ANALYSIS OF IRIS SEGMENTATION USING CIRCULAR HOUGH TRANSFORM AND DAUGHMAN'S METHOD

By

DIVYA ANN ROY * URMILA S. SONI **

* PG Scholar, Department of Electronics and Communication Engineering, CSIT, Durg, Chhattisgarh, India.
** Associate Professor, Department of Electronics and Communication Engineering, CSIT, Durg, Chhattisgarh, India.

ABSTRACT

Iris recognition is a special type of biometric system, which is used to identify a person by analyzing the patterns in the iris. It is used to recognize the human identity through the textural characteristics of one's iris muscular patterns. Although eye colour is dependent on heredity, iris is independent even in the twins. Out of various biometrics such as finger and hand geometry, face, ear and voice recognition, iris recognition has been proved to be one of the most accurate and reliable biometric modalities because of its high recognition. Iris recognition involves 5 major steps. Firstly, image acquisition is done in which the image is captured by a high resolution camera, then the iris and the pupillary boundary are extracted out from the whole eye image, which is called segmentation. After segmentation, the circular dimension is converted to a fixed rectangular dimension which is called normalization. From this normalised image, the feature is extracted from Gabor filter, DFT, FFT, etc. At last, the iris code is matched using Hamming distance and Euclidean method. This project focuses on iris segmentation. Iris segmentation is the most important part in the iris recognition process because the areas that are wrongly considered as the iris regions would corrupt the biometric templates resulting in a very poor recognition [16]-[21]. The main objective of iris segmentation is to separate the iris region from the pupil and sclera boundaries. There are various methods for segmenting the iris from an eye image to give a best segmented result. In this project, iris segmentation is done using Daugman's integro differential method and Circular Hough Transform to find out the pupil and the iris boundaries. Iris images are taken from the CASIA V4 database, and the iris segmentation is done using Matlab software where iris and pupilary boundaries are segmented out. The experimental result shows that 84% accuracy is obtained by segmenting the iris by Circular Hough Transform and 76% accuracy is obtained by segmenting the iris through Daughman's method. It is concluded that, the Circular Hough Transform method of iris recognition is more accurate than the Daughman's method.

Keywords: Daughman, Segmentation, Recognition, Biometric, Circular Hough Transform.

INTRODUCTION

Biometric

The term "biometrics" is derived from the Greek words "bio" meaning life and "metric" meaning to measure. Biometrics is defined as the measurement and statistical analysis of the people's physical and behavioural characteristics. The basic principle of biometric authentication is that, every person is unique and every individual can be differentiated by his or her intrinsic physical or behavioural traits. Iris is made up of many layers which gives an unique appearance. Under high resolution camera, and with illumination, the uniqueness of the iris is visually plain when we look at its each and every detail under.

Iris Recognition

The iris recognition system is the system of recognising a person by analysing the random pattern of iris. Iris recognition can be considered as one of the most reliable and accurate method of biometric technology when compared with other biometric technologies such as face, fingerprint, and speech recognition [17]-[9]. Segmentation is to subdivide an image into its component regions or objects. It should stop when the objects of interest in an application have been isolated. It is a process of localizing iris from the entire part which are acquired. Iris can be approximated by two circles.

The iris recognition system (Figure 1) has five major components, viz.,

1. Image Acquisition
2. Image Segmentation
3. Image Normalisation [22]
4. Image Extraction
5. Iris Template Matching

Advantages of Iris Recognition

- Iris scanning is not very invasive because there is no direct contact with the subject and the camera.
- Iris recognition has high speed and scalability.
- Every individual has different iris patterns, so no one can duplicate or steal the templates.

Disadvantages of Iris Recognition

- Iris is a small organ, so it is difficult to scan iris from distance.
- The Camera should have an accurate amount of illusion.
- The stored biometric iris cannot be used, if the individual has any kind of eye operation.

Iris Segmentation

Segmentation is the process of accurately separating the iris from the whole eye image. In segmentation, the eye information is focused on iris portion and all the other parts of the eye like sclera, eyelashes, eyelid, etc, are ignored. The data acquired from the iris portion are very useful to identify and authenticate each user, because the iris portion is divided into multiple segments. The eyelids and eyelashes hide the upper and lower portion of the iris region [2], [3]. The accuracy of segmentation is totally dependent on the imaging quality of an eye image. Data having noise and error representation causes poor recognition rates [13], [25], [2].

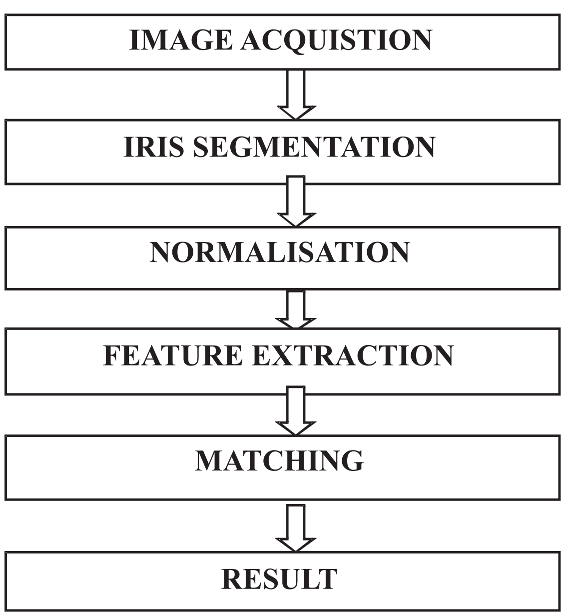


Figure 1.Flow chart of Iris Recognition

1. Proposed Methods

1.1 Daughman's Integro Differential Operator

The proposed methodology uses Daughman's Integro Differential Operator (DIO) algorithm. Daughman makes use of an integro-differential operator for segmenting the circular iris and pupil regions and also the arcs of the upper and lower eyelids. Figure 2 shows the flowchart of Daughman's method.

Daugman's formula is given below.

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

where I(x, y) is the eye image,

r is the radius, and

G(r) is the Gaussian smoothing function and contour of the iris.

The smoothed image is scanned for a circle that has a maximum gradient change, which indicates an edge.

The operator searches for the circular path by the change in the maximum pixel values by varying the radius and the centre of x and y positions of the circular contour to attain the precise location of the eyelids [10]-[12].

The DIO also uses the first derivatives of the image to find geometric parameters. Thresholding problem is avoided like in Hough transform DIO that uses basic raw derivative information [14], [15], [26].

1.2 Circular Hough Transform (CHT)

The Hough transform is a standard algorithm that is used to determine the parameters of geometric objects, such as lines and circles which are present in an image [23], [24]. It is the transformation of a point in the x, y-plane to the

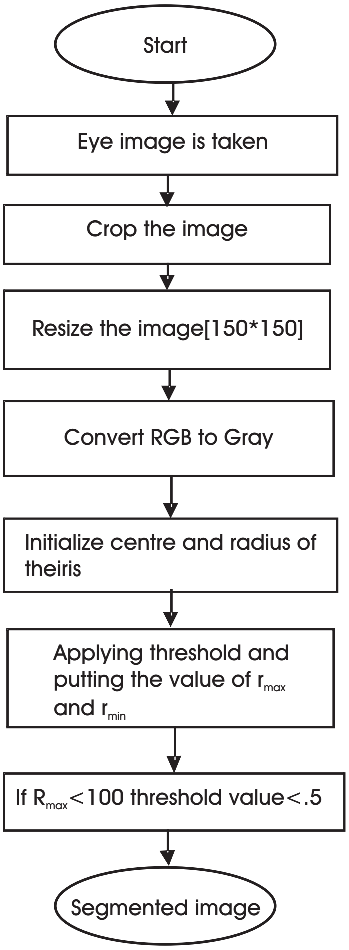


Figure 2. Flowchart of Daughman's Algorithm

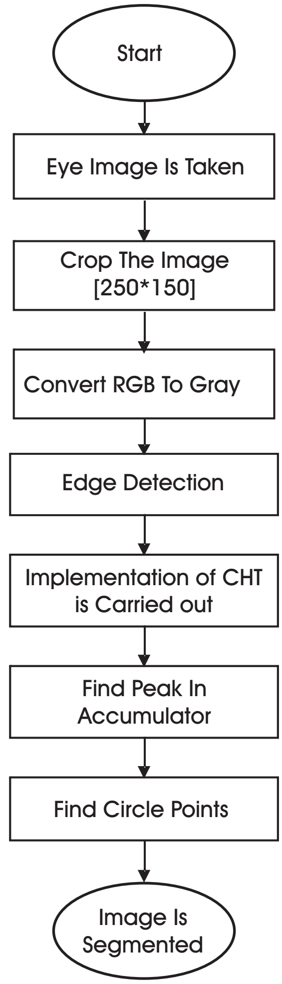


Figure 3. Flowchart of Circular Hough Transform

parameter space. Figure 3 shows the CHT method.

The circle is simple to represent in the parameter space, as compared to other shapes, because the parameters of the circle can be directly transferred to the parameter space.

The equation of a circle is

$$r^2=(x-y)^2+(y-b)^2 \quad (2)$$

Here, r is the radius;

a & b are the center of the circle in the x and y directions respectively.

The parametric representation of the circle is,

$$x=a+r\cos\theta \quad (3)$$

$$y=b+r\sin\theta \quad (4)$$

The Circular Hough Transform can be used to find out radius and centre coordinates of the pupil and the iris regions [30].

2. Methodology

2.1 Methodology of Daughman's Method

2.1.1 Input Image

The input image is taken from the CASIA (Chinese Academy of Sciences-Institute of Automation) database, which contains 756 grayscale eye images with 108 unique eyes and 7 different images for each unique eye. Images from each class are taken from two sessions within a month interval between the sessions. The eye images are mainly from Asian decants, whose eyes are characterized by irises that are densely pigmented, with dark eyelashes. Features in the iris region are highly visible due to the specialized imaging conditions using the infrared light, and there is good contrast between the pupil, iris and sclera the regions [4].

2.1.2 Cropping the Image

The input image is cropped to a dimension [150*150]. By cropping the image, we can remove the eyelids, eyelashes and the sclera, which causes errors in the iris segmentation.

2.1.3 Resizing the Image

The authors have cropped the image in a rectangular dimension rather than a circular dimension, because the iris which is in an oval shape, does not support a circular dimension [250*150].

2.1.4 RGB to Gray

The image is converted from RGB (Red, Green, Blue) to gray because of which we can easily detect the changes in pixel value that occurs between the pupil and the iris.

2.1.5 Initialize Centre and Radius

The radius and the centre coordinates are initialized as the radius and the coordinates can be placed within the particular range of radius .

2.1.6 Applying Threshold and R_{max} and R_{min}

Here, thresholding is applied for successful implementation of the Daughman method. Before thresholding, the pixels are called as object pixels, which are darker than the background pixels and are called as centre pixels. The centre pixels for both the iris and the pupil lie inside the dark pupil region. A range of [0,1] for intensity values of the pixels in the eye images has been selected, where 0 represent the black pixels and 1 represent the white pixels. To get the best result, all the object pixel values below 0.5 are marked before being implemented. Here , the R_{max} value should not be more than100, or else an error occurs.

2.1.7 Segmented Image

The iris is segmented out by applying all the methods. Some iris images are not properly segmented out. The iris is segmented by applying an accurate radius to get the segmented output of the iris.

2.2 Methodology of Circular Hough Transform Method

2.2.1 Input Image

The input iris image is taken from the CASIA (Chinese Academy of Sciences-Institute of Automation) database. It contains 756 grayscale eye images with 108 unique eyes and 7 different images of each unique eye. The eye images are from Asian decants, whose eyes are characterized by irises that are densely pigmented, and with dark eyelashes. In CASIA images, the iris features are highly visible because of the specialized imaging conditions using infrared light and between the pupil, iris and the sclera regions, there is a good contrast.

2.2.2 Cropping Image

Input image is cropped to dimension [150*150]. By cropping the image, we can remove the eyelids, eyelashes and the sclera, which causes errors in the iris segmentation. The image is cropped in rectangular dimension rather than circular dimension because an iris is an oval shape, which does not support circular dimension [250*150].

2.2.3 RGB to Gray

The authors convert the image from RGB (Red, Green, Blue) to gray because of which, we can easily detect the changes in pixel value that occurs between the pupil and the iris.

2.2.4 Edge Detection

The edges are detected using Canny Edge detector. Canny Edge detector is considered to be the best edge detector for finding out the edges in an image.

2.2.5 Implementation of Circular Hough Transform

Circular Hough transform is applied after edge detection to find out the circle in an image.

2.2.6 Find Peak In Accumulator

The authors use the neighbourhood suppression method of peak finding to ensure that we find the spatially separated circles.

2.2.7 Finding Circle Points

The circles found in the image, are drawn using both the positions and the radii stored in the peaks array. The circle point's function is convenient for this.

2.2.8 Segmented Image

This is the last process where we get the segmented image of the iris boundaries.

3. Results and Discussion

In this project, the following results are found using the Daughman's method and the Circular Hough Transform method for iris.

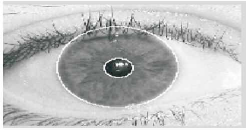
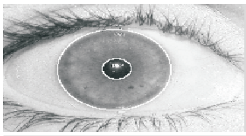
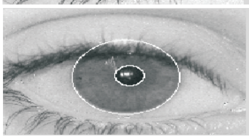
Maximum & Minimum Radius (R_{max} & R_{min})	Result	Remarks
Minimum Radius (R_{min}=42) Maximum Radius (R_{max}=48)		The segmentation of image is accurate from the given R_{max} and R_{min}
		The accurate result is obtained from the given R_{min} and R_{max}
		

Table 1. Accurately Segmented Iris using the Circular Hough Method

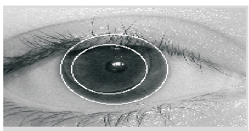
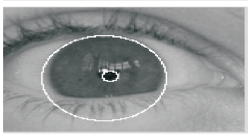
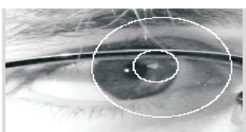
Maximum & Minimum Radius (R_{max} & R_{min})	Result	Remarks
Minimum Radius (R_{min}=55) Maximum Radius (R_{max}=48)		The inner boundary gets enlargened when we change the inner radius (R_{min}).
		In the give image, The inner boundary move toward right hand side and the inner boundary does not get properly segmented.
		In the image, the iris boundary both inner and outer boundary move towards the right hand side.

Table 2. Minimum Radius is Changed in Circular Hough Method

Table 1 shows the accurately segmented iris using the Circular Hough Method. Table 2 shows when the minimum radius is changed as, R_{min}>42. The accurately segmented iris using Daughman's method is shown in Table 3. Error in the image occurs when R_{min} is constant and R_{max} is more than 100 during segmentation as shown in Table 4. When the maximum radius, R_{min} value is changed, their results are shown in Table 5.

From the results shown above, it is found out that the eye input image is segmented out using Circular Hough Transform and Daughman's intro differential operator. Images are taken from the CASIA database. Hit and trial method is used to find out the segmented output of iris and pupilary boundary.

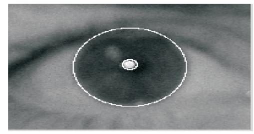
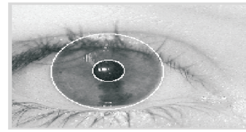
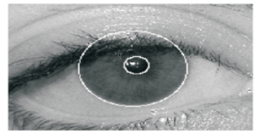
R_{max} & R_{min}	Output	Discussion
Maximum Radius (R_{max}=50) Minimum Radius (R_{min}=45)		The segmentation of iris from the image is done accurately.
		
		

Table 3. Accurately Segmented Iris using Daughman's Method

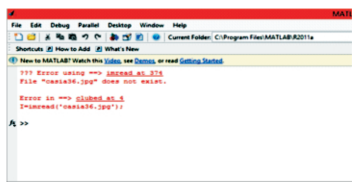
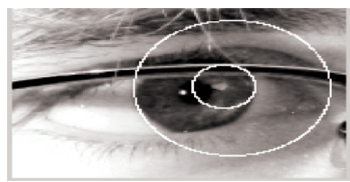
R_{max} & R_{min}	Output	Discussion
Minimum Radius (R_{min}=45) Maximum Radius (R_{max}=100)		When R_{max} value is more than 100. then the is found out Which is shown in the image.
Minimum Radius (R_{min}=45) Maximum Radius (R_{max}=88)		In the given image, it is shown that Iris and pupilary boundary move towards the right hand side.

Table 4. Error in the Image

In this project, 100 CASIA images are taken. These images are segmented using two different methods in which, 50 where of Daughman method and 50 of Circular Hough Transform. The first method used is Circular Hough Transform, where the accurately segmented image is 42 out of 50 eye images.

The second method is Daughman's method, in which 38 images are accurately segmented out of the 50 eye images. It is observed that in Daughman's method, if the R_{max} value is greater than 100, then the image will not get segmented and error occurs. Similarly, if the value of R_{min} is less than 0, then also the error occurs and the image will not be segmented out and the threshold value should be less than 5 to obtain a better result. Such errors were not found in Circular Hough Transform, as when we put the R_{max} value greater than 100, there will be no error and the image gets segmented out [27]-[29], [31].

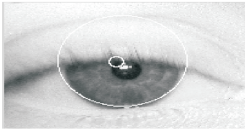
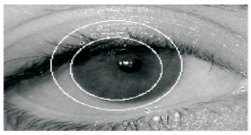
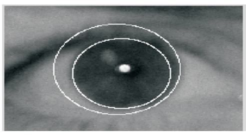
R_{max} & R_{min}	Output	Discussion
Maximum Radius (R_{max}=55) Minimum Radius (R_{min}=52)		When R_{min} value is increased then the inner boundary segmentation of iris move toward left side.
		When the inner radius R_{min} then the inner segmentation of iris expands and hence the accurate segmen tation does not take place
		

Table 5. Show when maximum radius R_{min} value is changed

Method	Accurately Segmented	Not Accurately Segmented	Accuracy (%)
Circular Hough Transform	42	8	84%
Daughman's Method	38	12	76%

Table 6. Accuracy Percentage of Segmentation

Table 6 shows that, Circular Hough Transform has more percentage of accuracy than the Daughman's method. The Circular Hough Transform accuracy percentage is 84%, whereas the Daughman's method has the accuracy percentage of 76%.

Hence, the total result of Iris segmentation shows that Circular Hough Transform method has better segmentation than the Daughman's method.

Conclusion

Iris recognition system is the system of recognising a person by analysing the random patterns of iris. Iris recognition can be considered as one of the most reliable and accurate methods of biometric technology, when compared with other biometric technologies such as face, fingerprint and speech recognition of segmenting the iris from the whole eye image. In iris recognition, there are 5 major steps namely, image acquisition, iris segmentation, iris normalisation, iris feature extraction, and iris template matching. In this paper, research has been done on the iris segmentation. Iris segmentation is the process of segmenting the iris portion from the whole eye image. It is the most important task in iris-based biometric authentication system and if the iris part of an eye image is not detected precisely, then an error is created in the overall iris recognition method. The work has been stressed more on efficient and accurate iris segmentation method using Circular Hough Transform and Daughman's method for developing the best biometric identity. The Circular Hough Transform and Daughman's method segment the iris portion by using hit and trial method and segments out the iris and the pupilary boundary. The percentage of accuracy obtained by both the methods are different.

In this paper, 100 CASIA images were taken, in which 50 images were segmented from Circular Hough Transform and another 50 from Daughman's method. It is found that, the percentage of segmentation in Circular Hough Transform is more as compared to the Daughman's method. The accuracy percentage of Circular Hough Transform is 84%, whereas the accuracy percentage of Daughman's method is 76%. The eye image is taken from the CASIA V1 database and MATLAB software are used to perform the segmentation. Therefore, it is concluded that iris segmentation using Circular Hough transform provides a much better segmentation accuracy than the Daughman's Method.

Future Scope

From this research work, extensive future scope can be carried out.

- Different databases can be used such as, UBRIS, MMU (Multimedia University) database, and IIT Delhi database for further research work.
- The Active contour method can be implemented in the iris segmentation, because it segments the image by snake method which directly targets to the contour closed curve like a snake crawling constantly changes its shape.
- Real time model can be made using an FPGA.

References

[1]. **Ahmad Ayatollahi and Seyedzade Seyed Mohammad (2010).** "A Novel Iris Recognition System Based on Active Contour". *17th Iranian Conference of Biomedical Engineering (ICBME2010).*

[2]. **Anawar S, Ayop Z and M. Manaf, (2012).** "Iris Segmentation Analysis using Integro-Differential Operator and Hough Transform in Biometric System". *Journal of Telecommunication, Electronic and Computer*

Engineering, Vol. 4.

[3]. Adegoke, B. O, Omidiora, E. O, Falohun, S. A. and Ojo, J.A. (2013). "Iris Segmentation: A survey". *International Journal of Modern Engineering Research,* Vol.3, No. 4.

[4]. Basu Somak and Dubey Maheedhar, (2013). "Daughman's Algorithm Method For Iris Recognition: A Biometric Approach". *International Journal of Emerging Technology and Advanced Engineering,* Vol. 2, No. 6.

[5]. Bendale Amit and Gupta Phalguni, (2012). "Iris Segmentation using an Improved Hough Transform". *Springer 2012.*

[6]. Chawla Sunil and Oberoi Ashish, (2011). "A Robust Segmentation Method for Iris, Recognition". *International Journal of Advanced Research in Computer Science,* Vol. 2, No. 5.

[7]. Chen Yen, Chang Han, Andrim Jean and Rishe N. (2009). "A highly accurate computationally efficient approach for unconstrained iris segmentation". *Elsevier.*

[8]. Cherabit Noureddin, Chelali Fatma Zohra and Djeradi Amar, (2012). "Circular Hough Transform for Iris localization". *Science and Technology.*

[9]. Daugman J, (2007). "New Methods in Iris Recognition". *IEEE Transactions on Systems, Man, and Cybernetics-Part B: Cybernetics,* Vol. 37, No. 5.

[10]. Dubey R. B and Madan Abhimanyu, (2014). Iris Localization using Daugman's Intero-Differential Operator, Vol. 93, No 3.

[11]. Djoumessi Maeva, (2012). "Iris Segmentation using Daughman's Intro-Differential Operator". Conference Paper, University of North Carolina, Chapel Hill.

[12]. Dobeš M, Martineka M, Skoupila D, Dobešováb Z, and Pospíšilc J, (2005). "Human eye localization using the modified Hough transform". *Elsevier.*

[13]. Gupta Rajeev and Kumar Ashok, (2013). "An Effective Segmentation Technique for Noisy Iris Images". *International Journal of Application or Innovation in Engineering & Management,* Vol. 2, No. 12.

[14]. Ito Y, Ohyama W, Wakabayashi T, and Kimura T, (2012). "Detection of Eyes by Circular Hough Transform and Histogram of Gradient". *21st International Conference on Pattern Recognition (ICPR 2012).*

[15]. James Sahaya Mary, (2015). "A Review of Daugman's Algorithm in Iris Segmentation". *International Journal of Innovative Science, Engineering & Technology,* Vol. 2, No. 8.

[16]. Kayaoglu M, and Uludag U, (2015). "Biometric Matching and Fusion System for Fingerprints from Non-Distal Phalanges".

[17]. Kadry S, (2007). "A design and implementation of a wireless iris recognition attendance management system". *Information Technology and Control,* Vol.36, No. 3.

[18]. Kaur Navjot, (2014). "An Iris Localization Method for Non-ideal Eye Images". *Journal of Emerging Technologies in Web Intelligence,* Vol. 6, No. 4.

[19]. Krishna M, and Reddy S, (2014). "Automated Iris Localization using Active Contour Model for IRIS Recognition". *International Journal of Ethics in Engineering & Management Education,* Vol. 1, No. 2.

[20]. More Manisha, Narale Vishakha and Tonge Vanita, (2015). "A Survey on Iris Recognition Techniques". *International Journal of Novel Research in Computer Science and Software Engineering,* Vol. 2, No. 1.

[21]. Nguyen Thanh, Kien and Fookes, Clinton B. and Sridharan Sridha, (2010). "Fusing shrinking and expanding active contour models for robust IRIS segmentation". *10th International Conference on Information Science, Signal Processing and their Applications,* 10-13 May 2010, Renaissance Hotel, Kuala Lumpur.

[22]. Nithyanandam S, Gayathri K. S, and Priyadarshini P. L. K, (2011). "A New Iris Normalization Process For Recognition System With Cryptographic Techniques". *IJCSI International Journal of Computer Science Issues,* Vol. 8, No. 4, No 1.

[23]. Nkole Ifeanyi Ugbaga, Sulong Ghazali Bin, and Saparudin (n.d). "An Enhanced Iris Segmentation Algorithm Using Circle Hough Transform". *International Conference,* Kudai, Johor, Malaysia.

[24]. Rizon M, Yazid H, Saad P, and Saad A. R, (2005). "Object Detection using Circular Hough Transform". *American Journal of Applied Sciences,* Vol. 2, No. 12, pp. 1606-1609.

[25]. Ross Arun and Shah Samir, (2009). "Iris Segmentation using Geodesic Active Contours". *IEEE Transactions,* Vol. 4,

No. 4.

[26]. **Soltany Milad, Zadeh Saeid Toosi and Pourreza Hamid-Reza, (2012).** "Daugman's Algorithm Enhancement for Iris Localization". *Advanced Materials Research,* pp. 403-408

[27]. **Suen Ching Y, Bhattacharya Prabir, and Roy Kaushik, (2010).** "Unideal Iris Segmentation using Region-Based Active Contour Mode". *Springer-Verlag,* Berlin, Heidelberg 2010.

[28]. **Sundaresan M, and S. Jayalakshmi, (2014).** "A Study of Iris Segmentation Methods using Fuzzy C Means and K-Means Clustering Algorithm". *International Journal of Computer Applications,* Vol. 85, No 11.

[29]. **T. K Sruthi, and K. M Jini, (2013).** "A Literature Review on Iris Segmentation Techniques for Iris Recognition Systems". Vol. 11, No. 1.

[30]. **Walia Mrigana and Jain Shaily, (2015).** "Iris Recognition System Using Circular Hough Transform". *International Journal of Advance Research in Computer Science and Management Studies,* Vol. 3, No. 7.

[31]. **Zhang Zhengben and Wang Chongke, (2015).** "Research on Iris Localization Algorithm based on the Active Contour Model". *International Journal of Security and Its Applications,* Vol. 9, No. 3.

ABOUT THE AUTHORS

** PG Scholar, Department of Electronics and Communication Engineering, CSIT, Durg, Chhattisgarh, India.*

*** Associate Professor, Department of Electronics and Communication Engineering, CSIT, Durg, Chhattisgarh, India.*