PAPER • OPEN ACCESS

Pupil Segmentation of Abnormal Eye using Image Enhancement in Spatial Domain

To cite this article: R. A. Ramlee *et al* 2017 *IOP Conf. Ser.: Mater. Sci. Eng.* **210** 012031

Related content

- Advanced Digital Imaging Laboratory Using MATLAB® (Second edition) : Methods of image enhancement
  L P Yaroslavsky
- Vascular and Intravascular Imaging Trends, Analysis, and Challenges, Volume 1: Graph-based cross-sectional intravascular image segmentation
  P Radeva and J S Suri
- Application of Gaussian as Edge Detector for Image Enhancement of Ancient Manuscripts
  N. Jayanthi and S. Indu

Recent citations

- Distance-Based Method used to Localize the Eyeball Effectively for Cerebral Palsy Rehabilitation
  G. Sumathy and J. Arokia Renjit

IOP Conf. Series: Materials Science and Engineering **210** (2017) 012031 doi:10.1088/1757-899X/210/1/012031

Pupil Segmentation of Abnormal Eye using Image Enhancement in Spatial Domain

R. A. Ramlee[1, 2*], A. R. Ramli[1] and Z. M. Noh[2]
[1]Faculty of Engineering, Communications and Network Engineering
Universiti Putra Malaysia, 43400 UPM Serdang, Selangor Darul Ehsan, Malaysia.
[2]Faculty of Electronics and Computer Engineering (FKEKK),
Universiti Teknikal Malaysia Melaka (UTeM), Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

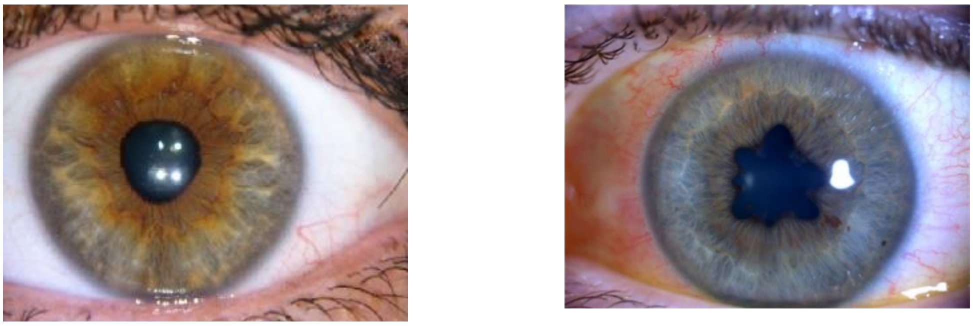
Email: *ridza@utem.edu.my

Abstract. Segmentation is one of the important elements in image processing. There are various types of algorithms that have been developed by researchers, for segmenting the interesting area for classification and identification purposes. This paper, presents the pupil segmentation using logarithmic transformation (LT) and power law transformation (PLT). It is obviously seen in most of the work on pupil segmentation where assumption is made that the pupil has a homogeneous circular. However, there are cases where the shape of pupil is inhomogeneous, for instance, in synechia case. Therefore, the use of circumference equation such as circular Hough transforms (CHT) and Daugman's Integra-differential operator (DIDO) for section the non-uniform pupil will produce inaccurate segmentation. We propose a new method for pupil segmentation using the combination of LT and PLT algorithm in order to enhance the pupil segmentation. The morphological operators and black white (BW) removal are used the segmentation of pupil. The proposed system uses CASIA V1, CASIAV3 Interval and MMU1 iris database. The results show his method gives accurate segmentation compared to CHT or DIDO technique.

1. Introduction

In the iris recognition system, the segmentation process is an important step to get correct selection of pupil and iris region. Through accurate segmentation, the valuable information of iris patterns can be achieved and will increase the accuracy of the iris recognition system. However, there are cases where the pupil is seemed to be inhomogeneous circular, thus causing the segmentation to become difficult. The condition of non-uniform shape of the pupil is known as synechia. This situation also can occur due to some reasons, such as diseases and infection at pupil and iris regions. This paperwork on the abnormal pupil region segmentation which caused by eye diseases. In additional this proposed segmentation method can yield accurate pupil segmentation compare to segmentation using DIDO [1] or CHT [2].

Figure 1 shows the condition of pupils in various irregular shape. The pupil such in Figure 1, (a) and (b) are not in circular shape, where it is absolutely seen in (a) the pupil is slightly irregular oval while in (b) the pupil shape look like a star shape. These non-circular pupil condition will cause challenging to make correct segmentation, especially when using circular method such as circular CHT or DIDO.



(a) (b)

Figure 1. Image of non-circular pupil, (a) pupil in oval shape, (b) pupil like star shape [3]

2. Literature Review

In this section various studies of pupil segmentation are studied. Amongst these studies, Abdullah *et al.* [4] proposed a segmentation using morphological operation and Chan-Vese active contour model to determine the pupil and iris boundary. The same authors [5] in another work propose the segmentation method using combination morphological operations and snake active contour. Their proposed system capable to detect the pupil boundary successfully.

The authors [6] proposed the angular integral projection function (AIPF) for determining the pupil boundary. For limbus boundary, they used AIPF applied in between two rectangles on both iris side.

Romaguera *et al.* [7] proposed a method using histogram equalization, threshold and morphological operations. Next to detect pupil they used canny edge detection and Hough transform.

Santis *et al.* [8] indicated the segmentation of biomedical images is vital and can be used as non-invasive diagnosis. They studied on the pupil geometrical features such as diameter, area, centroid coordinates, and implemented these values in their algorithm.

In [9] the authors have similar opinion with [4]–[6] about non-circular shape of pupil. According to [9] the error in detecting the pupil boundary cause the quality of the identification system become low. Thus they proposed accurate pupil boundary using graph cuts. According to them the gray level values is used to compute the weights of the link in graph. The graph is divided into two areas pupil and the background. They have tested 756 images using their proposed system. All of these images were segmented successfully. However they did not stated exactly the accuracy percentage yield by their system. Another work related to pupil segmentation as reported by Bastos et al. [8]. They indicate most of the pupil segmentation algorithms assumed the pupil has a uniform circular. These assumption will cause inaccurate segmentation for the non-circular pupil. For this problem they propose a new method based on pull and push method and batch-SOM neural network to improve the pupil segmentation.

3. Methodology

The aim of this system is to design the segmentation of the pupillary. This system consists of the following stages such as: (a) Original image, (b) filtering, (c) Illumination removal, (d) Logarithm operator, (e) Power law transformation (exponential), (f) Morphological, (g) Binary removal and (h) segmentation pupil. The overall of our proposed system is illustrated in Figure 2 beginning with the original image and the whole process until segmentation of the pupil is achieved. For this system we had used the images from CASIA [10] and MMU [11] database.

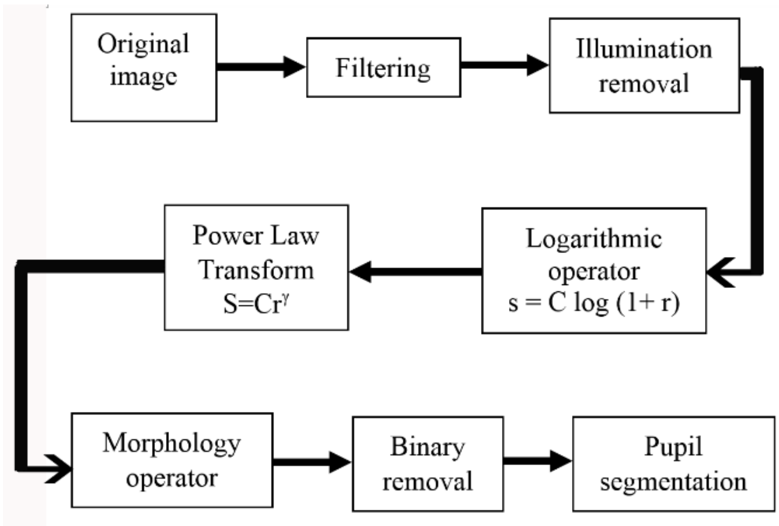
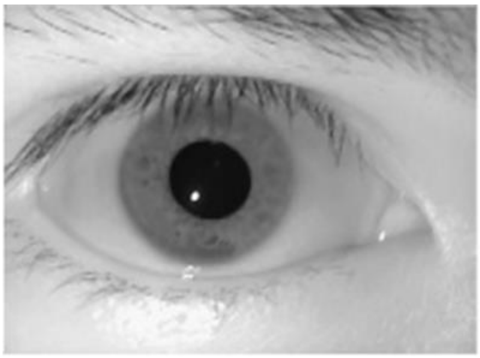


Figure 2. Flow chart of the overall steps for this pupil detection system.

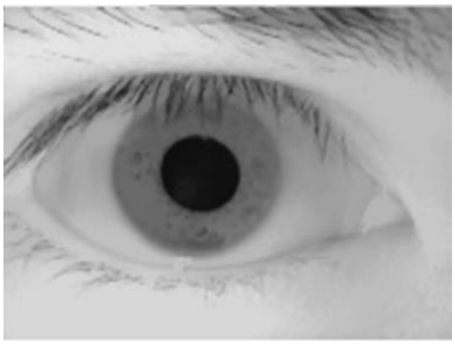
3.1 Filtering

The purpose of filtering is to remove noise from the image. Therefore in this proposed system the image is filtered using the image processing filter function in the Matlab [12]. The function is 'filter2' will perform 2D finite impulse response (FIR) filter. Figure 3 shows the different between the original image in (a) and the output of the 2D filter FIR in (b). More detail of the images in Figure 3 are zoomed out by Figure 4. In Figure 3 (a), is the original image taken from (MMU 2005 database. This database contains 46 folders, where in each folder include two sub folder for left and right eye. The sub folder contains five samples of eyes with size of 320 x 240 pixels; the type of image is BMP file. In Figure 3 (b), is the image that has been filtered, in which there are significant differences in terms of texture images that are smoother than ever before. While the image of Figure 3 (c) is the result of removing illumination. Refraction of light contained in the original image was successfully removed. The aim is to avoid localization and segmentation of mistakes by detecting pixel dots of light as the pupil edges. Fig. 4 is to give an overview of refraction of light on the pupil area. Figure 4 (a) is an original pupil before pre-processing. While Figure 4 (a) is the pupil after the filtering process and lastly is refracted light on the circumstances of the pupil has been removed (Figure 4 (c)).

(a)

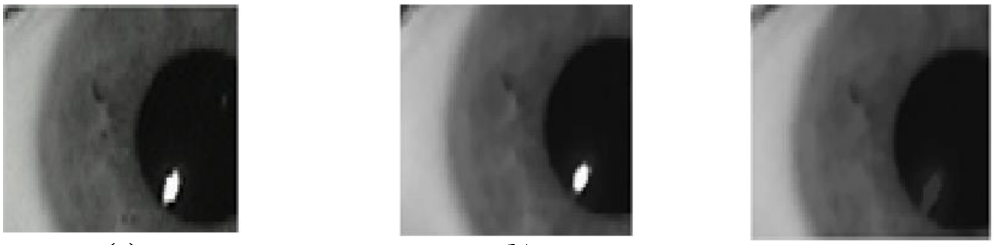


(b)



(c)

Figure 3. Image from MMU1[11] (a) original image (b) image filtering (c) image after illumination removing



(a) (b) (c)

Figure 4. Image zooming from Figure 2 (a) original image (b) image filtering (c) image after illumination removing

3.2 Illumination removal

Illumination effect can reduce the quality of segmentation if not be eliminated in the early process of segmentation. Therefore, in this proposed system, the illumination effect is removed using the Matlab function, namely 'incomplement' in the binary image. Where, this function makes all the zero's value converted to ones, and all one's values will become zeros; white and black are reversed. As a matter of fact, the illumination consists of bright pixel, which assuming around 240 to 255.

3.3 Logarithmic transformation

Logarithmic transformation (LT) is used to reduce the contrast of the brighter regions. Elements such as the eyebrow, sclera and part of eyelid texture are removed. However the eyelash is normally still existed. The LT basically operates using logarithmic function as stated in (1), where ***r*** representing the image processed, ***s*** representing as the output and ***c*** is the constant value. The equation of LT is given as:

$$s = c\log(1 + r) \tag{1}$$

3.4 Power law Transformation

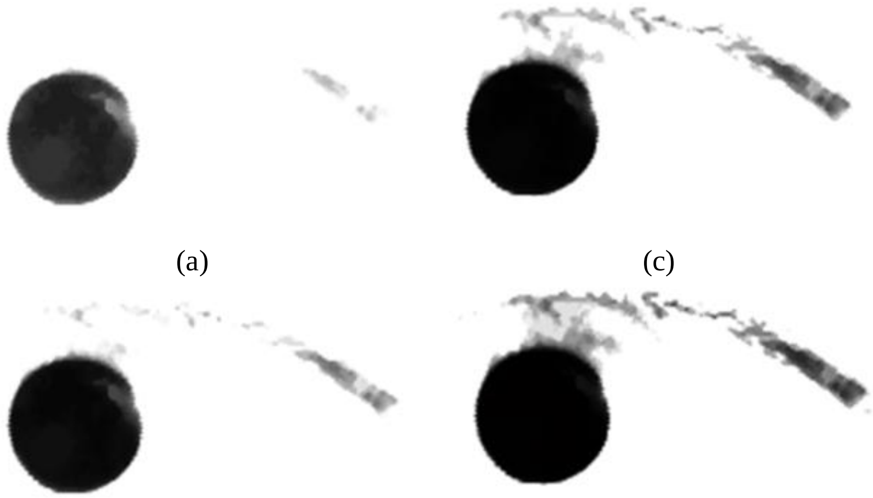
Power-law transformations (PLT) have the basic form as in equation (2), below:

$$s = cr^{\gamma} \tag{2}$$

Where, ***s*** is the output image given by manipulation of ***c*** and ***γ*** where both are positive constants. Basically PLT enhancing contrast of brighter regions of the image. By increasing the value of gamma the image become darker and oppositely the lesser value of gamma the image become brighter, (as shown in Figure 5).

3.5 Morphology

Morphology was originally used for binary images and later prolonged to grayscale images. For this proposed system we use basic morphological operations such as dilation and erosion. Basically dilation is the process adding pixels to the images boundaries while the erosion act opposite to dilation by removing the pixels from the images boundaries. Thus we use erosion operator to remove the eyebrow from the black and white (BW) images.



(a) (c)

(b) (d)

Figure 5. Image of pupil using PLT enhancement, starting from the top left clock-wise (a) γ**=2**, (b) γ**=3**, (c) γ**=4** and (d) γ**=5**

3.6 Removal object

The image black and white (BW) also known as binary image, where each pixel is represented by the value either zeros or ones. The value zero will represent black pixels whereas value one represent as white pixels. In this work we use the operation of BW to eliminate the small object or pixel according to number of pixel fixed in algorithm. For removing the unwanted pixel the 'bwareaopen' operation by Matlab is used. This operation will cause all connected components (objects) which values are less than setting pixels will be removed.

3.7 Segmentation.

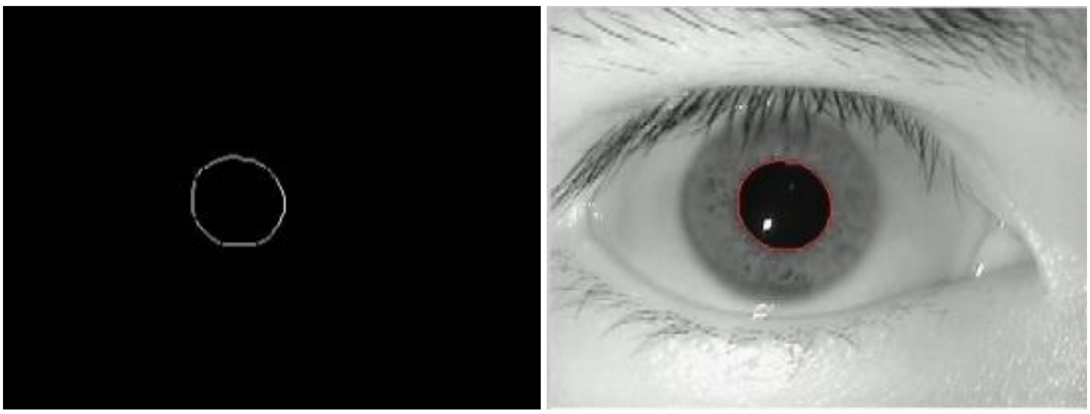
The remaining BW pixel will be segmented as a mask. This mask later will be attached to original image to remove the non-interested area from the original image.

(a) (b)

Figure 6. Image output (a) Logarithm operator image, (b) power law transform (PLT) output

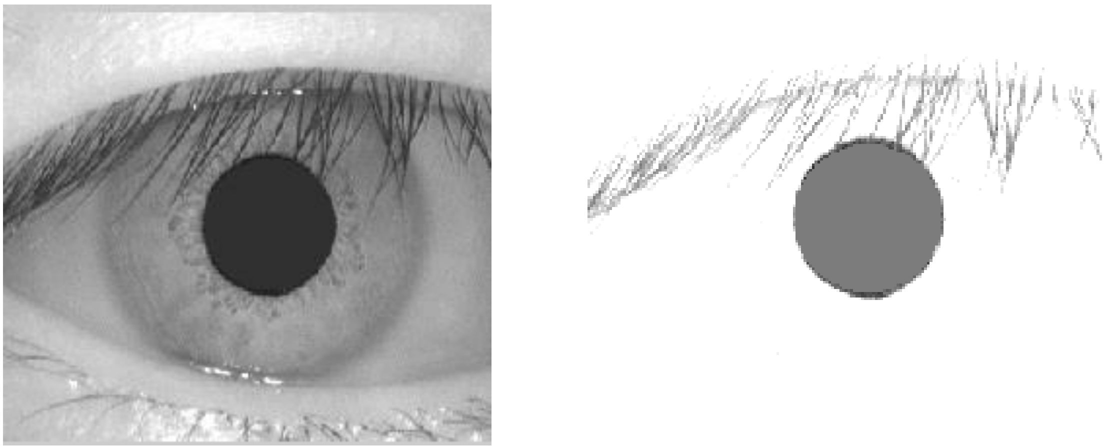
(a) (b)

Figure 7. Image output (a) black and white image (b) morphology output image



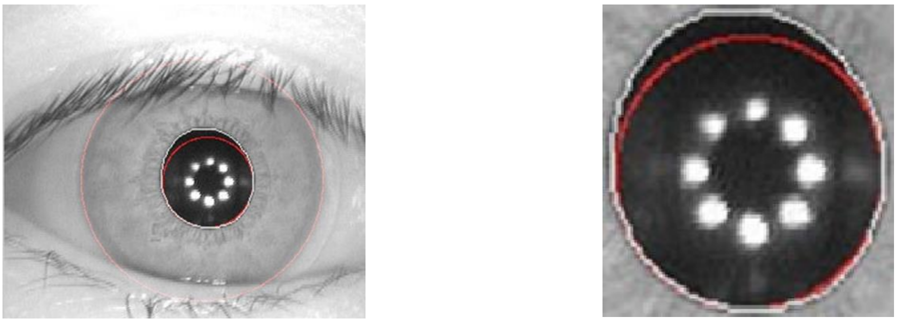
(a) (b)

Figure 8. Image output (a) outline morphology image (b) pupil segmentation



(a) (b)

Figure 9. Image (a) original image (b) Logarithm operator output



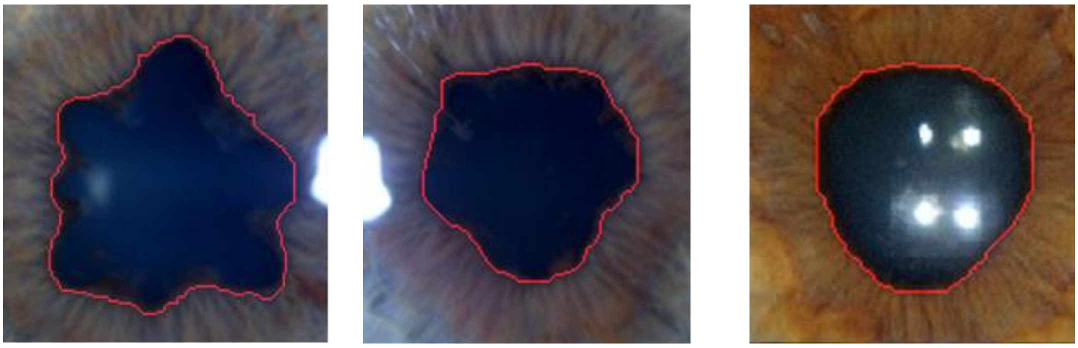
(a) (b)

Figure 10. Image (a) Comparison of segmentation method using Anirudh's algorithm [13] and our proposed algorithm (b) Zooming of segmentation pupil area; red outline using Anirudh's algorithm and white outline using proposed algorithm.

4. Result and Discussion

Experiments carried out in this project used CASIA and MMU iris image database and for synechia eye the images taken from online website iritis with synechia. In Figure 10, the segmentation result of the pupil is shown based on the proposed algorithm and the algorithm by [13]. The red outline is the segmentation result [13], while the white outline segmentation is the suggested algorithm. It demonstrated that our proposed algorithm able to segment fully, the region of the pupil. However, the algorithm by [13] failed to do so, because their method based on the circular segmentation.

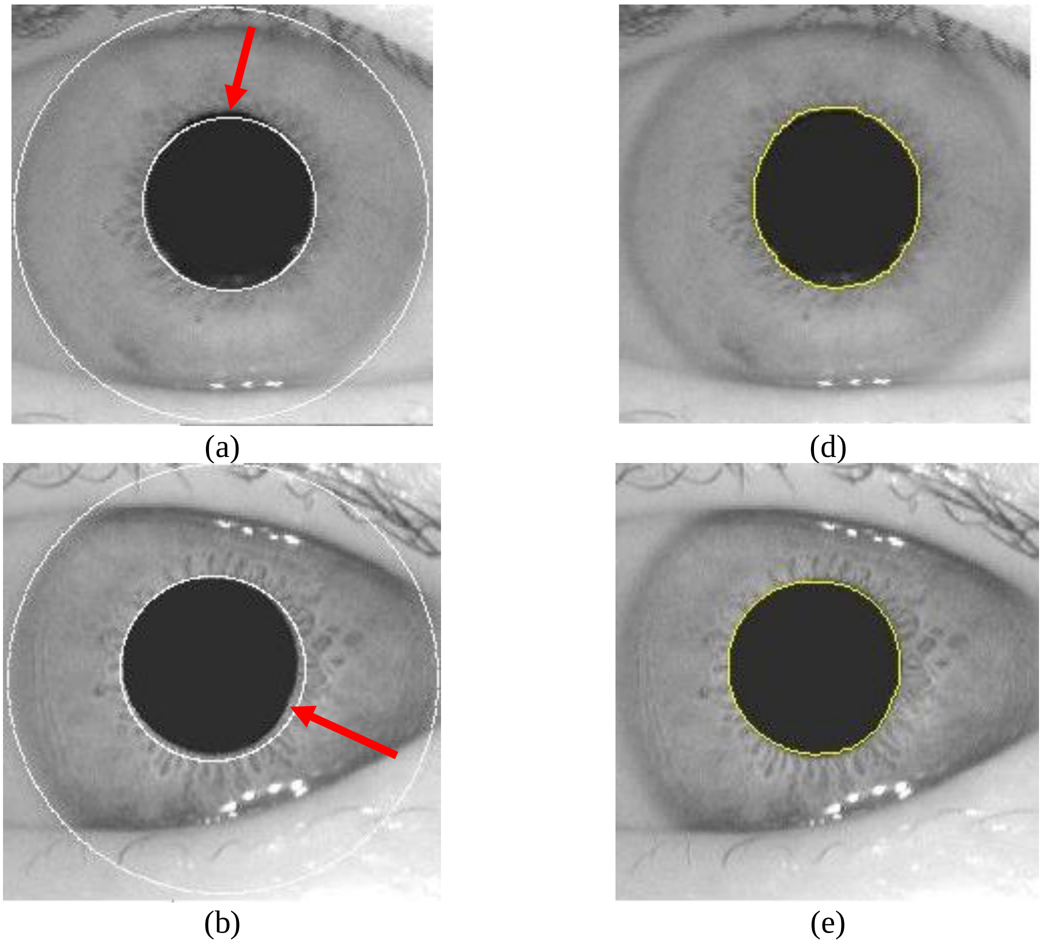
In Figure 11, demonstrated some form of segmentation of abnormal pupil who has succeeded in segmenting correctly according to the shape of the pupil. Figure 11 (a) and (b), is a condition known as a synechia pupil. A synechia is a condition where the iris structure attached to the adjacent openings causes the pupil to be abnormal. Meanwhile, the Figure 11 (c) is the condition of the pupil which is a non-symmetrical shape.

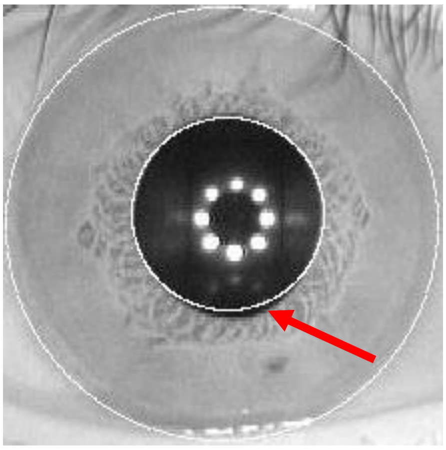


(a) star s synechia (b) synechia (c) non-symmetrical pupil

Figure 11. Images show several shape of non-circular pupil are segmented successfully using proposed segmentation system.

Figure 12 is the segmentation using CHT method and our proposed algorithm. It has obviously seen that using the CHT technique, the area covered by this technique fails to segment properly the region of the pupil as shown by figure (a) to (c). This failure occurs in two situations; whether segmentation exceeded the ROI or segmentation obtained is not the proper covering of the pupil area. Meantime the proposed algorithm successfully segmenting the pupil region correctly such as in the picture (d) to (e).




(c)

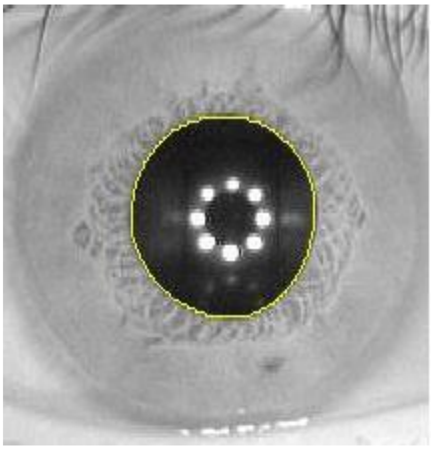

(f)

Figure 12. The experiment results, figures (a), (b), and (c) using the CHT method for segmentation the pupil region, while figures (e), (f), and (g) using the proposed algorithm.

5. Conclusions

Segmentation is one of the primary operations in image processing. The accurate segmentation is important, especially in the iris recognition system in order to reduce mistakes of selection the ROI. In this paper, we propose an exact segmentation system for non-circular pupil (NCP). The NCP normally occurs in the abnormal eye, such as the synechia. To do segmentation process for synechia condition, we use the combination of LT and PLT to get the apparent area, of the pupil region. For synechia condition, the segmentation based on a circle equation is won't work accurately. There is also an eye condition that is not in the circumstances, such as synechia, but has a shape of pupil that is not symmetrical rounded. This will lead to the segmentation using the CHT or DIDO not managed to get the exact section. From the experiments conducted using the proposed algorithm, can produce a more accurate segmentation quality.

In future, we consider doing segmentation based on the other cases of eye diseases such the pterygium, since these diseases related to the part of the pupil, hence our method seen suitable for that matter.

Acknowledgment

The authors would like to thank Universiti Putra Malaysia (UPM) and Universiti Teknikal Malaysia melaka (UTeM) for the support and guidance. The authors would also like to acknowledge the Malaysia of Higher Education (MOHE) for funding this project.

References

[1] J. Daugman 2004 *IEEE Trans. Circuits Syst. Video Technol* **14** 21–30
[2] R. O. Duda and P. E. Hart 1972 *Commun. ACM* **15** 11–15
[3] M. Poe, 2014 [Online]. Available: http://www.ophthalmicphotography.info/website/slit lamp/iritis.html
[4] M. A. M. Abdullah, S. S. Dlay, and W. L. Woo," 2014
[5] M. Abdullah 2014 *Int. J. Inf. Electron. Eng.* **4**
[6] A. a. Jarjes, K. Wang, and G. J. Mohammed 2010 *2010 2nd Int. Asia Conf. Informatics Control. Autom. Robot.* **1** 349–352
[7] L. V. Romaguera, F. P. Romero, C. R. V. Seisdedos, and J. E. Neto 2015 *In VI Latin American Congress on Biomedical Engineering CLAIB 2014, Paraná, Argentina 29, 30 & 31 October 2014* **49** 429–432

[8] A. De Santis and D. Iacoviello 2006 *Comput. Methods Programs Biomed.* **84**, 174–187
[9] H. Mehrabian and P. Hashemi-Tari 2007 *Conf. Image*, no. December 77–82
[10] CASIA, 2003, http://www.sinobiometrics.com.
[11] MMU, 2005, http://pesona.mmu.edu.my/~ccteo/.
[12] MATLAB, 1994, http://www.mathworks.com/products/matlab/.
[13] Anirudh Sivaraman, 2007, http://www.mathworks.com/matlabcentral/fileexchange/15652-iris-segmentation-using-daugman-s-integrodifferential operator/content/Integrodifferential_operator.zip.