# A New Technique for Fast and Accurate Iris Localization

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**Abstract-   Iris Recognition is an emerging technology in today's world; in both research and practical applications. The human iris contains rich texture information. This texture information is highly stable and distinct biometric characteristics. Iris biometry is used to recognize any individual in a natural and intuitive way. Iris localization is the most important step in Iris Recognition System and it determines the accuracy in feature extraction and matching. This paper proposes a new, fast and accurate algorithm for iris localization. In this proposed iris localization technique, three points were selected to detect the center of the pupil, inner and outer boundaries. The verification performance of the proposed algorithm is validated and compared with other algorithm by using CASIA version 1.0, CASIA version 3.0 Interval, CASIA version 4.0 Interval and MMU version 1 and 2 databases. Few iris images of PALAKY database were also tested with the proposed algorithm. The experimental result on the CASIA version 4.0 Interval demonstrates that the proposed method has better performance and it improves speed and accuracy for iris localization.**

**Keywords – Biometrics, Biometric Authentication, Iris, Iris Recognition, Iris Localization, Thresholding.**

## I. INTRODUCTION

The increasing requirements of security due to advancement in Information Technology sector especially Cyber Security and Banking etc have led to rapid development of personal identification or verification system based on Biometrics. Iris is the most reliable biometric among all the biometric traits such as fingerprint, palm, retina, face, voice, signature etc because of its uniqueness, stability and non-invasive nature. [4] An E-security is the critical need to find accurate, secure and cost-effective alternative for PIN and password [5] Basic need for every person is to secure data, information and money. Biometric solutions are useful to solve these problems as biometric data is unique and non-transferable. Biometric is the method which identifies and / or verify a person automatically by using either physiological or behavioural characteristics. [6]

Initially Flom and A. Safir proposed the automated Iris Recognition System. [7] Iris is the unique organ which offers highest accuracy in identifying any individual. Two irises are alike between two identical twins and even between left and right eye of an individual. Irises are stable throughout the life and the pattern is formed only once by ten month of the age of gestation. [8] Iris pattern variability among different persons is enormous. [9] Iris patterns are more stable and reliable because it is internal organ and protected by aqueous humour and cornea. [10] Iris has a various features such as pigment frill, collarette, crypts, radial furrows etc. Figure 1 shows the features of an iris. [11]

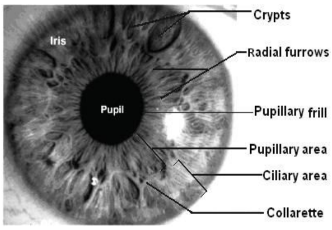



Figure 1. Structure of an Iris

Iris is a diaphragm with rich texture enriching a circular region. There are two brilliant characteristics in iris which are useful in detection process; the more darkness of the pupil and medium gray level of iris. That is why localizing the inner and outer boundaries of iris become easier. [12]

The iris image may contain some irrelevant information such as pupil, eyelashes, reflection etc. In an iris recognition system, it is difficult to find perceptible feature points in the image and to keep their representation high with efficient way. Even the identification and/or verification process should provide high accuracy. This is achieved by localizing the iris image correctly. The localization step is crucial as the falsely represented iris may lead to corrupted iris template and generate the poor result. [13]

Iris image acquisition is the first step in digital image processing which is the most difficult process. Image formation is done with the help of a digital camera or some special device like CCD camera for iris, face etc. In image formation the radiant energy emitted from the source is converted to 2-dimentional image. While capturing the image, due to motion or interference, spectacles or illumination conditions some disturbance, blur etc is automatically added in the image. This is called noise. The features can not be extracted correctly from such images. To improve the quality of image, enhancement techniques such as edge sharpening, noise removal etc can be used. [1, 2, 3]

To extract the correct features, the correct region of interest is necessary. The region of interest is segmented for getting meaningful information from it. The specified pattern can be searched through segmented region of interest. Before segmenting the image of an iris, morphological operations are performed on an iris image. The reflection through illumination conditions may degrade the performance of an Iris Recognition System. The segmentation process may include edge detection, inner and outer boundary localization.

The following are the observations from the literature reviewed:

1. The pupil and iris boundaries are not circular.
2. Image quality is degraded with low contrast.
3. Iris part is occluded with eyelid and eyelashes.
4. Reflection through illumination degrades the performance.
5. More computation cost.

This paper presents a novel iris localization technique in detail. The paper is organized follows: The following section shows related work. Iris localization technique is described in section III. In section IV, the new proposed iris localization method is discussed. Section V shows the practical implementation of this paper. Section VI and VII presents the experimental results and our conclusions respectively.

## II. RELATED WORK

Daugman [1993] proposed an Integro-Differential Operator for localizing the pupil and circular iris as inner and outer boundaries. The eyelid noise was also removed by this technique. The fast and accurate computation is the main advantage of this method. [13] But this operator is sensitive to the specular spot reflection of non diffused light and noise of the pupil added due to imperfection in detecting the iris boundaries. The noise of pupil and eyelash is not be eliminated by this method. This algorithm may fail if reflection is available in the image as noise. It takes more time to localize the iris. [14, 15] This algorithm is used by many researchers for iris localization in their research. [16, 17, 18, 19, 20, 21, 22, 23, 24]

Wildes [1997] proposed gradient based Hough Transform to localize iris. He has also used first derivative of image intensity to find the location of edges corresponding to the borders of iris. In this case a binary edge map is generated and then votes in a circular space are analysed to find three parameters of a circle ($x_0$, $y_0$, r). [25] The same approach is used by many researchers called circular Hough transform. [26, 27, 28] Even Circular Hough Transform takes more time to localize the iris. It is very difficult to improve the recognition accuracy by using Hough transform. [27, 30] The main disadvantage of this algorithm is to choose the correct threshold for edge detection otherwise it is very difficult to detect the circle or an arc. Secondly, Circular Hough transform has the brute-force problem so it may not be used for real time applications. This method is used by many researchers. [31, 32, 33] Both methods i.e. Integro-differential operator and Hough Transform impose great computational cost as these techniques uses three-dimensional parameter space. The localization accuracy has a great influence on the feature extraction and classification. [34]

The black hole search method is used to lower down the computational cost, to reduce the region of edge detection and reduce the search space by Hough Transform. [32, 35] Binarization is used in this method. Binarization of input gray-level image approach is very simple but it is not robust since its accuracy is strongly dependant on the setup of Binarization threshold. It is very difficult to set a proper threshold suitable for different image types even by using adaptive threshold technique. [34]

The Black hole search and Integro-differential operator is used together by many researchers to localize the iris. [36] Similarly, the Integro-differential operator and Hough transform is used together to localize iris. It reduces the computation time but eyelash and pupil noise is not considered. [37, 38, 39, 40]

The Canny edge detection and bisection method is used to find pupil center and edges of the eyelid. Eyelids, Eyelashes and shadows (EES) localization is important as the iris is partially occluded by them and it will increase the danger of false acceptance. [31]

The iris recognition rate depends on the iris localization and edge detection techniques used. From the above related work we may note that the iris image quality, noise like eyelid, eyelashes etc are not explicitly considered and thresholding is necessary in almost all the techniques.

## III. Proposed Method

In this section we discuss our proposed approach of iris localization. A critical step in the iris recognition includes segmentation or extraction of the visible part of iris by excluding the obscuring elements such as eyelids, eyelashes, reflections from cornea and eyeglasses. [42] Segmentation is a process of partitioning any image into group of pixels. It can be done locally [i.e. segmenting sub-images] or globally [i.e. segmenting whole image]. The number of pixels available in local segmentation is less than that of global segmentation. [1] The proposed algorithm is discussed below:

**Step 1**- Read the iris image from the database.

**Step 2**- Graphical unit is used to accept three points on the iris image. The first point has to be the approximate center of pupil. The second point has to be on the pupil boundary and third point has to be on iris boundary.

**Step 3**- Assign these point values to respective x and y co-ordinates. For center it is [x1, y1], for pupil boundary point [x2, y2] and for iris boundary point [x3, y3] respectively.

**Step 4**- Calculate pupil radius and iris radius by using mathematical formula as shown in expression (1) and (2).

$$\text{Radius1} = \text{SQRT}\,(\,(X2 - X1)^2 + (Y2 - Y1)^2) \qquad (1)$$

$$\text{Radius 2} = \text{SQRT}\,(\,(X3 - X1)^2 + (Y3 - Y1)^2) \qquad (2)$$

**Step 5**- Describe the shape ‘circle’ as string shape using additional parameters i.e. point and radius for pupil and iris boundaries.

**Step 6**- Plot these circles on iris image to get segmented image.

In our approach, we have calculated the time required for the localization process and it has been observed that the required time is very less as compared to Daugman’s method. By using our approach, we got the following advantages:

1. Requires very less time to localize the iris i.e. fast localization of iris.
2. User has the complete freedom for selecting the region of interest.

3. Noise can be manually excluded by selecting the third point accordingly by changing the iris radius.
4. Eyelid and eyelash occlusions, reflection noise can be avoided.
5. Less time complexity.
6. Performance increased.
7. No extra morphological processing is required as noise is avoided automatically by our approach.

## IV. IMPLEMENTATION

This paper discusses a pre-processing technique where iris localization is more important. The iris localization can be done by finding the pupil [inner] boundary and iris [outer / sclera] boundary. With edge detection techniques, other algorithms such as Hough Transform, Integro-differential operator etc can also be used to localize the iris. This paper presents a new technique where three points were selected on the input iris image manually with the help of mouse or keyboard. The first point has to be a center of an iris. The second point has to be on the pupil boundary and the third point has to be on the sclera or iris boundary. The implementation is done using MatLab R2012a on core2 Duo Intel with 2.00 GHz speed. The following steps were carried out.

### *A. Step 1 –Acquire Database –*

The freely available database is considered for implementation i.e. CASIA 1.0 which includes 756 images, CASIA V3 Interval which includes 2125 images, CASIA V4 which includes 54601 and MMU V1 database which has 450 images, MMU V2 database which has 995 images. [43, 44] The iris image can read from the stored database.

### *B. Step 2 –Convert Image to Gray Scale –*

As coloured image needs more memory space for storage, we have to convert them in gray scale. For this, read the image from the database and convert the image into gray scale. By default the gray scale images were provided by many of the databases such as CASIA, MMU, etc. That is why there is no need to convert them in gray scale. But if we use any coloured iris image then this step needs to be followed.

### *C. Step3 –Histogram Equilization –*

Histogram equalization is a technique which evenly distributes the pixels to increase the contrast of an image. It treats an image as a probability distribution and then finds the cumulative distribution. But this method may not always provide the better result. [3] The CASIA 1.0 images are with low contrast. So we need to apply the Histogram Equalization to increase the contrast. The images provided by CASIA V3, CASIA V4, MMU [43, 44] database are of good quality; therefore, it is not necessary to increase the contrast. But it may not be always true with all the images of that database.

### *D. Step 4 –Iris Localization –*

Select first input point as center of the iris. Select two more points on pupil boundary and iris boundary. The first pixel value is assigned to x and second pixel value of the same point is assigned to y and it is the center of the iris [x1, y1]. Similarly the second point and third point values are assigned to [x2, y2] and [x3, y3] respectively. The radius is calculated from the center [x1, y1] to pupil boundary [x2, y2] called pupil radius and it is calculated by using a mathematical formula given in expression (1). Similarly iris radius is calculated from center [x1, y1] to iris boundary [x3, y3] using expression (2). The rsmak function is used which provides a rational spline in rBform that describes the shape being specified by the string shape and the optional additional parameters. So, here we get two boundaries i.e. pupil and iris boundary on an iris image. It means the iris is segmented or localized.

## V. EXPERIMENTAL RESULTS AND ANALYSIS

The implemented iris recognition system is tested with different images. It has been observed the results are similar with different images. This section displays the results to ensure the effect of each step.

### *A. Step 1 –Acquire Database –*

The iris image had been read from the directory where the CASIA database is stored. The original image of an iris is shown in figure 2. [42]


(a) (b)

Figure 2. (a) CASIA V 1 Image (b) CASIA V 4 Interval Image

*B. Step 2: Convert image to gray scale –*

This step is used to convert image into gray scale. Coloured image take more time for computation and more space for storage. But Gray scale image needs less memory for storage and less computational time. Here it is not required as CASIA database provides gray scale images.

*C. Step 3 –Enhance Iris Image –*

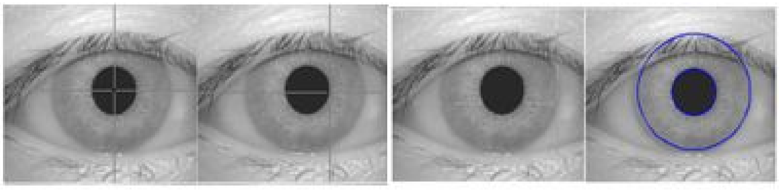
The contrast is increased by histogram equalization. It is done by probability density function and cumulative distribution calculation. For all the gray levels, uniform histogram is given. But it is not required for the images of CASIA V 1.0, MMU 1, and CASIA V 3 Interval, CASIA V 4 Interval etc.

*D. Step 4 –Iris Localization –*

Select center point and two radius points and assign those values to respective x and y coordinates. Figure 3a, 3b, and 3c shows the same and the localized iris is shown in figure 3d.

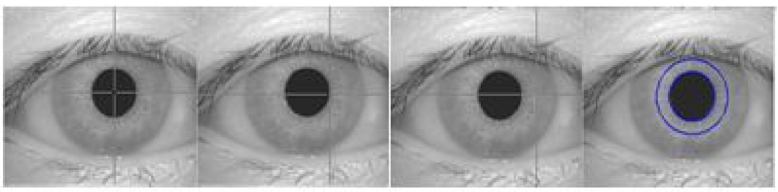
The proposed technique provides a choice for selecting third point on iris area by avoiding noise of reflection, eyelashes and eyelid. Figure 4a, 4b, 4c shows the same selection and localised iris is shown in figure 4d. This is done on CASIA V 1. The same thing is applied on CASIA V 4 Interval database. Figure 5a, 5b, 5c, 5d, 6a, 6b, 6c and 6d used to show the result.

In our test we have used the images from CASIA V 1, MMU V 1, MMU V 2 and CASIA V 4 Interval database [43] which contains variety of images under different conditions of illuminations. The proposed algorithm was tested on 100 images of 61 subjects of CASIA V4 Interval database [43]; out of which 48 are right iris images and 52 are left iris images.



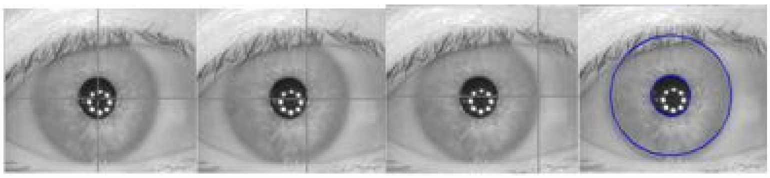
(a) (b) (c ) (d)

Figure 3. CASIA V 1 Database (a) Original image with center point (b) select pupil point (c) select iris point (d) localized iris



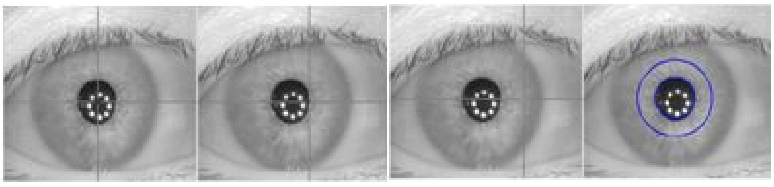
(a) (b) (c ) (d)

Figure 4. CASIA V 1 Database (a) Original image with center point (b) select pupil point (c) select iris point (d) localized iris



(a) (b) (c ) (d)

Figure 5. CASIA V 4 Database (a) Original image with center point (b) select pupil point (c) select iris point (d) localized iris



(a) (b) (c ) (d)

Figure 6. CASIA V 4 Database (a) Original image with center point (b) select pupil point (c) select iris point (d) localized iris

The region of interest can be selected as per the need of the application. The iris localization rate achieved is 87.50% for right iris and 88.46% for left iris images respectively. The proposed algorithm is compared with Daugman's algorithm i.e. integro-differential operator [15, 38] and it is observed that the localization rate of the iris image is very less where the threshold *rmin* value is 95 and *rmax* value is 170. The achieved localization rate of Daugman method is 47.91% for right iris and 32.69% for left iris respectively. Table 1 shows this comparison.

We have also observed that the time required for iris localization is less in our proposed approach than the Daugman's method. Hardly four to five images were shown amongst the 100 images of 61 subjects. Table 2 show the comparative chart of time for the same in microseconds.

Table -1 Comparison of Proposed method with Daugman Method

| | | **Subjects =61 (100 Images)** | |
|---|---|---|---|
| | | **Right Iris** | **Left Iris** |
| | | **48 Images** | **52 Images** |
| **Daugman Method** | **Correctly Localized** | **23** | **17** |
| | **Falsely Localized** | **25** | **35** |
| | **Localization Rate** | **47.91%** | **32.69%** |
| **Proposed Method** | **Correctly Localized** | **42** | **46** |
| | **Falsely Localized** | **06** | **06** |
| | **Localization Rate** | **87.50%** | **88.46%** |

Table -2 Localization Time for Proposed Method and Daugman Method

| File Name | Subjects =61 (100 Images) | | | |
|---|---|---|---|---|
| | Proposed Method | | Daugman Method | |
| | Time Needed (microsecond) | Recognized or Not | Time Needed (microsecond) | Recognized or Not |
| **S1001L05.jpg** | **6.4511** | **no** | **428351** | **no** |
| **S1001L06.jpg** | **6.2483** | **yes** | **29.7501** | **no** |
| **S1001L07.jpg** | **5.9851** | **yes** | **26.2977** | **no** |
| **S1001R01.jpg** | **7.7846** | **yes** | **21.6311** | **no** |
| **S1001R02.jpg** | **5.4995** | **yes** | **13.9083** | **Yes** |

## VI. CONCLUSION

Since localization is the initial step in any iris recognition technique, it is important to know the time complexity for localizing the iris as fast as possible. The most important metrics of localization algorithm is accuracy and speed. The implementation of new iris localization technique is done using MatLab R2012a on core2 Duo Intel with 2.00 GHz speed. The Integro-differential operator is very sensitive to noise and takes more time to localize the iris. It does not consider the high frequency variation. It is very difficult to improve the recognition accuracy with Hough transform. Using our approach the above said problems and the problems like eyelash obstruction, eyelid occlusion, reflection and blurring has been solved easily. The iris localization process is faster and required time for iris localization is less. The iris localization rate achieved is 87.50% for right iris and 88.46% for left iris images respectively. Experimental result shows that the proposed method achieves better performance in both accuracy and speed in iris localization.

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