# Iris Image Normalization Method to Pupil Detection with Intensity Transformation

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***Abstract*—Iris image taken by infrared camera is often applied to security system, and it is called an iris recognation system. On the iris identification system, iris detection is a crucial factor to determine the iris localization. So, if the pupil detection fallacy occurs it can be said that the iris localization is wrong. Every iris image from the acquisition of infrared camera has a different variation of contrast, illumination, and noise so the image normalization stage is need to be done. This research aims to propose the normalization method to detect pupil by changing the image intensity to the new intensity so that the image contrast can be stretched. Therefore, the pupil area is dark and other area is bright. This normalization also aims to maximize the image illumination so that the contrast between dark and bright on the image after contrast stretching can be seen clearer. The method used to this normalization are contrast stretching and gamma which the value gained from the maximize limit of contrast stretching. A very irritating image noise in the pupil detection process is reflection which comes from either inside or outside the pupil area. This noise can be deleted by the closing morphology operation. Then, the result of normalization image is become as an input image to pupil detection with Circular Hough Transform. The result of this experiment from 150 dataset images taken randomly from Biometric Ideal Test 4.0 version using the proposing method shows that an optimal pupil detection accuracy is 99,33%. Therefore, the pupil detection with the proposed method is suitable to be applied to iris recognition system.**

**Keywords.** pupil detection, iris normalization method, intensity transformation, circular hough transform.

## I. Introduction

A trusted security system has been a necessity for both public and government to run many activities such as a security in accessing computer, a security in banking transaction, a security in identifying citizen and a security in entering one country[2]. Nowadays the biometric system has been developed to answer a challenge in security issues. The Biometric System works in the way the system is recognizing unique physical features of someone. These features include facial pattern, palm, finger print and iris. Iris recognation is hard to be reconstructed and it needs some times to do because the iris pattern is difficult and complex. In order to clarify the iris pattern so that it can be seen clearly, an infrared camera is needed to acquire the iris image. It is difficult to define the iris localization on the image which comes from the infrared camera acquisition.

In previous study, Kumar et al and Wang et al has described that to define the iris localization easily, the pupil detection is need to be done prior. Consequently, the pupil detection becomes a crucial factor inasmuch inaccuracy in pupil detection results incorrectness of the iris localization[13][20]. In their research, to detect the pupil on the public dataset CASIA-Iris V3 and V4, Kumar et al has been proposing edge-map generation to take a feature extraction that is pupil outline, after that the pupil detection is done by using CHT (Circular Hough Transform) algorithm. The result of this experiment shows 99.10% of accuracy value[13].

Satriya et al also conducts the pupil detection research in eye tracking system. The masking technique is used to lessen the noise so that the pupil area extraction is easy to do with the ellips fitting using CHT algorithm[17]. The other ways that can be used to extract the pupil area is fixing the image quality by stretching the contrast image in order to see the color differentiation between pupil area and other areas of pupil more clearly. Various stretching contrast methods such as Contrast-limited adaptive, Histogram Equalization, Decorrelation Stretch and Contrast Stretching have been tested and its performance has been compared to PSNR (Peak Signal Noise Ratio) and MSE (Mean Squered Error). The higher the PSNR value and the lower MSE value the better the result of the stretching contrast image. The testing result shows that the best image from the stretching contrast method is the Contrast Stretching with the highest PSNR value 70.9049 and the lowest MSE value 0.0053. Contrast Stretching can work adaptively as long as the determining of the maximum and the minimum limits of the stretching adjusts the maximum and the minimum limit contrast of the image[19][16]. Besides contrast, image quality is affected also by the illumination. Image illumination can be fixed by the gamma correction. A research about the use of gamma value to fix the contrast image has been conducted by finding out the pixel mean on a gray scale image which is considered as an important factor in defining the gamma value. Local Gamma Adaptive uses the pixel mean on the gray scale local image resulting a sharpen image contrast and a better illumination image[15].

The focus of the research is the pupil detection by proposing the normalization method of iris image from the infrared camera acquisition which results the image having different contrast variation, illumination, and noise. The foundation of the normalization method is altering the image intensity to the new intensity in order to stretch the image contrast so that the pupil area can be darken and all area other than pupil can be brighten and then changing the image illumination uses gamma value based on maximize limit from image with Contrast Stretching method. As a result, a high contrast image is produced which is the dark pupil image in a bright area. In this case, it can optimize the work of CHT to detect the pupil circle because CHT is difficult to find the circle contour if the image has a low contrast. Noise is a light reflection which exists either inside or outside the pupil area and it can aggravate the pupil detection process so this noise should be erased. If it still exists, it can crate hole after the normalization process. Using the closing morphology operation, the hole can be covered by the pixels which have the same intensity as the neighbor pixels.

## II. Method

The image normalization method to detect pupil which is proposed is shown in fig. 1.

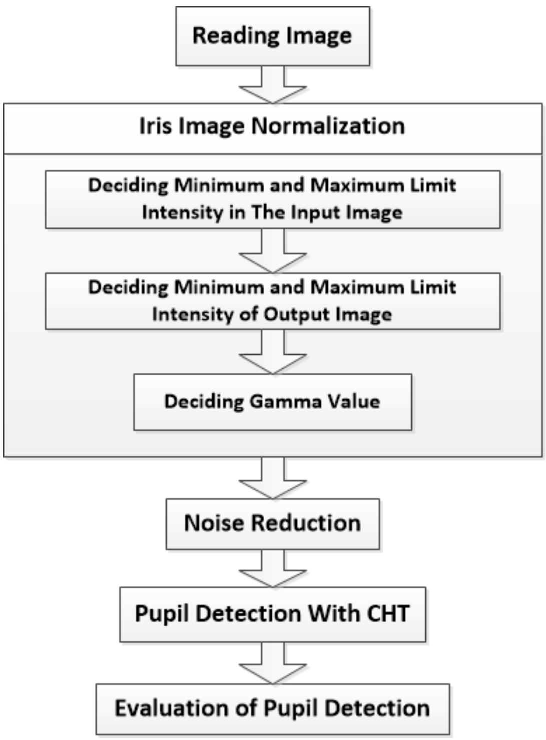



Fig. 1. Proposed Method

### A. Reading Image

As many as 150 images were taken randomly from public dataset of BIT (Biometric Ideal Test) version 4.0, this dataset image was acquired using infra red camera CASIA, OKI IRISPASS-h and IKEMB 100. It produced a grayscale image which has resolution 480x640 pixels and has intensity range between 0 and 225. It can be described that the closer the intensity to 0 the darker the color of the pixels, and the closer the intensity to 255 the whiter the color of the pixels. Otherwise, the color within the intensity between 0 and 225 is gray.

### B. Iris Image Normalization

Every dataset has different contrast, illumination, and noise, so normalization stage with intensity transformation is needed. The transformation intensity aims to alter the image intensity to the new intensity. The following formula 1 is used.

$$y = \left(\frac{i-a}{b-a}\right)^{\gamma} (d-c) + c \tag{1}$$

i is image intensity f(x), a is low in value, b is high in value, $\gamma$ is gamma value, c is low out value and d is high out value. The purpose of this normalization is producing dark color in pupil area and bright color in area other than pupil. Followings are the normalization steps.

*1) Deciding minimum and maximum limit intensity in the input image:* Intensity transformation is affected by low in and high in vector containing minimal and maximal intensity limit in the input image f(x). In this research, deciding low in value is obtained through testing the double type intensity value which is chosen randomly range from 0 to $<$high in value. it is tested with the intensity 0, 0.05, 0.071, 0.072, 0.073, 0.074, 0.075, 0.076, 0.077, 0.078, 0.079, 0.08 and 0.1. Meanwhile, to obtain high in value, intensity image mean f(x) is divided to 2 The formula showing how to decide the low in value is shown as follow [15]. Formula 2

$$highin = \frac{\frac{\sum f(x)}{n}}{2} \tag{2}$$

*2) Deciding minimum and maximum limit intensity of output image:* The result of intensity transformation is affected by determining the minimum and maximum limit intensity of output image. It is called low out and high out vector. Deciding low out and high out value is obtained through Contrast Stretching Method. The contrast stretching method is resulting minimal limit 1% from minimal intensity limit and maximum limit 99% from intensity maximum range from 0 to 1 with double type.

*3) Deciding gamma value:* The shape of intensity transformation curve is affected by gamma. Gamma value affects the illumination as a result it affects the color of the image, whether it is dark or bright. If the gamma = 1, then the intensity transformation is called linear transformation And, the image produced by this transformation is the same as the original image. If the gamma $<1$, the image is bright. Then, if the gamma $>1$, it is resulted dark image. The gamma value used in this research is the maximum intensity limit comes from Contrast Stretching method. The maximum limit in contrast stretching results $<1$ for sure.

### C. Noise Reduction

The light reflection in the pupil area can create hole circle. Consequently it can lessen the pupil detection accuracy through CHT. Therefore, covering the hole is needed by fulfilling the hole intensity with the pixels intensity which have the same intensity as the hole pixels had by its neighbor. Here are the stages.

*1) Converted to the binary image:* To extract only on the pupil area, an analysis in grayscale image normalization intensity is needed. The pixels intensity in the pupil area has intensity <75. On the other hand, the other area except the pupil have intensity >=75. With the result that, global thresholding is implemented to convert the image into the binary image using the formula 3.

$$g(x,y) = \begin{cases} 1 & f(x,y) \geq 75 \\ \\ 0 & f(x,y) < 75 \end{cases} \tag{3}$$

All of the pixels intensity which is <75 on the image f(x,y) is changed into color black in the image g(x,y). And, all of the pixels intensity which is >=75 on the image f(x,y) is changed into color white on the image g(x,y).

*2) Closing Operation:* After the image is converting to be the binary image, the hole which is seen in the pupil area can be covered by the closing operation using the formula 4.

$$A \bullet B = (A \oplus B) \ominus B \tag{4}$$

A is the image g(x,y), B is the element matrix. Closing operation is a combination of dilated operation A $\oplus$ B It means that A $\cup$ B and then the result is done with erosion operation $\cap$ B. The element matrix used in this research is disk matrix element. Disk matrix element creates a circle so it is assumed that it can covered the hole circle with the pixels from closing operation.

### *D. Pupil detection with CHT*

CHT is used ro detect pixels creating a curve. So, CHT can be used to extract the circle in the image. CHT formula is shown in number 5.

$$(x-m)^2 + (y-n)^2 - r^2 = 0 \tag{5}$$

The value m and n is a coordinate from the circle center on the 2 dimension point of x,y. And r is a radius from that circle. CHT has two parameters. They are the circle center and the radius or the radius of the circle.

### *E. Evaluation of Pupil Detection*

The evaluation of the pupil detection is measured by accuracy using the Matrix Confussion. The way it is measured is comparing all the images which is detected correctly to the sum of the whole dataset image. The formula is shown in number 6

$$Accuracy = \frac{TruePositive}{N}.100\% \tag{6}$$

True positive is the sum of the image detected only on the pupil and N is the sum of the whole data.

## III. Result and Discussion

The iris image dataset from BIT version 4.0 is acquired by the different distance, point of view and exposure. So that it is affected to the size of the pupil either big or small, the illumination, the contrast, and the position of the light reflection. It is shown in the pictures 2a and 2b.

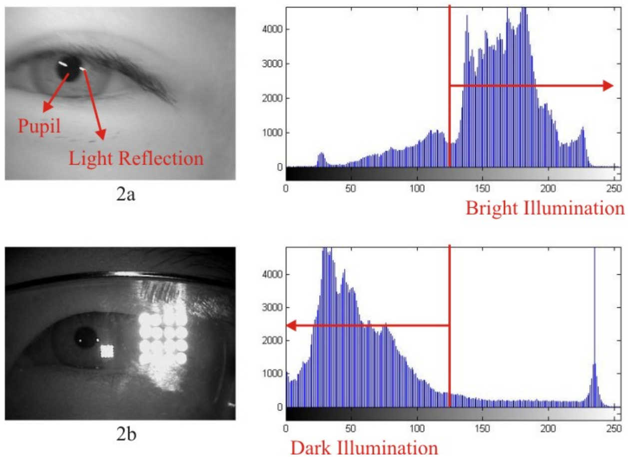



Fig. 2. Iris image

The real image illumination can be explained using the histogram in fig. 2a and 2b. The histogram curve in fig. 2a tends to approach 255 values that is white color so the illumination in fig. 2a tends to looks bright. Otherwise, the histogram curve in fig. 2b tends to approach 0 value that is dark color so the illumination in fig. 2b tends to dark. The illumination can affect the contrast of the image. If the image has a bright illumination, then the contrast image can be seen clearer. As shown in fig. 2a, the contrast between the pupil area and other pupil areas is shown clearly that the pupil area is darker if it is compared to other pupil areas. Otherwise, in fig. 2b it has a low contrast; the contrast image between pupil area and other pupil areas is almost the same that is tends to dark.

Based on the issue, image intensity needs to be transformed into new intensity using the proposed normalization method. The color stretching of dataset image is done because it makes the pupil area darker and other pupil areas brighter. So, the contrast of both areas can be seen clearer. According to the experiment result, defining low in value gives a considerable impact to the color stretching result so it affects the pupil detection accuracy shown at fig. 7. The highest accuracy is 99.33% with the low in value range from 0.07 to 0.074. This value is an ideal limit of minimum intensity to the entire image dataset which is transformed into low out. It can be seen on the fig. 3a and 3b below.

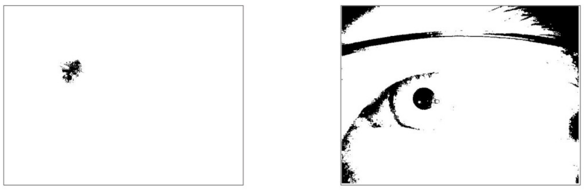

Fig. 3. Normalization Image

If the low in value is >0.074 then the pupil cannot be detected on the image which has dark illumination. The reason is because there are too many intensities whis transformed into the low out, consequently it creates noise that is the dark pixels which is located in the area other than pupil. And, if the low in value is <0.07 Then the pupil cannot be detected on the image which has bright illumination, because The intensity transformed to the low out is too small so the dark pixels in the pupil area is lessen. The low out value is obtained based on the minimum intensity limit from Contrast Stretching method which the intensity value is closer to or tend to 0, the pixels color is tend to dark.

The high out value is obtained based on the intensity maximum limit from Contrast stretching method which its value tends to close to 1 and its pixels color tends to bright. The purpose of the transformation, from high in to high out, is to sharpen the pupil area by illuminating the area other than pupil. If the high in < high out then the contrast can be stretching so it is resulted the bright image in the area other than pupil. It is shown in fig. 3a and 3b and if the high in >high out then it is resulted the dark image.

So as the illumination coming from the contrast stretching can be seen brightly, the gamma value <1 is used. The gamma value is obtained from the maximum intensity limit of Contrast Stretching which value is exactly <1. It can be seen in the fig. 3a and 3b.

Based on the observation in normalization pixels intensity, pixels in the pupil area f(x,y) is still having noise such as light reflection existed in the pupil area and it creates hole. To fix that problem, the image needs to be converted to the binary image first, as it is shown in fig. 4a and 4b.



4a 4b

Fig. 4. Conversition to the binary image

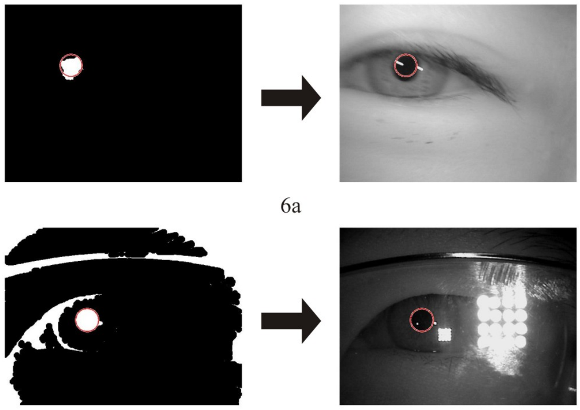
Then, The hole located in the pupil area as in fig. 4a and 4b is covered with the pixels as in pupil pixels from closing operation using 8 pixels diameter element disk. The hole closing with the disk element is only for the pixels having the intensity value 1 which is white. So, the image needs to be negated. The result is shown in fig. 5a and 5b.

From fig. 5a and 5b pupil detection is conducted by the CHT and the minimal radius parameter is decided = 23 pixels and the maximum radius is = 300 pixels. The curve sensitivity is 0.869. The result of pupil detection is shown in fig.6a and 6b. The accuracy of pupil detection in fig. 7 is supported by those parameters. If the minimal radius parameter is <23 pixels or the sensitivity value is >0.869 so the area other than pupil can be detected as the pupil. And if the sensitivity value is

5a 5b

Fig. 5. Convering hole with closing operation

<0.869 so the pupil cannot be detected on the binary image which has a few curve lines in the pupil area.



6a

6b

Fig. 6. Pupil detection with CHT

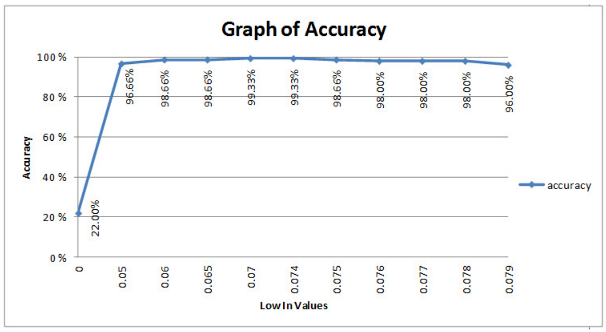



Fig. 7. Accuracy of pupil detection using proposed method

From the experiment result, in fact, the pupil can be detected using the method proposed by the writer even though the shape and the size of the pupil is different and the area around the pupil still has many noises such as hair, eye lashes, eyebrow and glasses frame. It happens because the establishment of some parameters precisely represents whole of the dataset. Based on the observation result, the fault of pupil detection emerges in the image having too much bright and too much dark illumination. It happens because pupil detection produces very few pupil pixels which have glare illumination, and when it produces excessive pupil pixels, the pupil area widen so the pupil is detected more than one for one iris image.

The result of pupil detection using normalization method of iris image with using dataset is rising 98.66% if it is compared to pupil detection only using CHT, because only one pupil image can be detected by using that algorithm. And, the accuracy of the iris image normalization is also rising 0.23% when it is compared to the research in previous year with the 99.10% of accuracy[13]. Therefore, normalization method of iris image to detect pupil with intensity transformation can be a reference to the next research which is iris recognation system.

## IV. CONCLUSSION

Pupil detection is the early important stage in determining the iris position to develop iris identification system. The iris image used in this research is taken from the BIT version 4.0. This image has illumination, contrast, and noise variation. So, the stage of normalization image is needed to transform the image intensity into new intensity by stretching its contrast using Contrast Stretching and fixing its illumination using the gamma value. The result of normalization is the dark pupil area extraction in the bright area. As a result, the pupil detection can be conducted easily using the CHT. By using the normalization image method, 99.33% or high accuracy is obtained in detecting pupil. Therefore, the normalization image method can be as reference in research of iris identification system with dataset image from BIT 4.0 version or from other sources as long as the iris image comes from the result of infra red camera acquisition having a standard camera used by BIT.

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