Feature Extraction From Epigenetic Traits Using Edge Detection In Iris Recognition System

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***Abstract*— Iris recognition is the most accurate biometric identification system on hand. Most iris recognition systems use algorithms developed by Daugman. The performance of iris recognition is highly depends on edge detection. Canny is the edge detectors which commonly used. The objectives of this research are to a) study the edge detection criteria and b) measure the PSNR values in estimating the noise between the original iris feature and new iris template. The eye image with [320x280] dimension is obtained from the CASIA database which has been pre-processed through the segmentation and normalization in obtaining the rubber sheet model with [20x240] in dimension. Once it has been produced, the important information is extracted from the iris. Results show that, the PSNR values of iris feature before and after the process of extraction, was 24.93 and 9.12. For sobel and prewitt, both give 18.5 after the process. Based on our findings, the impact of edge detection techniques produces higher accuracy in iris recognition system.**

Keywords: Iris Recognition System, Feature Extraction, Edge Detection, Canny, Prewitt and Sobel, PSNR.

I. INTRODUCTION

A biometric system offers an individual recognition based on unique features or behaviours. Iris recognition system is a reliable method for identity authentication, such as access control, e-commerce, banking online transactions and logistics.

The uniqueness of iris pattern comes from the texture in iris images, such as freckles, coronas, crypts and furrows. These iris patterns determine the one of the kind information and only a specific human's iris contains a unique iris biometric data. In comparison with other biometric technologies, such as face and finger recognition, iris pattern is the most reliable for identifying individuals because the iris is unique due to epigenetic factor [1] that remains stable throughout adult lifetime.

The process of feature extraction is important in acquiring the information of an individual. The process comes after the segmentation and normalization phases. The application of feature extraction is mainly in iris recognition, for identification which is a combination of edge detection and classifiers, to measure the speed of time in recognition. To remove noise, such algorithm is useful as salt and pepper, assist in noise removal in iris accuracy performance. Feature extraction creates new templates from the original features and simplifies the large data set into smaller sizes. The large data set consists of redundant and irrelevant information. Therefore, it produces higher cost and hassle in maintenance to the existing system. In fact, obtaining important information from the iris template, demand algorithms of feature extraction. Feature extraction is based on boundary detection, shape transform, template matching and thresholding, which make it a unique problem.

The authenticity of the person's iris, need to be based on an algorithm in finding the most accurate iris key feature during extraction and matching phases. Therefore, the operators of edge detection such as Canny, Sobel and Prewitt are applied in this study. It helps the iris recognition system and human detection, based on physical and genotypic and epigenetic traits. The biometric data or templates belong only to a person and neither is used by other person, nor forgotten.

The purpose of this study is to investigate whether the edge detection helps in iris recognition in biometric systems. Another objective is to get the PSNR values of human iris before and after the process of edge extraction.

The experiments are undergo in determining whether performing the edge detection gives better PSNR value before and after the edge processing. In order to determine the PSNR value, the noisy iris feature has been reduced to extract the most important information in the iris region. This process produced the value of PSNR value at certain threshold.

II. FEATURE EXTRACTION IN IRIS RECOGNITION

Iris recognition is a method of biometric authentication which involves pattern recognition techniques on iris codes of a human's eyes. The iris pattern may look like rings, furrows and freckles in shapes. Meanwhile, the information inside this iris pattern or called as iris feature is processed from the eye image, converted into a rectangular shape and stored into the database using the information processing technique. The stored iris features is a unique representation of a human and useful for future matching process. Typical iris recognition involves three main phases:

- Segmentation

The assumption which is iris in circular boundaries of region has been a frontier in iris segmentation algorithms, even though the iris boundaries not constrained to be circles. A number of researches considered various approaches to segmenting iris through finding the center of pupil, the inner and outer iris boundaries. Daugman [2] implements integro-differential operators to detect the limbic and pupil boundaries. Another method which is proposed by Wildes [3] introduces an edge detection operator and Hough Transform in iris segmentation. The iris texture is represented with a Laplacian pyramid constructed with four different resolution levels and has used the normalized correlation to determine whether the input image and the model image are from the same class. asek [4] implements Canny edge detection and Hough transform to segment the iris. The same approach has been developed by other researches with a small variation [5–8]. The direction of research in feature extraction has progressed to thresholding and morphological transformations areas. [9] Another study proposed by [10] shows the cholesterol detection in iris segmentation phase. In this study, Hough transform and the edge detection operator which consists of Canny, Sobel and Prewitt are employed in segmenting the iris boundaries in producing the normalized iris feature as in the next section.

- Normalization

After the iris region is successfully segmented from an eye, the next phase is to transform the iris region to a 20x240 dimensions of matrix for further verification. The dimensional between eye images are due to the stretching [11] of the iris caused by pupil dilation which is from varying levels of illumination. It produces iris regions which have the constant dimensions in different conditions and location. The selected region of iris feature is transformed into a Daugman's rubber sheet model as in Fig. 1.

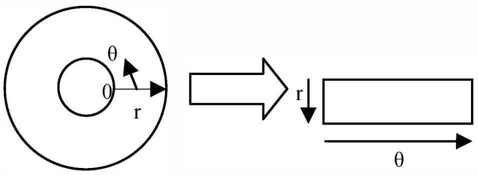


Fig. 1. Daugman's rubber sheet model

The Daugman normalization method transforms the Cartesian model in iris texture from Cartesian to polar coordinates.[12] The method is capable of compensating the unwanted variations due to distance of eye from camera and its position with respect to the camera. The Cartesian to polar transform is defined as:

Where

$$x_p(\theta) = x_{p0}(\theta) + r_p * \cos(\theta),$$
$$y_p(\theta) = y_{p0}(\theta) + r_p * \sin(\theta),$$
$$x_i(\theta) = x_i(\theta) + r_i * \cos(\theta),$$
$$y_i(\theta) = y_{i0}(\theta) + r_i * \sin(\theta).$$

The process is in fewer dimensions in the angular direction. In the radial direction, the texture is assumed to change linearly, which is known as the rubber sheet model. The rubber sheet model linearly maps the iris texture in the radial direction from pupil border to limbus border into the interval [0 1], and creates less dimension transformation in the radial direction as well.

- Feature Extraction

The feature extraction is a key component of iris recognition system since it acquires the most valuable information in iris and determines the system's performance. It performs accurate results through the iris feature extraction of input images and matching these features with the iris patterns in the database. The boundary detection, shape transform, thresholding and template matching are the techniques for feature extraction. Here, the edge detection is focused and experiments are conducted to extract the iris information. Further explanation on edge detection using Sobel, Prewitt and Canny operators is elaborated in section III.

III. Edge Detection

Edge detection provides a number of derivative operators which significantly detect the local changes of intensity in an image. It occurs on the boundary between two different regions of iris features. The goal of edge detection is to produce drawings for instance corners, lines, curves and points in order to extract the key features of key information from the iris feature. The typical operator is sensitive to horizontal edges, vertical edges, or both. The purpose of edge detection is to significantly reduce the amount of data in an image, while preserving the structural properties to be used for further matching process. It returns a binary image containing 1's where edges are found and 0's elsewhere.

In this study, Sobel, Prewitt and Canny edge detection operators are used. The most powerful edge-detection method is the Canny method. The Canny method differs from the other edge-detection methods because it uses two different thresholds in detecting between the strong and weak edges. [13] If the output at the weak edges is connected to weak point, it means weak edges. The sensitivity level of thresholds at the weak edges determines the number of information to be extracted.

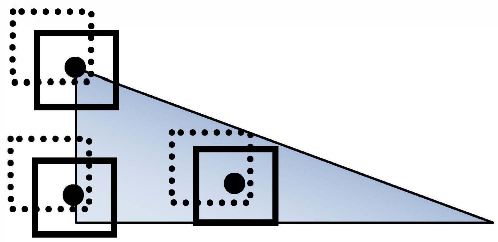


Fig. 2. The diagram of strong and weak edges in thresholds

Refering to Figure 2, corners have been the most reliable feature used to find the correspondence between images.[14]

A corner means a pixel whose surroundings are different from the surroundings of all of its neighbours in all directions. Fig 2 shows three pixels which one inside the object, one on the edge of the object, and one on the corner.

The solid square represents the pixel which is inside an object. In the other hand, the dotted square shows the pixel that is outside of an object. If the neighbour of a pixel is inside an object, and similar to the outside neighbour of the pixels at the outside neighbour; it signifies that the neighbouring pixels in all directions are true. If a pixel is on the edge of an object, its surroundings are different from the surroundings of its neighbours in one direction, but similar to the surroundings of its neighbours in the other direction; it signifies that the surroundings are different from all of its neighbours in all directions.

Two corners are said to be correlated if cross correlation coefficient is greater than a given threshold value. Then iris verification is done using corners. According to [8] it is observed that canny operator is best suited to extract most of the edges to generate the iris code for comparison. Recognition rate of 89% and rejection rate of 95% is achieved.

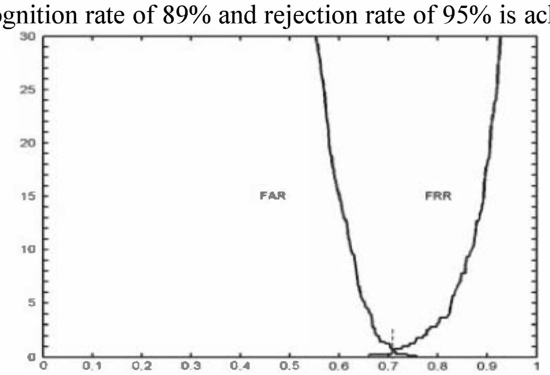


Fig. 3. FAR versus FRR based on histogram [15]

Sobel operator is a discrete differentiation operator, which computes the gradient of image intensity. The result of Sobel operator is correspond to gradient vector and convolving the iris feature with small, separable, and filter in horizontal and vertical direction for high frequency variations in iris feature.

Mathematically, the operator uses 3x3 kernels convolved with original image. Let say A is the iris feature; G_x and G_y are reference and sample iris features which contain the horizontal and vertical approximations. Since the kernels can be decomposed as products of average and differentiation kernel, thus compute the gradient with smoothing. At each point in the iris feature, the gradient can be combined by gradient magnitude:

$$G = \sqrt{G_x^2 \text{ and } G_y^2} \quad (1)$$

The overall performance of iris segmentation using Sobel and Hough transform is illustrated in Fig. 4. According to [16], iris is segmented partially using Sobel and Hough transform in iris recognition system. The accuracy performance for iris recognition is 94.86% at threshold of 0.3944.

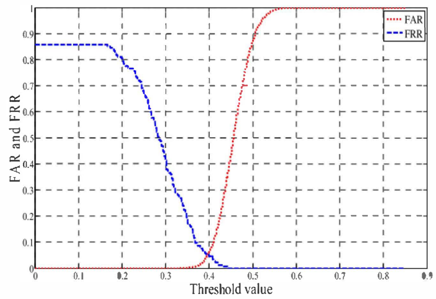


Fig. 4. FAR versus FRR [16]

The characteristics of Prewitt operator is almost the same with Sobel operator, provided that the operator is not divided by 2. It is a discrete differentiation operator and computes the gradient of the image intensity at each point. The smooth edge gives the magnitude which is more reliable and easier to interpret than the direction of calculation. Mathematically, the operator uses 3x3 kernels convolved with original image. Let say B is the iris feature; I_x and I_y are reference and sample iris features which contain the horizontal and vertical approximations. Since the kernels can be decomposed as products of average and differentiation kernel, thus compute the gradient with smoothing. At each point in the iris feature, the gradient can be combined by gradient magnitude:

$$I = \sqrt{I_x^2 \text{ and } I_y^2} \quad (2)$$

A comparison of output image between different edge detection operators is as in table 1.

TABLE I
A COMPARISON OF OUTPUT BASED ON THE EDGE DETECTOR

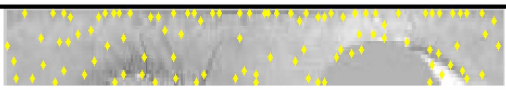
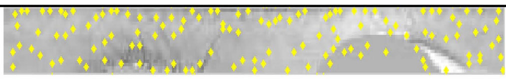
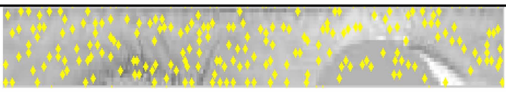
Edge	S1001L04.jpg-polar.jpg - CASIA
Sobel	
Prewitt	
Canny	

B. Sensitivity Levels of Thresholds Settings

To determine the sensitivity level, two thresholds is set, which is the weak and strong edge. The gradient is measured in identifying the weak edges. The Canny algorithm is robust to noise and able to find the object edge by looking for the local maxima of the gradient in the iris feature. The low threshold provides fewer edge pixels. The scalar of 0.4 is determined for low threshold settings since it gives better results through the number of trials of errors. Meanwhile, the higher threshold value gives more edge pixels of information. The level of sensitivity based on the thresholds settings has been implemented. The higher the number of sensitivity, the higher feature extraction will be. However, if the threshold is set to 0.25, the result shows insignificant values. If range is in between 0.2 > threshold <0.25, it produces a good results. The results at level 0.04 are approximately similar as the sensitivity level values at 0.02 and 0.03. Table II represents the output iris feature at level of sensitivity of thresholds.

TABLE II
IRIS FEATURE EXTRACTION USING CANNY EDGE DETECTION

S1001L04 - CASIA

Sensitivity of Thresholds	Iris points of feature extraction according to thresholds
0.04	
0.14	
0.24	

C. Experiment Results and Discussions

The experiments have been implemented using human eye images from CASIA database. Using the Matlab R2010, experiments have been conducted in measuring the PSNR before and after the edge detection implementations. Table III shows that the PSNR value before the employment of edge detection is 24.93. After the edge detection implementation, Canny operator shows that the value of PSNR is 9.123 which is less than the Prewitt and Sobel Operators. Both of Prewitt and Sobel give the same value of PSNR, which is 18.5. The experiments show that the Canny operator is more reliable and produce accurate performance compared to the other two operators.

TABLE III
COMPARISION OF PSNR IN EDGE DETECTION TECHNIQUES

PSNR values for S1001L04.jpg-polar.jpg			
Before	After		
	Canny	Prewitt	Sobel
24.93	9.123	18.5	18.5

The process of feature extraction in edge detection produces a matrix of [20x240] in matrix dimension of the iris feature. In this case, the person with S1001L04 from CASIA has been segmented and normalized. As the results, the binary representation is partially showed as in Fig 5. The encoded iris feature is ready for the next process which is the matching phase in the iris recognition system.

Refer to Fig 5, '0' means input agree while '1' defines input disagree. In row 12 and column 66 to 68, Sobel and Prewitt give '1''0''1' but Canny produces '0''0''1'. It is shown that the bits extracted are more reliable using Canny since twice '0' is achieved. It means, the authenticity of person of S1001 is the genuine person. However, the Prewitt and Sobel operators are unable to detect the variance accurately.

Sobel

	[c60]	[c61]	[c62]	[c63]	[c64]	[c65]	[c66]	[c67]	[c68]	[c69]
[r11]	0	0	0	0	0	0	0	0	0	0
[r12]	0	0	0	0	0	0	1	0	1	0
[r13]	0	0	0	0	0	0	0	0	0	1
[r14]	0	0	0	0	0	0	0	1	0	1
[r15]	0	0	0	0	0	0	0	1	0	1
[r16]	0	0	0	0	1	1	0	0	0	0
[r17]	0	0	0	0	1	1	0	0	0	1
[r18]	1	1	1	1	0	1	0	0	1	1
[r19]	0	0	0	0	1	0	0	1	0	0
[r20]	0	0	0	0	0	0	0	0	0	0

Prewitt

	[c60]	[c61]	[c62]	[c63]	[c64]	[c65]	[c66]	[c67]	[c68]	[c69]
[r11]	0	0	0	0	0	0	0	0	0	0
[r12]	0	0	0	0	1	0	1	0	1	0
[r13]	1	0	0	0	0	0	0	1	1	1
[r14]	0	0	0	0	0	0	0	0	0	1
[r15]	0	0	0	0	0	0	0	1	0	1
[r16]	0	0	0	0	0	0	0	1	0	1
[r17]	0	0	0	1	1	1	0	0	0	0
[r18]	1	1	1	1	0	1	0	0	1	1
[r19]	0	0	0	0	0	0	0	0	0	0
[r20]	0	0	0	0	1	0	0	1	0	0

Canny

	[c60]	[c61]	[c62]	[c63]	[c64]	[c65]	[c66]	[c67]	[c68]	[c69]
[r11]	0	0	0	1	0	0	0	0	0	0
[r12]	0	0	1	1	1	1	0	0	1	0
[r13]	1	1	0	0	0	0	0	1	1	1
[r14]	0	0	0	0	0	0	0	0	0	0
[r15]	0	0	0	0	0	0	0	0	0	0
[r16]	0	0	0	0	0	0	0	0	0	0
[r17]	0	0	0	1	1	1	0	0	0	0
[r18]	1	1	1	0	0	0	1	1	1	0
[r19]	0	0	0	0	1	0	0	1	0	1
[r20]	0	0	0	0	0	0	0	0	0	0

Fig. 5. Binary representation of the iris feature extraction

IV. CONCLUSION AND FUTURE WORK

This paper presented a study on the edge detection criteria and measures the PSNR values in estimating the noise between the original iris feature and new iris template. The evaluation is conducted using eye image with [320x280] dimension which is obtained from the CASIA database. The eye image has been pre-processed through the segmentation and normalization in obtaining the rubber sheet model with [20x240] in dimension. During the evaluation, Canny, Sobel and Prewitt operators is used as a benchmark for this work. Findings have shown that, the PSNR values of iris feature before and after the process of extraction, was 24.93 and 9.12. For Sobel and Prewitt, both give 18.5 after the process. This study suggests that the impact of edge detection techniques produces higher accuracy in iris recognition system.

In future it is recommended to continue this work on the iris encoding in phase entropy where higher entropy can determine a higher accuracy. In addition, this work can also be extended to other area of iris recognition system such as iris clustering and further matching process.

ACKNOWLEDGMENT

A highly appreciation to Universiti Teknikal Malaysia Melaka (UTeM) for sponsor this research through the short term grant (no. PJP/2011/FTMK(19B)/S00965). Thank you to all friends and staff from Faculty of Information and Communication Technology (FTMK) for giving support to complete this project. A special gratitude to CASIA for sharing human eye images.

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