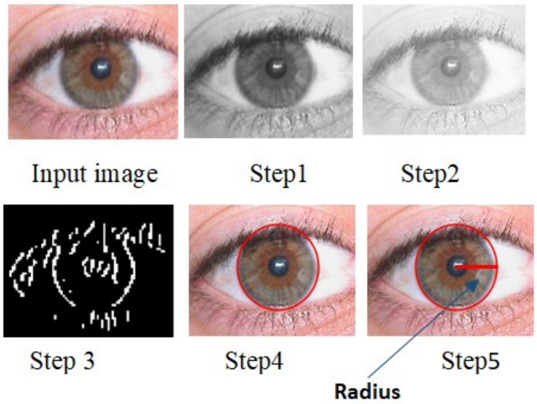

Figure 3: Steps of proposed iris localization

5. EXPERIMENTAL RESULTS

The experiment results are obtained from using a database of 1877 iris images of standard color UBIRIS.v1. The size of each image is reduced to 200 ×150. Different types of noise are presented in the dataset of UBIRIS like for example focus, reflections, and tiny visible iris; thus, the proposed algorithm utilizes an image processing technique to create an approach since it handled various types of noisy image. Figure 4 demonstrates samples of the used UBIRIS database. This dataset contains images that have large reflective areas or with small areas of the visible iris because of the eyelashes and eyelids obstruction.

Figure 4: Samples of UBIRIS database

The white spot in Figure 5 is specified by the blue circles which are showed the effect of light reflections in the eye images of wrong localization of pupils using IDO. The effect of the light reflections covers the portions of the eye image resulting in some difficulties in the iris localization procedure. It is noticed that the 'light reflection affected region' is a region involving high intensity values' pixels. The region surrounding it is a region consisting of the pixels with low-intensity values. The light reflection on eye images has a great impact on the iris detection, where there is a noticeable distinction in the values of intensity among the light affected area and its adjacent darker area.

In order to overcome this failure some preprocessing and enhancement techniques are used. The result obtained after enhancing the pupil localization method is successfully detecting the iris border as shown in Figure 6.

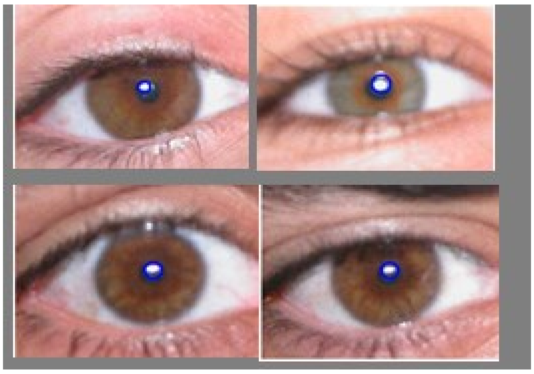

Figure 5: Light reflection affected eye image by using IDO

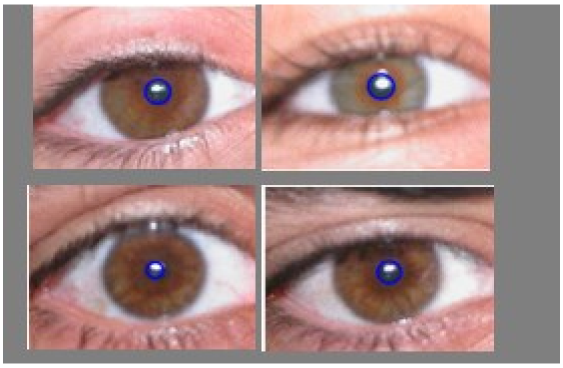

Figure 6: Correct pupil localization after applying proposed pupil localization

On the other hand, error detection in iris localization is caused by overlap between the eyelids and the iris region. Figure 7 shows the error in iris localization after performed Canny edge detector followed by Hough transform (i.e. Edge-based methodology). After preprocessing the eye image with enhancement techniques before Edge-based method is implemented. It is noticed that the iris is correctly localized as depicted in Figure 8.

Figure 7: Noise affected eye image by using Edge-based method

Figure 8: Correct iris localization after applying proposed iris localization

Table 1 shows the results of localization of both pupil and iris after implementing the proposed enhancement approach on the UBIRIS database.

TABLE I: Results of proposed iris localization on UBIRIS Dataset

Stage No.	Segmentation region	No. of images	Precision
1	Pupil area	1877	98.40 %
2	Iris area	1877	99.84 %

$$precision = \frac{No.\ of\ Sucuessful\ Images}{Total\ No.\ of\ Images} \times 100\% \quad (4)$$

In Daugman's methodology, the circumference (center and radius) parameters are identified wherever the average intensity values have the maximum derivative in relation to neighboring ones. Therefore, with some images that have slight disparity in intensity amid the iris and the sclera border, it is very difficult to reveal the precise iris of the image with fewer precision as a notice in Table 2. And the results of Edge-based method as in [17, 5, 18] have some fails to find right binary edge maps due to the noise which is added to eye images. Table 2 shows distinction Precision levels on UBIRIS database which are calculated according to Eq. (4) [19], and compared with the proposed method.

TABLE II: Segmentation accuracy results of UBIRIS dataset

Methodology	Parameters	Accuracy
Daugman [12]	None	93.53%
Wildes [17]	Hysteresis' Thresholds: High=50, Low=44, Gaussian' Kernel Dimensions=5	89.12%
Masek [5]	Gaussian' Kernel Dimensions=5, Kovesi Parameters= 40, 35	87.12 %
Liam and Chekima [18]	Threshold= 140	47.90%
Ashwaq and Duaa [15]	Inner thresholding border = 71. 5 Outer thresholding border = 153	97.3%
The Proposed approach	α for inner border= 0.9 α for outer border= 2.5	99.12%

While in [15] method depended on hybrid image enhancement techniques and morphological operators.

The proposed method is developed the Daugman's methodology to successfully located pupil region by performing some preprocessing techniques to less the effected noise the eye image. And it is developed the edge-based method to localize iris correctly. Table 3 shows the time required for iris localization to one image using three methods.

TABLE III: Compression of time-consuming for iris localization

Table 3: Compression of time-consuming for iris localization

Methodology	Time-consuming (sec)
Daugman's operator	1.7
Edge-based method	0.4
Proposed method	0.5

6. CONCLUSIONS

A pupil and iris localization method is presented in this paper. The various type of noise will affect the iris localization these noise like a light reflex, poor of image quality, overlapping of eyelid and eyelashes, focus and small visible iris. All standard iris dataset has a different type of noise which is caused by errors in pupil and iris localization. To overcome these erroneous, the noise must be removed before performed the methods of iris localization. The proposed method exploited some enhancement techniques to overcome these noises to get good accuracy and reduce time consumption compared with previous methods

References

[1] E. Severo, R. Laroca, C. Bezerra and L. A. Zanlorensi, “A Benchmark for Iris Location and a Deep Learning Detector Evaluation,” International Joint Conference on Neural Networks (IJCNN) 2018, Rio, Brazil, 2018.

[2] A. Hashim and D. Noori, "An Approach of Noisy Color Iris Segmentation Based on Hybrid Image Processing Techniques," 2016 International Conference on Cyberworlds (CW), Chongqing, 2016, pp. 183-188.

[3] H. K. Rana, MS Azam, MR Akhtar, Quinn JMW, Moni MA. “A Fast Iris Recognition System through Optimum Feature Extraction,” PeerJ Computer Science, Vol. 10, No. 2, pp.1-10, 2019.

[4] R.P., Wildes, “Iris Recognition: An Emerging Biometric Technology,” Proceedings of the IEEE, Vol. 85, No. 9, pp.1348-1363, 1997.

[5] L. Masek, "Recognition of Human Iris Patterns For Biometric Identification", B.Sc. Thesis, the School of Computer Science and Software Engineering, The University of Western Australia, 2003.

[6] Y. Chen, M. Adjouadi, C. Han, J. Wang, A. Barreto, N. Rishe, and J. Andrian, "A Highly Accurate and Computationally Efficient Approach For Unconstrained Iris Segmentation," Image and Vision Computing, Vol. 28, No.2, pp.261-269, 2010.

[7] L.L. Ling, and D.F. de Brito, "Fast and Efficient Iris Image Segmentation," Journal of Medical and Biological Engineering, Vol. 30, No. 6, pp. 381-392, 2010.

[8] A. Uhl, and P. Wild, "Weighted Adaptive Hough and Ellipsopolar Transforms For Real-Time Iris Segmentation," In Proceedings of the 5th IEEE International Conference on Biometrics, New Delhi, India, pp. 283-290, 29 March–1 April 2012.

[9] J. J. Fernandez, and A. Mathew, "Irregular Pupil Localization Using Connected Component Analysis," Automation, Computing, Communication, Control and Compressed Sensing (iMac4s), 2013 International Multi-Conference on, pp. 155-159, 2013.

[10] Z. Zhao, and A. Kumar, "An Accurate Iris Segmentation Framework Under Relaxed Imaging Constraints Using Total Variation Model,” In Proceedings of the IEEE International Conference on Computer Vision, Santiago, Chile, pp. 3828-3836, 7-13 December 2015.

[11] Z. Li, "An Iris Recognition Algorithm Based on Coarse and Fine Location," Big Data Analysis (ICBDA), 2017 IEEE 2nd International Conference, pp. 744-747, 2017.

[12] J.G. Daugman, "High Confidence Visual Recognition of Persons By A Test of Statistical Independence," IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 15, No. 11, pp.1148-1161, 1993.

[13] Z. Yu and W. Cui, "A Rapid Iris Location Algorithm Based on Embedded," International Conference on Computer Science and Information Processing (CSIP), pp. 233-236, Xi'an, Shaanxi, 2012.

[14] A. Radman, K. Jumari, and N. Zainal, "Fast and Reliable Iris Segmentation Algorithm," IET Image Processing, Vol. 7, No. 1, pp.42-49, 2013.

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

[16] A. Hashim and Zina Saleh, “Fast Iris Localization Based on Image Algebra and Morphological Operations,” Journal of University of Babylon for Pure and Applied Sciences, Vol. 27, No. 2, 2019.

[17] P. R. Wildes, “Iris Recognition: An Emerging Biometric Technology, “In Proceedings of the IEEE, Vol. 85, No.9, pp. 1348-1363, U.S.A., 1997.

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

[19] S. A. Ali, ”Irregular Iris Identification and Verification using Texture Methods”, Ph.D. Thesis, Babylon University, Iraq, 2014.