Iris Recognition in Visible Spectrum by Improving Iris Image Segmentation

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***Abstract*—** Iris recognition system of the biometrics discriminate the human being by the unique characteristics of their individuality. Iris Image segmentation, as a part of the iris recognition procedure requires higher level of accuracy and effectiveness to achieve greater security for the system. Additionally, eye images captured in visible spectrum need special segmentation care then NIR bases eye image. Iris segmentation highly depends on the acquire image condition. To achieve this, we have calculate improve results for iris segmentation that consists retinex based contrast enhancement for better accuracy. Isophote curvature base eye center localization is implemented to define region of interests with canny edge detection and circular hough transform to accurately locate the boundaries of iris and pupil. Morphological operation base eyelash detection steps are also implemented which regularize final segmentation results. Experimental results on the sample images of UBIRIS database reveals effectiveness in segmentation as well as recognition rate. It fails on few iris images consider to be resolve in future work. From performance evaluation, it seems clearly that proposed iris segmentation has achieved greater level of recognition rate with effective FAR and FRR for sample sub test dataset.

***Index Terms*— Iris Segmentation, Eye Center Estimation, Iris Recognition, Iris Localization, Pupil boundary detection, Contrast enhancement**

I. INTRODUCTION

We individual possess some unique characteristics or features based on which a biometric systems discriminate ourselves in some sort of categories. Characteristics or features like fingerprints, retinas, handwriting, facial features, voice, hand geometry and one considered over here -'The Iris' keep all individual unique to us. Biometric systems creates database with set of templates at initial phase. Templates that contain the information such as captured face image for face recognition, voice sound signal for voice recognition provide the highly discriminative representation of the features, which can compare with the other templates for identity determination. Creating templates for database comes under mode of enrolment and comparing the template with enrolled user, lies in identification mode. Features that are highly unique (having same characteristics near about to zero), stable (feature change about the time goes) and be easily captured (convenience to the user), discriminate individual on the basis of their uniqueness and biometric quality.

Iris pattern remain stable for individual for whole life and have some distinct advantage to maintain the individuality. Probability of getting the same iris for individual is near to zero. The uniqueness of these characteristics gives the higher priority to increase the reliability and the security for the authentication. Lots of advantageous factors like speed and accuracy compared to other traits of iris recognition attracted a lot of attention. Modules that lies within Iris Recognition System shown in the below Fig. 1.

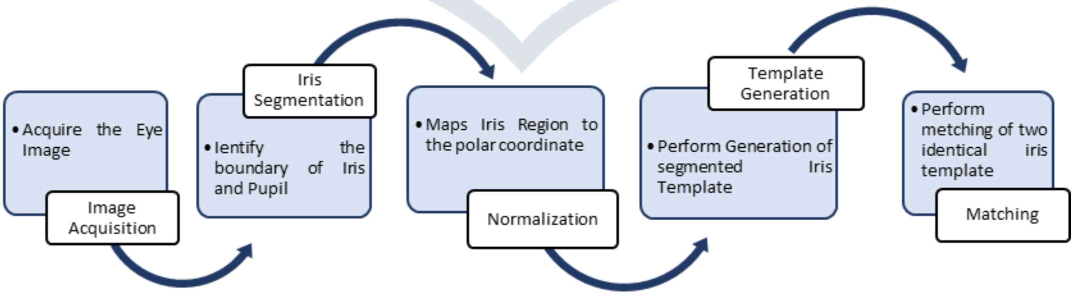

Figure 1 Modules of Iris Recognition System

Begin with image acquisition in the visible spectrum while person moving in front of camera, it captures the eye image from the tracked eye portion of the person's face. One of the major challenges of automated iris recognition is to capture a high-quality image of the eye with proper details about regions i.e Iris, Pupil, Eyelash, Scalera, Noise etc. Image acquisition require careful engineering with taking points with the care that, (a) acquired image should contain sufficient resolution and sharpness to support recognition, (b) should have good contrast in the interior iris pattern, (c) artifacts like specular reflection, optical illusions should be eliminated from the acquire eye image. Localization of iris as well as pupil boundary in the captured eye image by detecting plus eliminating various occlusions like eyelashes, eyelids comes under the iris segmentation module. For the purpose of storing this segmented patterns in some unique form normalization procedure took place after locating boundaries of iris and pupil. From the normalized structure of segmented image, bit pattern templates are generated for storage purpose of test dataset and perform matching in next module of iris recognition procedure. For verification or identification of subject, two identical template matching perform in last module of iris recognition system. As the whole system efficiency depends on the accuracy of iris segmentation, to achieve good recognition rate for iris recognition system we improve this iris segmentation module with additional techniques and procedures.

II. RELATED WORK

From the decade, lots of research work took place in this area and different methods are incorporated together to achieve better results for the iris recognition rate. Widely used and highly deployed iris segmentation approach for iris recognition is based on the integrodifferential operator [1]. Another proposed research where gradient information of eye image considered for locating boundaries of iris and pupil in [2] where prior to segmentation eyelids are detected by implementing morphological operations for better results. Similarly, optimized color mapping based pupil boundary detection procedure describe in the [3] utilize an optimized color mapping procedure performed over the original eye image that outputs a new image for hough transform described in [4] that accurately detect pupil boundary. A mathematical morphology operator based approach for uncalibrated noisy iris images is implemented in [5] which improved the segmentation procedure time. Mathematical morphology operator locate boundary of iris and pupil from generated polar coordinates of grey scale image. Circular Hough transform and active contour based enhanced iris segmentation approach of [6] detects the circle approximation for the outer and the inner boundaries of the iris subsequently. To exclude eyelids and eyelashes linear Hough transform and intensity threshold based operations perform respectively. Reverse function based accurate iris and pupil localization perform in [7] where reverse function based thresholding distinguish the portion of the pupil from other eye image regions effectively. Additionally four neighbor method of [8] applied to locate accurate pupil boundary. Iris boundary is located with contrast enhancement and thresholding operations. Proposed approach of [9] generate edge map with the help of canny edge detector for easy detection of the iris and scalera boundary. Circular pattern of iris and pupil is detected with the help of circular hough transform. Eyelashes and eyelids are detected with linear hough transform. CGF (Circular Gabor Filter) based segmentation technique has been proposed in [10] that identify the initial pixels for pupil and non-pupil regions followed by optimization and regularization. Accurate boundary of the iris and pupil were refined at last. The algorithm neither depends on the edge detection nor on the active contour. Instead of that initial pixels are used to identify the iris and the sclera regions. The morphological closing and dilation operations are performed which eliminate the eyelash regions from the segmented iris and regularize the detected iris boundary accurately at final stage. Similarly circle fitting technique is adopted for pupil boundary regularization.

Proposed approach of [2] detects the center and boundaries quickly and reliably, even in the presence of eyelashes and in the presence of excess illuminations. While very low contrast interface affect the segmentation and cause the imperfection in detecting accurate circular boundary. Optimized color mapping method of [3] can be employed along with texture features of iris to accurately locate iris boundary for complete iris-pupil segmentation from an eye image for further improvements. The proposed approach of [5] lacks to deal with off-angle and top-cut iris eye images. Hough transform based approach of [9] evaluated only on images taken in NIR medium which lacks to detect the boundary for images captured in visible medium. Method proposed in [10] method achieves the highest accuracy in eye image segmentation compared to IDO and Hough Transform based eye image segmentation approaches. Their non-iterative type of method has improved the segmentation time and performed reliable in the presence of specular and lighting reflection. The algorithm degrades in terms of the accuracy when deal with presence of lower contrast and specular reflection in eye image.

III. PROPOSED WORK

In the proposed approach, an efficient iris segmentation algorithm design to address the issues of iris segmentation for the noisy captured eye images of visible spectrum where we try to eliminate as much as noise before the actual segmentation. Our approach has also gain relative computation cost and higher recognition rate. Proposed segmentation work flow is shown in Fig 2.

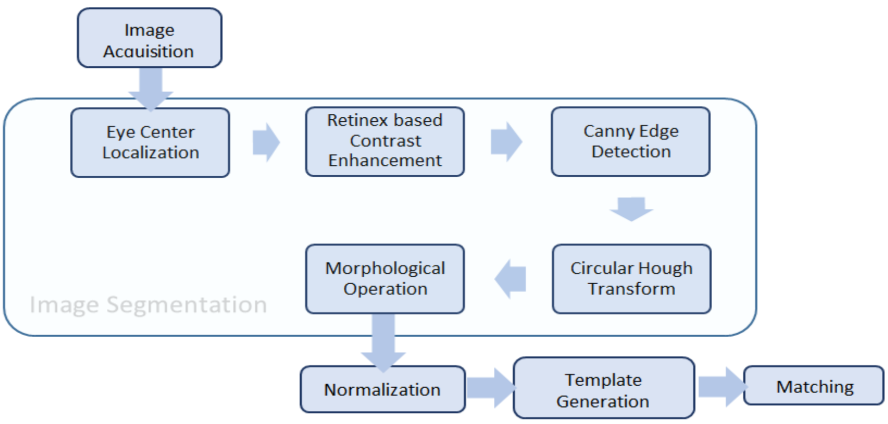

Figure 2 Proposed Iris Recognition Diagram

To eliminate processing over entire captured eye image we prefer to locate the region where needful details about iris can be obtain. For that center of eye is estimated by which image with region of interest is cropped by specifying accurate parameters. Contrast enhancement of that cropped image is perform that helps in detecting iris and pupil boundary very effectively by canny edge detector and circular hough transform. In the final step, morphological operations are performed to detect eyelash and eyelid regions in eye image. As most reliable stage of iris recognition we concentrate only to improve the iris segmentation stage. After excessive study for normalization, template generation and matching as explained in [9] are implemented to complete the whole iris recognition system.

Proposed Algorithm steps:

Detailed iris segmentation flow of proposed algorithm is shown in below Fig. 3. Among the number of eye center detection algorithms, isophote property based eye center localization proposed in [11] processed on inputted eye image. Due to independency against rotation and linear lighting changes, isophotes have been considered as a feature in object detection and image segmentation. Eye center localization starts with isophote curvature estimation which detects the edges in the eye image. Then after by using direction of gradients for circular patterns in eye image 'centermap' are mapped. Finally, center voting operates to select the centers term as isocenters where each isophote lied on the edge of the object took part in it. Depend on these isocenters, the one with maximum isocenter is considered as center of the eye.

With estimated center of eye image region of interest is define with specific parameters of image size and image is cropped along with those values for further processing. Purpose of eliminating area outside the ROI is to decrease the overall processing.

For enhancing image contrast, retinex based contrast enhancement of [12] is implemented in next step. Compared to other histogram equalization, adaptive histogram equalization retinex has shown effective results for enhancing image contrast discussed in implementation section.

To detect circular geometry of iris and pupil, canny edge detector specified in [13] is applied first on the contrast enhanced cropped image that generate edge maps. Then after circular hough transform [15] is applied that detect the circles from generated edge map of the image and return back the center and radius of detected circles. The return circle parameters are used to map the boundaries of detected iris and pupil on the original ROI cropped eye image.

Morphological operations are processed on gray scale of input image to detect eyelashes and eyelids. Processing steps for that are,

- Apply Morphological Closing on gray scale image that results in image (I_C) and perform subtraction of original image and morphological closed image ($I_{ORI} - I_C$) that generate image (I_E)
- Now perform Binarization on generated image that gives Binarized image ($I_E \rightarrow I_B$)
- Apply morphological dilation on Binarized image that generated eyelash detected image (I_{LASH})

With the help of I_{LASH}, eyelashes can be isolated from the segmented iris image to finalize detected boundaries of iris and pupil. The detected results are then passed back to the normalization stage for further processing.

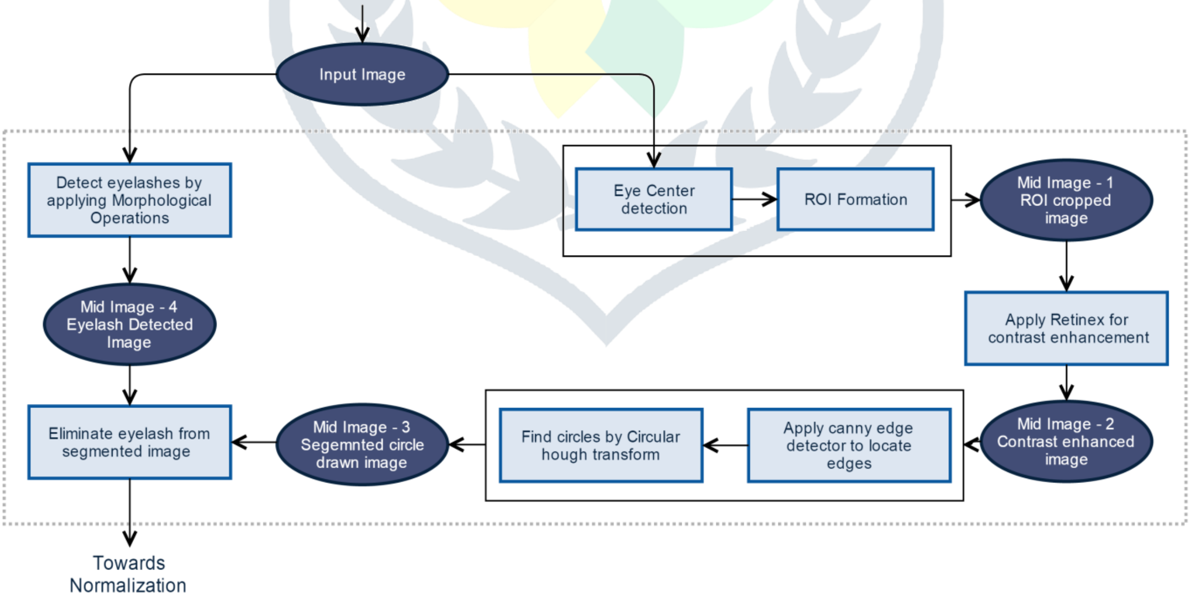

Figure 3 Proposed Iris Segmentation Flow

IV. Implementation and Results

First stage of our proposed work is to form region of interest by locating center of eye in eye image. The implementation of isophote based eye center localization performs very well on the images of subset generated from UBIRIS local dataset. Result of center pointed image is shown in Fig. 4(a). For few sample images it also fails to locate center of eye as shown in Fig. 4(b). From the located eye center coordinates eye image is cropped by taking appropriate rectangular parameters reliable with image size. The result of one cropped eye image after ROI formation is shown in Fig. 4(c). The contrast of cropped eye image is further enhanced with retinex based one of technique that enhance details of regions in cropped image as shown in Fig. 4(d).

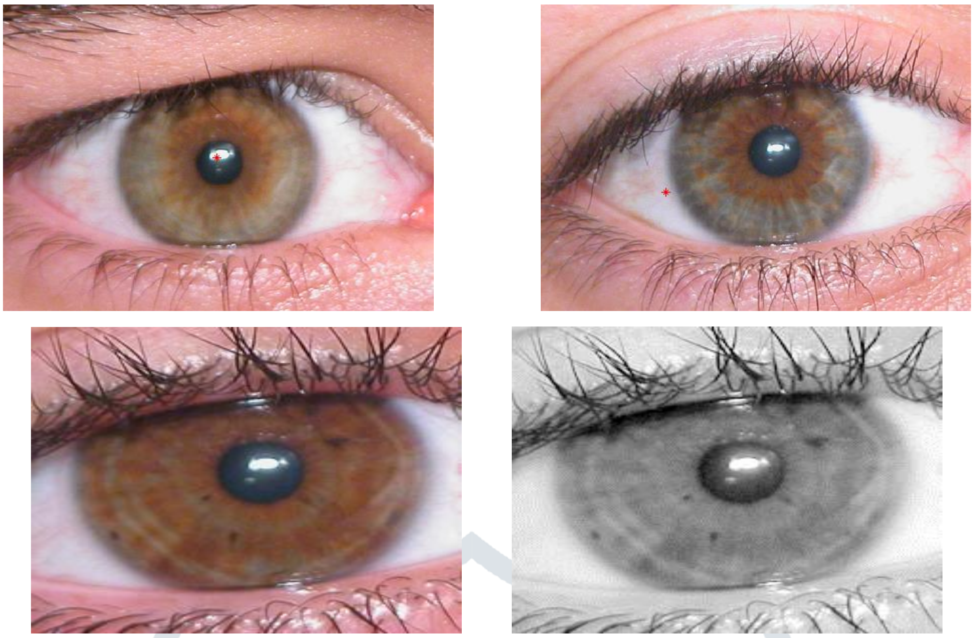

Figure 4 (a) Image with center pointed (b) Fail result Image of center localization
(c) Image after cropped within ROI (d) contrast enhanced cropped image

Better results in contrast enhancement gains some advantage for further iris segmentation procedure. Next, in enhanced region canny edge detector specified in [13] and circular hough transform applied to detect circular boundaries of iris and pupil with specified appropriate parameters range. Iris boundary is detected prior to pupil boundary thus later within region of iris boundary, boundary of pupil is detected. Successful results of locating iris and pupil boundary is shown in below Fig. 5(a). Due to presence of lower contrast after contrast enhancement and excessive presence of blur in input image, de boundaries of iris and pupil could not be successfully detected as shown in Fig. 5(b). The successful detection of eyelashes by morphological operations is shown in Fig. 5(c). The detected eyelashes from the eye image can be isolated from the inside region of iris circle.

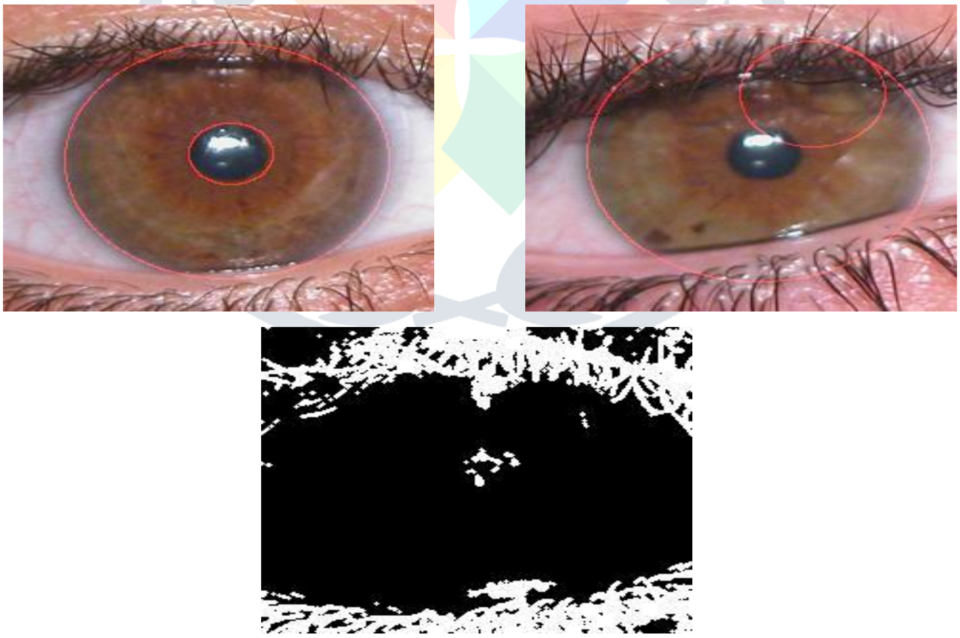

Figure 5 (a) Image with successful Iris Segmentation Result (b) Image with failed Iris Segmentation Results
(c) Eyelash detected Image

The results of segmentation process without the contrast enhancement on the subset of 59 eye images generated from UBIRIS database gain 59.32 % successful segmentation results with 35 images segmented accurately. While for remaining images segmentation process and eye center localization fails due to lower contrast and less details of the regions in the eye image. While improved segmentation process of our propose algorithm with contrast enhancement on same iris database of 59 images comes out with 93.22% successful segmentation results for 55 images segmented accurately. The results are properly shown in the Table 1.

Table 1 Segmentation Results

Method	No of images in Subset	No of images segmented successfully	Results (%)
Segmentation (without contrast enhancement)	59	35	59.32
Propose Segmentation Process	59	55	93.22

To measure identification ratio of proposed segmentation process in the iris recognition we develop all the stages of iris recognition system and achieve effective results as compare to segmentation process without contrast enhancement. The FAR and FRR [14] values for corresponding value of hamming distance is shown in Table 2 for relative approaches. For the same results FAR and FRR results are plotted in Fig. 6.

Table 2 FAR and FRR relate to Hamming Distance- HD (Left) For Segmentation (without contrast enhancement) (Right) Propose Segmentation Process

HD	FA	FR	FAR (%)	FRR (%)
0.3	1	4	2.857	11.429
0.32	1	3	2.857	8.571
0.33	**2**	**2**	**5.714**	**5.714**
0.34	6	0	17.143	0.000
0.35	11	0	31.429	0.000

HD	FA	FR	FAR (%)	FRR (%)
0.32	0	3	0.000	5.455
0.33	0	1	0.000	1.818
0.34	**0**	**0**	**0.000**	**0.000**
0.36	0	0	0.000	0.000
0.37	1	0	1.818	0.000

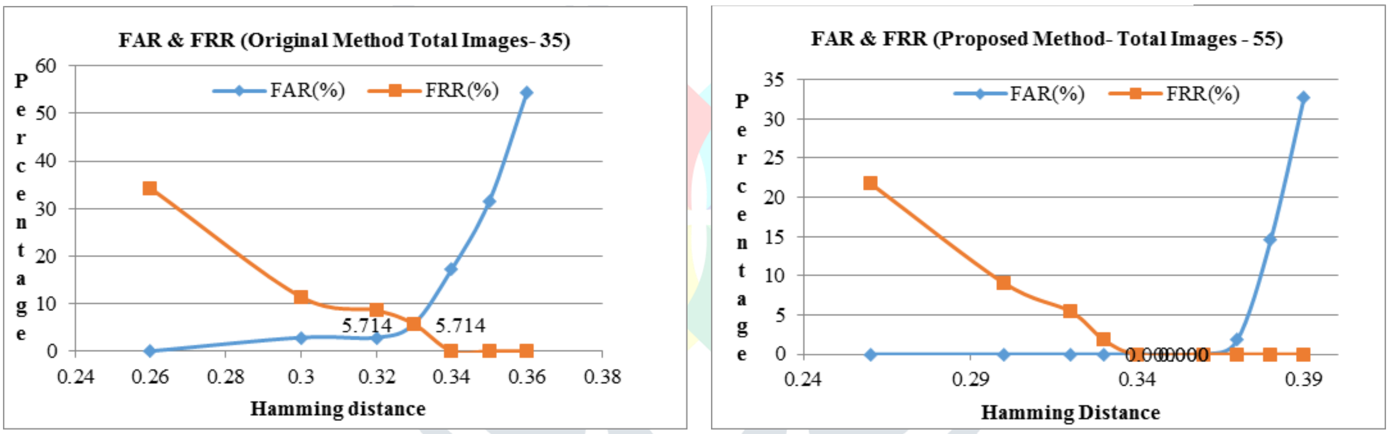

Figure 6 Plotted Hamming Distance corresponding to Percentage
(Left) Segmentation without Contrast enhancement (Right) Propose Segmentation Process

Identification results clearly show that two users are falsely accepted and falsely rejected for relative hamming distance value 0.33 which is the minimal. Where the identification results for proposed approach clearly shows no user is falsely accepted and falsely rejected for relative hamming distance value 0.34.

V. CONCLUSION AND FUTURE WORK

Proposed improved approach for iris segmentation clearly achieves improved results as discussed in the previous section. Contrast enhancement and processing over only region of interest gain advantage for overall segmentation process. Initial stage of eye center detection helps to form ROI effectively and improve the processing also. As a crucial stage of the iris recognition, we achieve improved results for our propose work. Morphological operations for detecting eyelashes also shows effective results for finalize the detected boundaries. Moreover, we try to enhance as much regions with contrast enhancement but yet few results fail for detecting boundary of iris and pupil due to excessive presence of blur and noises. Better optimization of noise parameters can improve these results in the future work. Additionally, elimination of detected specular reflection can be possible future enhancement to improve the results of propose segmentation work.

VI. ACKNOWLEDGEMENT

I take this opportunity to express my sincere gratitude to my guide **Mrs. Krupa N. Jariwala, Assistant Professor, SVNIT, Surat** for the invaluable guidance and moral support rendered by her in the fulfillment of my paper work. I am thankful to her for her constant constructive criticism and invaluable suggestions, which benefited me a lot while doing my research. Without her encouragement and guidance this research work would not have been materialized. I am also thankful to my family and friends who supported me during the preparation of my work.

REFERENCES

[1] John G. Daugman, “High Confidence Visual Recognition of Persons by a Test of Statistical Independence”, IEEE Transaction on Pattern Analysis and Machine Intelligence, Vol.15, No.11, November 1993.

[2] Amjad Zaim, “Automatic segmentation of iris images for the purpose of Identification”, IEEE International Conference on ICIP 2005, Vol.3, pp. 273-6.

[3] Kheirolahy, Rasoul, Hossein Ebrahimnezhad, and MohammadHossein Sedaaghi. “Robust pupil boundary detection by optimized color mapping for iris recognition”. Computer Conference, 2009. CSICC 2009. 14th International CSI. IEEE, 2009.

[4] P. Hough, "Method and means for recognizing complex patterns", U.S. Patent 3,069,654, Dec 1962.

[5] Luengo-Oroz, Miguel A., Emmanuel Faure, and Jesús Angulo. "Robust iris segmentation on uncalibrated noisy images using mathematical morphology."Image and Vision Computing 28.2 (2010): 278-284.

[6] Alaa Hilal, Bassam Daya, Pierre Beauseroy, (2012). “Hough Transform and Active Contour for Enhanced Iris Segmentation”. IJCSI (International Journal of Computer Science Issues), Vol.9, Issue.6.

[7] Ramakumar, R. P., and S. Arumugham. “Accurate Pupil and Iris Localization using Reverse Function”. (2012).

[8] Almisreb, Ali Abd, Nooritawati Md Tahir, and Mustaffa Samad, “Pupil Localization Using Negative Function and the Four Neighbours”. Computational Intelligence, Modelling and Simulation (CIMSiM), 2010 Second International Conference on. IEEE, 2010.

[9] Masek, Libor. Recognition of human iris patterns for biometric identification. Diss. Master’s thesis, University of Western Australia, 2003.

[10] Radman A., Jumari K., and Zainal N, “Iris segmentation in visible wavelength Images using Circular Gabor Filters and Optimization”. Arab J Science Engineering (2014) 39:3039–3049.

[11] Valenti Roberto, and Theo Gevers. "Accurate eye center location and tracking using isophote curvature." Computer Vision and Pattern Recognition, 2008. CVPR 2008. IEEE Conference on. IEEE, 2008.

[12] Rahman, Z-U., Daniel J. Jobson, and Glenn A. Woodell. "Multi-scale retinex for color image enhancement." Image Processing, 1996. Proceedings., International Conference on. Vol. 3. IEEE, 1996.

[13] P. Kovesi. MATLAB Functions for Computer Vision and Image Analysis. Available at: http://www.cs.uwa.edu.au/~pk/Research/MatlabFns/index.html.

[14] http://www.bayometric.com/blog/false-acceptance-rate-far-false-recognition-rate-frr/

[15] https://www.cis.rit.edu/class/simg782/lectures/lecture_10/lec782_05_10.pdf