International Journal of Engineering & Technology, 7 (4.31) (2018) 34-39

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

An Efficient Iris Image Thresholding based on Binarization Threshold in Black Hole Search Method

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Abstract

In iris recognition system, the segmentation stage is one of the most important stages where the iris is located and then further segmented into outer and lower boundary of iris region. Several algorithms have been proposed in order to segment the outer and lower boundary of the iris region. The aim of this research is to identify the suitable threshold value in order to locate the outer and lower boundaries using Black Hole Search Method. We chose these methods because of the ineffient features of the other methods in image indetification and verifications. The experiment was conducted using three data set; UBIRIS, CASIA and MMU because of their superiority over others. Given that different iris databases have different file formats and quality, the images used for this work are jpeg and bmp. Based on the experimentation, most suitable threshold values for identification of iris aboundaries for different iris databases have been identified. It is therefore compared with the other methods used by other researchers and found out that the values of 0.3, 0.4 and 0.1 for database UBIRIS, CASIA and MMU respectively are more accurate and comprehensive. The study concludes that threshold values vary depending on the database.

Keywords: *Iri;, Image processing; Black Hole Search Method; Segmentation.*

1. Introduction

As technology growing from time to time towards a higher level in human mankind, security systems also take place in leading as the technology. Security systems play an important role to identifier the right user for access certain information. The verifier can be identified by what they know such as password, by what they own such as passport or by who the person is such as biometrics. Biometrics is one of the high-level security systems because it recognizes a person based on their physiological and behavioral characteristics such as face, palm, fingerprints, hand geometry and iris [3].
Iris patterns are suitable for high level security system as it is widely applied in both public and personal security areas. Iris is an annular ring that is between the pupil and the sclera of the eye [3]. Given that the iris of each eye is completely different from the other eye, users can be easily authenticated and differentiate between another user [4]. The flowery pattern of iris is unique for everyone and the patterns are not related to genetics. Both right and left iris are distinct to each other even between identical twins, their irises are not the same [5]. Besides, iris is stable throughout life and iris patterns do not change with age, which makes it unique and can be used for a long time.
Iris recognition system is made up of four stages; image acquisition, preprocessing which include (segmentation and normalization), feature extraction and matching. The verification process will have to go through these stages before the verifier can access the system. The segmentation is the first stage isolates and detects the actual iris region from eyelids and eyelashes in a digital eye image. Segmentation is critical to the success of an iris recognition system, since the data that is falsely represented as iris pattern data will corrupt the biometrics templates generated, resulting in poor recognition rates [7].
Teo and Ewe proposed the Black Hole Search Method to compute the center and area of pupil. This approach applies threshold to find the dark region in the iris images [10]. Given that pupil is the darkest areas in the eye images, binarization threshold is applied to convert grayscale image to binary images so that dark region can be detected. This binary image contains only two classes of pixels which white as the background and black as the foreground [11].
Binarization is an image processing technique that converts the gray scale image to binary image contains only black and white image [12]. The two classes of pixel are obtained from separating of intensity value called threshold [11]. Thresholding is one of the methods for to separating foreground from the background. Thresholding is used to create binary images from gray scale image and its requires threshold value as a parameter [13]. There are two categories of thresholding: global thresholding and local thresholding. For global thresholding, the value is set for the whole image while local thresholding applies different threshold value to different regions of the image [14]. The thresholding is a transformation of an input image to the output binary image *g* as represented by the next formula, where *g(x, y)* is a threshold version of *f (x, y)* at some global threshold t:

$$g(x,y) = \begin{cases} 1 & if\ f(x,y) >= T \\ 0 & otherwise \end{cases} \tag{1}$$

However, previous methods used in iris recognition and segmentation were found ineffective based on the research of [10], they reaffirmed that used of methods other than black hole search methods would definitely give some inefficient findings.
Therefore, the objective of this research paper is to employs an efficient iris image segmentation thresholding based on binarization threshold in black hole search method.
This paper is further divided into three sections. The first section provides the introduction of the subject area. The second section discusses some related works in area of iris recognition. The third section discusses the methodology of this paper. And lastly the forth section provides the analysis and concluding remarks of the paper.

2. Related Work

This chapter discusses some related works in iris recognition, which involves the states and processes involved in image processing. Image processing is processing of an image by using formula or algorithm from certain technique for which the input is the image itself and the output is something that related to the image like the value or coordinate of the image processed. The properties of chosen method and data set used is also discussed in this section.

2.1 Image Processing

Image processing is a process to acquire an area of image containing certain value or text, preprocessing the image then segmenting, describing and recognizing the individual characters obtain from the image processed [15]. Image processing is a technique use to enhance raw image. In image processing, there is color image processing that divided into two major areas: full color and pseudo color processing.

2.1.1 Color Model

A color model is a way to simply define color as accurately as possible and it is can defined by combinations of three basic color that known as primary colors. According to [15] there are several color models like CMYK (cyan, magenta, yellow, black) model, the CMY (cyan, magenta, yellow) model, RGB (red, green, blue) color model, and HIS (hue, saturation, intensity) model. But in this chapter, only RGB color model will be discuss further.

2.1.2 RGB Color Model

RGB color model is a combination of three primary color which are red, blue and green in a various way to produce a composite color image. Based on Figure 1 the RGB color model is shown as a Cartesian cube with the three primary values are at the corner with red being the x axis, green as y axis and blue as z axis. Black is at the beginning and white is at the corner farthest from beginning. Grayscale is located at the line joining black and white points.
The broad array of color in this model is points in the inside of the Cartesian cube. The RGB color model is also defined as full color image because when combined the number of bits used to represent in each pixel of the RGB space, the total is 24-bit because each image of red, green and blue is 8 bits. The bits for the image can represent as follows: (R, G, B) = (8 bits, 8 bits, 8 bits).

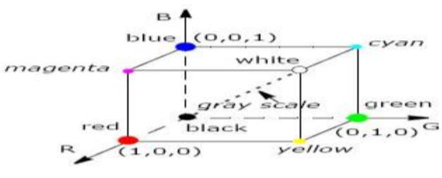

Fig. 1: RGB color cube

2.1.3 Gray Scale

Gray scale image that also called as pseudo color image processing is an image that only carries a simple range value that is 0 for black and 1 for white. Grayscale image that known as black and white image are composed only shades of gray that varying from the weakest intensity black to white at the strongest intensity.

2.2 Image Compression

Image compression is a process to reduce size of data from original image to a few bits, but the necessary information is still retained in it so that image can be transmit or store in efficient form [16]. The aim of this process is to enhance the storage quantity and space as much as possible, and so that the displayed compressed image can be functioning as much as the original image [17].
There are two classes of image compression techniques and that is lossless and lossy image compression [17]. Lossless image compression is used to pack pictures in basic claims as it permits the correct unique picture to be reproduced from the compacted one without any loss of the picture information. Lossy image compression, on the other hands, experiences on the loss of a few information. Thus, more than once compressing and decompressing a picture that brings about low quality of picture [17].

2.2.1 Image Compression Model

Image compression system contains an encoder that performs compression and decoder that perform complementary operations of decompression [15].

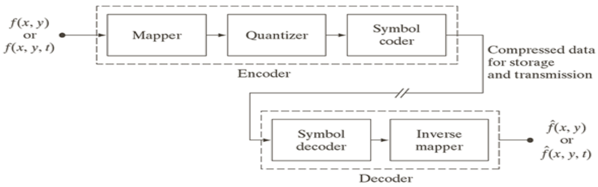

Fig. 2: Functional block diagram of a general image compression system [15].

The digram above clearly shows how the viables relates to each other to make image compression functional. Its shows Mapper as the first variable followed by Quantizer and then Symbol coder. These are used in compressing data for storage and transmission and they are called Encoder Variables. On the other hand, Symbol decoder and Inverse mapper serves as Decoder variables.

2.2.2 Image File Format and Compression Format

Image file format is an institutionalized method for arranging and putting away computerized pictures. Image file format like JPEG (Joint Photographic Experts Group), BMP (bitmap) and PNG (Portable Network Graphic) may store information in uncompressed, compacted, or vector positions.
In this paper, iris image in both JPEG and BMP will be used. JPEG file format is a lossy compression method while BMP file format are uncompressed, and therefore large and lossless. BMP file format have advantage because of their simple structure and wide acknowledgement in Windows programs.

2.3 Segmentation

2.3.1 Image Segmentation

Image segmentation is the process of separating an image into regions [18]. The objective of segmentation is to streamline as well as change the representation of an image into something that is more important and less demanding to examine. Image segmentation is typically used to locate objects and boundaries in images.

2.3.2 Iris Segmentation

Iris is the region between the pupil and the sclera of the eye [7]. Iris segmentation is a form of process to segment the focus region which is the iris region. Segmentation in iris image means that the actual iris region is being isolated from eyelids and eyelashes in digital eye image. Thus, the outer and inner boundary of iris region will also be detected to locate the real iris region. Figure 3 shows each region of eye is being labelled to clearly show the region of iris.

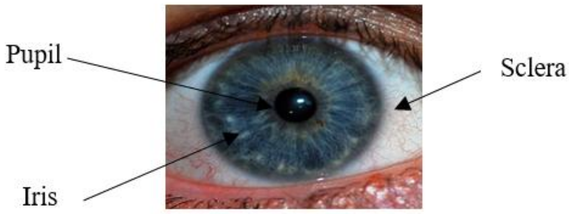

Fig. 3: The image of an eye

There are many methods of iris segment the iris region. The most popular method are Daugman's Integro-Differential Operator and Hough Transform. Both methods are widely use in biometrics system because of their higher accuracy in segmentation of iris regions. Other methods such as Discrete Circular Active Contour, Bisection Method and Black Hole Search Method can also be used for iris segmentation. However this paper will only focus on Black Hole Search Method.

2.4 UBIRIS

UBIRIS is a public and free tool used for iris recognition algorithms for biometrics purposes. This tool function as a database for global iris image. UBIRIS provides image with different type of noise since this type of use is much less invasive and will enable the spreading of iris recognition systems to dialy applications [19].
There are two versions of UBIRIS database which is version 1 and the latest version is UBIRIS version 2. The first version of UBIRIS database holds 1877 images collected from 241 eyes during September, 2004. The version two of the UBIRIS database has over 11 000 images and this number of images continuously growing and added with more realistic noise factors.

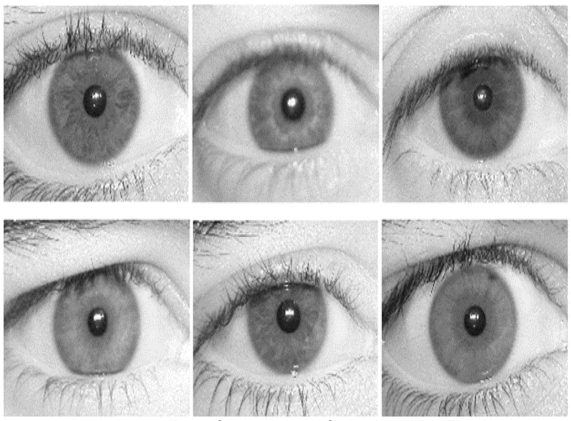

Fig. 4: Examples of iris images from UBIRIS database

Figure 4 shows the example of iris image exctracted using UBIRIS database. Its clearly shows how datas are in UBIRIS and how they helped in iris image recognition.

2.5 The Chinese Academy of Sciences – Institute of Automation (CASIA)

CASIA Iris Image Database (CASIA-Iris) introduced by an international research group of biometrics community. And this group has been updated from the version CASIA-IrisV1 to version CASIA-IrisV4. CASIA -Iris has proved that its data set give more excellent result in iris recognition and it is proved with more than 3,000 of users all over the world have been downloaded CASIA-Iris [21]. Besides, images in the CASIA iris database do not contain specular reflections due to the use of near infra-red light for illumination [7].

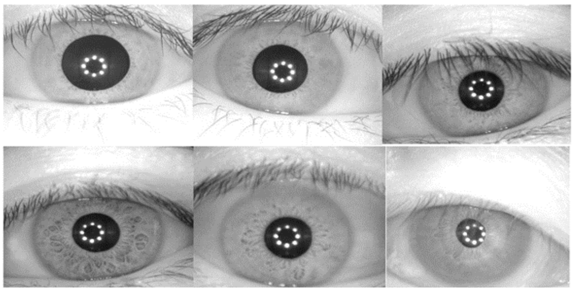

Fig. 5: Examples of iris images from CASIA database

Figure 5 shows an example of iris image from CASIA database. Its shows six different iris images with different iris recognition in the same data base.

2.6 Multimedia University (MMU)

Multimedia University (MMU) iris database, contributing a total of 450 image, five images per iris, two irises per subject. All images were obtain using the LG IrisAccess 2200 at a range of 7-25 centimeters. This iris database has a low resolution that become the largest drawback when using this data set [21].

Fig. 6: Examples of iris images from MMU database

The figure 6 above shows an example of iris image from MMU database. The figure shows six different iris images with different iris recognition in the same database.

2.7 Black Hole Search Method

Black hole search technique is used to compute the midpoint and area of the pupil [2]. Threshold is applied in this technique to find the iris region since the pupil is the darkest region in the eye image. The dark areas are called "black holes". The midpoint of mass of these black holes is calculated from the global image in database.
The area of pupil is the complete of black holes within the region. Meanwhile, the radius of the pupil can be solve using the circle area formula. Black hole search technique would detect the dark iris area instead of the area of pupil if the iris image has dark iris and this method is not suitable when it comes to this circumstance [1].
The black hole search technique is used to reduce down the calculated cost, to lower the region of edge detection and also lower the

search area by Hough Transform. Binarization is used in this technique. Binarization of input gray-level image method is simple but it is not enough since its accuracy is dependent on the system of binarization threshold. It is difficult to established a proper threshold suitable for different image categories even by using adaptive threshold method [20].

Black hole algorithm (black hole) begins with an initial amount of a sample solutions to an optimization problem and the objective function for the sample solution is asume. At each iteration stage of the Black Hole, the best sample is selected to be the black hole and the rest form the normal stars. After the initialization process, the black hole starts pulling stars around it. If a star goes too close to the black hole it will be consumed by the black hole and that star will be gone. In such a case, a new star (sample solution) is randomly generated and placed in the search space and starts a new search.

Therefore, the black hole is used in this research because its reduce down the calculated cost, to lower the region of edge detection and lower the search space by Hough Transform. Binarization is used in this technique.

3. Methodology

This chapter discusses about the framework implemented to carry out this project. Throughout this project, software and hardware that being used is being explained with their detail is stated.

3.1 Research Framework

3.1.1 Model Structure

The model presented in Figure 7 describes the method in which the experiment of this research will be conducted.

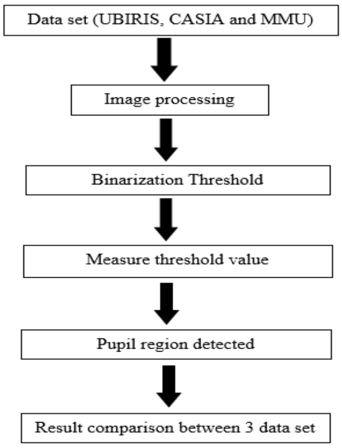

Fig. 7: The proposed framework

3.2 Implementation

3.2.1 Acquire Database

The database use is CASIA-Iris-Interval V3 which includes 2900 images and CASIA-Iris-Lamp which includes 8220 images, UBIRIS which includes 2435 images and MMU which includes 460 images. The iris image can be read from the stored database.

3.2.2 Image Processing

This process involves selecting an image from UBIRIS, CASIA and MMU database, and then pixel value of this image is extracted. This is a common process in image processing to know the raw data of the image. This process is run by using tool available in MatLab R2013a. Figure 8 shows that the iris image in bmp file format is being process using image tool in MatLab and Figure 9 shows the pixel value of the image in RGB form.

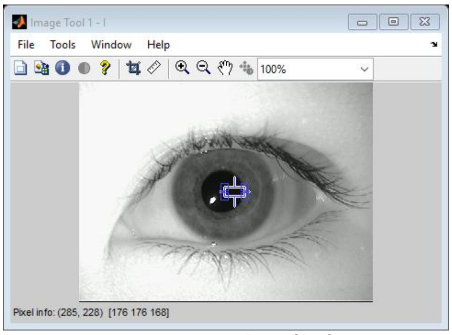

Fig. 8: Iris image in bmp file format

Fig. 9: The pixel value of iris image

3.2.3 Apply Binarization Threshold

Binarization threshold is then applied to get the pupil region and at the same time to detect dark areas in iris image. Threshold value is set differently based on the types of the images. Images with high quality have lowest threshold value. This process is carried out continuously by trial an error to gain accurate threshold value so that the region of pupil can be detected.

3.2.4 Final Result

The resulting images with proper detected pupil region will be record and the threshold value also will be taken so that comparison can be made between the three data set. The poor, average and good threshold value will be decided after several images in the three databases have been threshold

3.2.5 Experiment Requirement

The experiment was carried out using some software and hardware to make it possible to accomplish the objective of this study. Table 1 listed the software and hardware requirement for the development of the proposed project.

Table1: Software and hardware requirement.

Software requirement	Hardware requirement
• MATLAB (2013) • Window 10 Single Language x64-bit operating system • Paint	• 4GB RAM • Intel® Core ™ i3-5005U processor • Mouse and Keyboard

4. Analysis and Discussion

In this study, result is obtained by inserting threshold value for the images and comparing the result for every image. Threshold value can be set to 0.9, but in the research the threshold value is set only until 0.5. At 0.5, the result for detecting pupil region is poor and more area other than pupil is detected. Hence, if the threshold value is set higher than 0.5, the result obtain will be so poor.

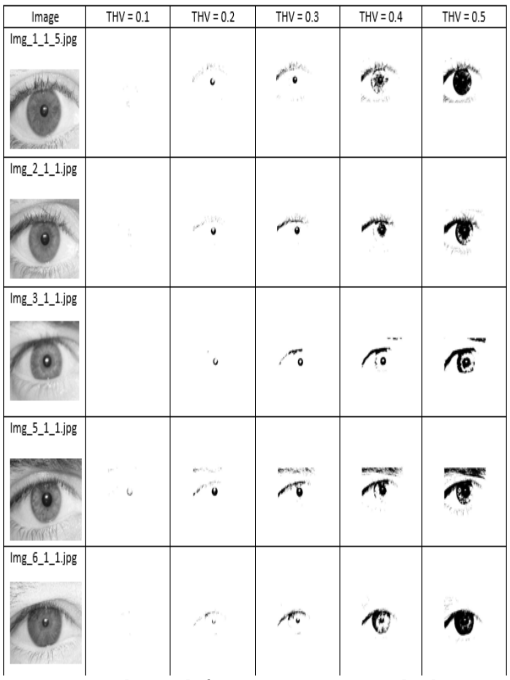

Fig. 10: The result for images in UBIRIS database

The above figure 10 shows the result of images in UBIRIS database, the figure shows five different images with five different threshold values from (0.1 to 0.5). Its clearly shows that at 0.1 the result is good while at 0.5 it's poor. This indicate that if the threshold is increase there is a probability of increase in iris recognition.

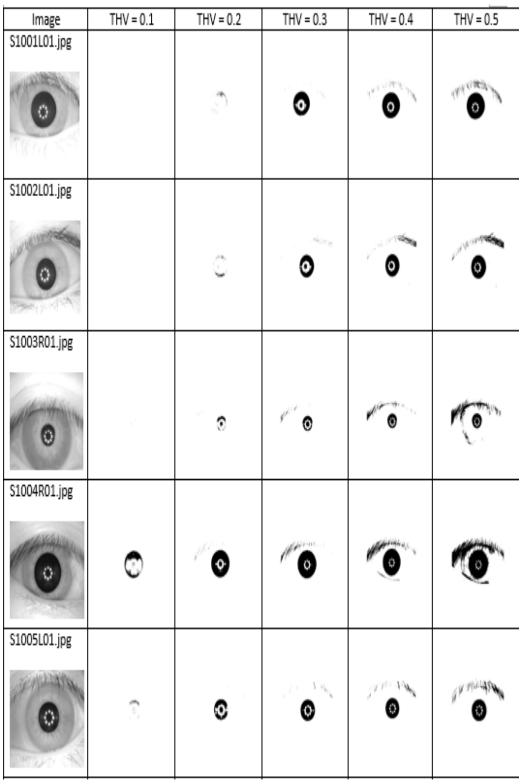

Fig. 11: The result for images in CASIA-Iris-Interval database

The above figure 11 shows the result of imges in CASIA-Iris-Interval database, the figure shows five different images with five different treshold value from (0.1 to 0.5). Its clearly shows that at 0.1 the result is good while at 0.5 it's poor. This indicate that if the threshold is increase there is a probability of increase in iris recognition process.

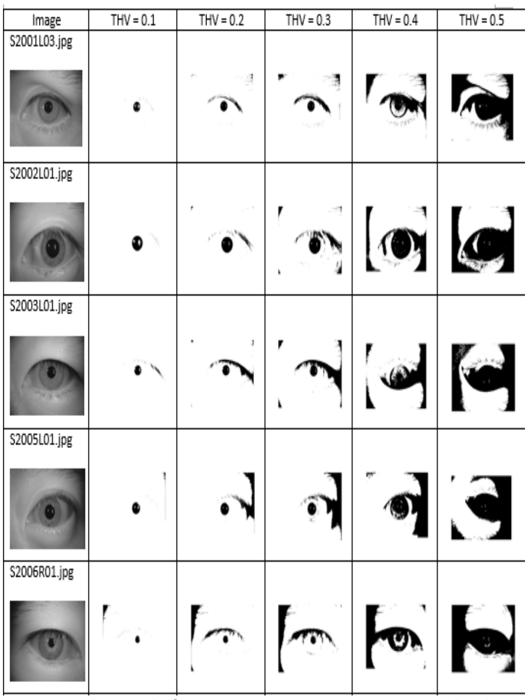

Fig. 12: The result for images in CASIA-Iris-Lamp database

The above figure 12 shows the result of images in CASIA-Iris-Lamp database, the figure shows five different images with five different threshold values from (0.1 to 0.5). Its clearly shows that at 0.1 the result is good while at 0.5 it's poor. This indicate that if the threshold is increase there is a probability of increase in iris recognition process.

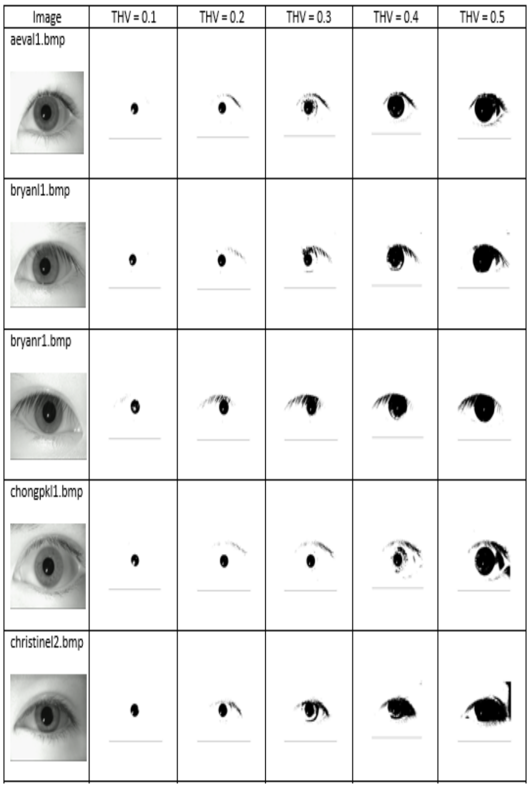

Fig. 13: The result for images in MMU database

The above figure 13 shows the result of imges in MMU database, the figure shows five different images with five different tresholf value from (0.1 to 0.5). Its clearly shows that at 0.1 the result is poor while at 0.5 it's very good. This indicate that if the threshold is increase there is a probability of increase in iris recognition process.

Table 2: The final result

Database	Poor threshold value	Average threshold value	Good threshold value
UBIRIS	0.1 , 0.4, 0.5, 0.6, 0.7, 0.8, 0.9	0.2	0.3
CASIA-Iris-Interval	0.1, 0.2, 0.5, 0.6, 0.7, 0.8, 0.9	0.3	0.4
CASIA-Iris-Lamp	0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9	0.2	0.1
MMU	0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9	0.2	0.1

Based on the experimentation, most suitable threshold values for identification of iris boundaries for different iris databases have been identified. Values of 0.3, 0.4 and 0.1 for database UBIRIS, CASIA and MMU respectively. It can be observed from Tables 4, 5 and 6 that threshold value greater than 0.5 results to poor detection of pupil region.

5. Conclusion

Binarization threshold is a simplest technique to segmented image since it converts the original image to binary image and this makes the implementation process for searching dark areas easier and faster.
Experimental result shows that every data set have a different most suitable threshold value. CASIA-Iris-lamp and MMU have the lowest threshold value because the images in this both database is high in quality. Hence why, the threshold value is lowest than the other database.

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