ISBN 978-93-84422-22-6
Proceedings of 2015 International Conference on Image Processing, Production and Computer Science (ICIPCS'2015)
Istanbul (Turkey), June 3-4, 2015 pp. 1-7

Half Iris versus Circular Iris Matching

Author Safaa Omran[1], Aqeel Al-Hilali[2]
[1] College of Elec. & Electronic engineering Techniques
[2] College of Elec. & Electronic engineering Techniques

Abstract: *Iris recognition system provides automatic identification of an individual based on a unique feature. Ridge Energy Detection (RED) algorithm is one of the most accurate identification method to detect the iris features today. RED algorithm is applied on rectangle iris that generated from the normalization process. RED algorithm constructed a template contains the features of the iris by using two type of filter (horizontal and vertical). This paper generated two different iris templates, one of the iris template contains the iris region of the lower part of the eye, the other iris template contains a ring from the iris that near to the pupil. These two iris templates are applied to the RED algorithm in order to compare the accuracy and time between them.*

Keywords: *Iris recognition, half iris region recognition, Ridge Energy Direction, Hamming Distance.*

1. Introduction

Iris recognition is one of the most accurate identification methods that verify user and secure the information. The iris identification was accepted in our world since the feature inside the iris is unchanged with the years and almost impossible to be imitated by others. This approach have been developed in past years to give more reliable secure for saving information and identification. The first iris recognition algorithm was introduced by Dr. John Daugman [1]. Iris recognition requires four main steps: 1) image capture; 2) preprocessing, which includes segmentation, and normalization; 3) feature extraction, which generates an iris template; and 4) comparison of iris templates and recognition (matching) decision. This paper will apply iris recognition on two different iris templates and comparing the result between them

2. Iris Recognition System

The first step in iris recognition is to capture the image. Ones the image captured various preprocessing steps are carried out on it. It includes segmentation, normalization (polar to rectangular conversion) and then template and mask generation by applying the RED algorithm to the rectangular template. This template is matched with the database using hamming distance (which the most foremost method that used for matching between irises) and the match identification is displayed. The flow of process is shown Figure 1. The CASAI V1 is used to capture the image.

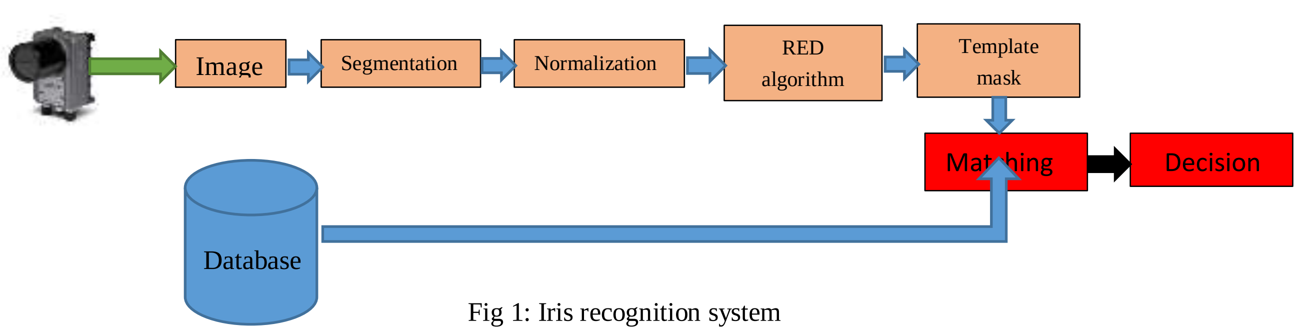
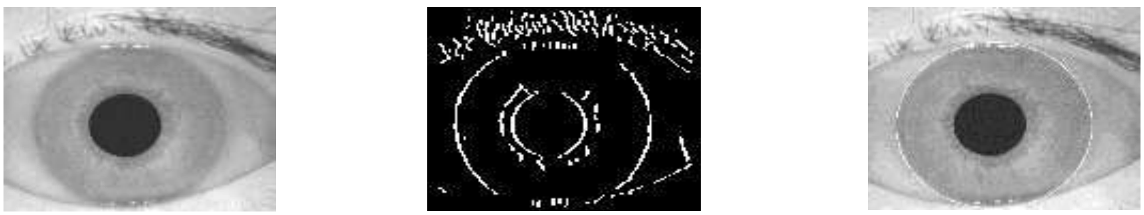


Fig 1: Iris recognition system

3. Segmentation

Segmentation process is used to isolate the Iris from the captured image. This is the most crucial factor in the Iris recognition, the more accurate of detection the pupil and Iris the most the accurate the identification will be. Hough transform is used to detect pupil and iris in this paper, which is an algorithm that can be used to determine the parameters of simple geometric objects, such as lines and circles, present in an image. The circular Hough transform can be used to detect the radius and center point of both pupil and Iris. An automatic segmentation algorithm based on the circular Hough transform is employed by Wildes et al. [2], Kong and Zhang [3], Tisse et al. [4] , and Ma et al [5]. To detect the iris a canny edge detector is applied to the captured image as shown in figure 2b. From the canny edge map of figure 2b, Hough space will detect the outer boundary of the iris by locating larger circle that constructed from edge detector. Equation (1) is used to define any circle by its parameters. These parameters are the center coordinates X and Y, and the radius r, and X_0, Y_0 is a shift in the x-axis and in the y-axis respectively.

$(y - y_0)^2 - (x - x_0)^2 = r^2$ ------------ (1)



(a) (b) (C)

Fig. 2: a) Original Image. b) Image after canny edge detection using the circular Hough transformer. c) Iris detection by using Hough transformer for Iris.

A maximum point in the Hough space will correspond to the radius and center coordinates of the circle that have defined by the canny edge points. The result of process for detection of iris is shown in figure 2c .After finding the iris from the captured image, it is the time to locate the pupil using also Hough transformer. First stage to detect pupil is to make a mask to the captured image and extract only the iris image as shown in figure 3a, since the pupil is always inside the Iris.

(a) (b) (c)

Fig. 3: a) Adjustment image extracted from original image based on the center point of the Iris. b) The canny edge detector of the pupil c) Pupil detection from the Hough transformer.

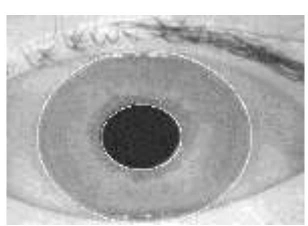


Fig. 4: Result after Segmentation process.

4. Normalization

Normalization is the process for converting the iris from the polar coordinate to the rectangular coordinate. After completing the segmentation process and locating the boundary of pupil and Iris. The next step is Polar to rectangular conversion. Rectangular conversion is applied to the region locating between the radius of pupil and the radius of the iris. This process will generate the rectangular template as shown in figure 5. Conversion process for iris image to rectangular template is performed using the common polar to rectangular coordinate transformation. This process is called as normalization. Re-maps each pixel within iris reign to pair polar co-ordinates (r, θ) where “r‟ lies in the unit interval [0, 1] and “θ‟ is the usual angular quantity that is cyclic over $[0,2\pi]$. This called homogenous rubber sheet model which used by Daugman [6].

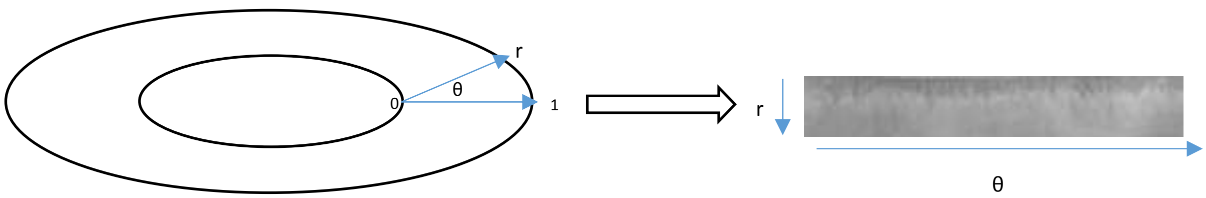


Fig. 5: Polar to rectangular templates conversion

The remapping of the iris image I(x, y) from raw Cartesian coordinates (x, y) to the dimensionless non-concentric polar coordinate system (r, θ) can be represented as:

$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta)$ ------------------------ (2)

$x(r,\theta) = (1-r)\, x_p\ (\theta) + r\, x_l(\theta)$ --------------- (3)

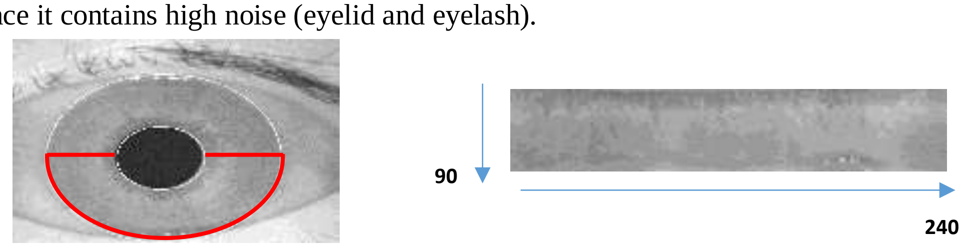
$y(r,\theta) = (1-r)\, y_p\ (\theta) + r\, y_l(\theta)$ --------------- (4)

Where $I(x,y)$ is the iris region image, (x,y) is the original Cartesian coordinates, (r,θ) is the corresponding normalized polar coordinate, and $x_p\ y_p$ and $x_l\ y_l$ are the coordinates of the pupil and iris boundaries along the θ direction. Since the radial coordinate ranges from the iris inner boundary to its outer boundary as a unit interval, it is inherently correct for the elastic pattern deformation in the iris when the pupil changes in size

$$r = \sqrt{x^2 + y^2} \qquad (5)$$

Where $x = r\cos\theta$ and $y = r\sin\theta$ ---------- (6)

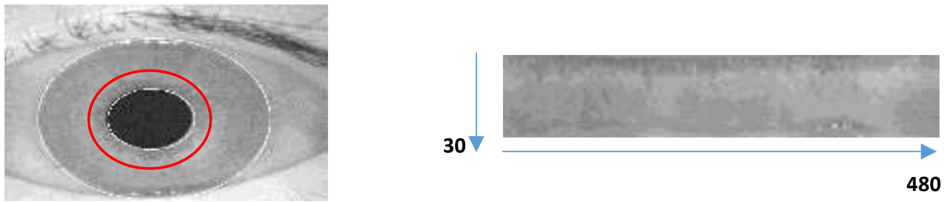
From these equations, Iris extracted from the captured image and two rectangular template is generated to comparing among them. First rectangle iris is generated with radial resolution of 90 pixel and angular of 240 pixel to generate 90*240 template as shown in figure (6). This rectangle iris is generated by using previously equations of normalization, taking only the lower area part of the iris. The second rectangle iris is generated using the same equations with radial resolution of 30 pixel and of angular 480 pixel. This rectangle iris contains a ring from the iris that near to pupil as shown in figure (7). Both rectangle irises that have been generated in this paper contain small amount of noise (eyelid and eyelash). The upper part of the eye is not taken as a part in the template since it contains high noise (eyelid and eyelash).



(a) (b)

Fig. 6: a) taking only the lower part of the iris. b) Rectangular Iris with height 90 pixel and width 240 pixel of the lower part of the iris.

The rubber sheet model takes into account pupil dilation and size inconsistencies in order to produce a normalized representation with constant dimension. In this way the iris region is modelled as a flexible rubber sheet anchored at the iris boundary with the pupil center as the reference point. The dilation and constriction of the elastic mesh work on iris when the pupil changes size [1].

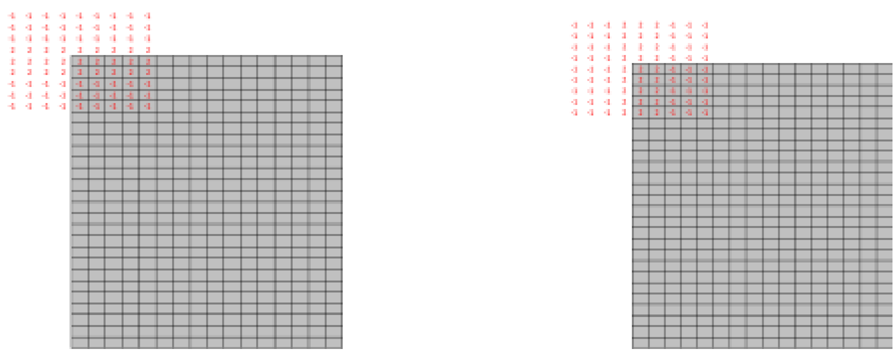


(a) (b)

Fig. 7: a) taking a ring from iris that near to the pupil. b) Rectangular Iris with height 30 pixel and width 480 pixel of ring form iris that near to the pupil.

5. Feature Extraction

The Ridge Energy Direction (RED) algorithm is used for iris recognition. Feature extraction is based on the direction of the ridges that appear on the image [7]. The energy of each pixel is simply the square of the value of the infrared intensity within the pixel and is used to detect features. After converting the Iris into rectangular coordinates, then the RED algorithm takes place on the rectangle iris. RED algorithm is applied for two different rectangle iris. One of them contains the lower part of the eye as shown in figure 6b, while the other template rectangle iris contains a ring of iris that near to the pupil as shown in figure 7b. The RED algorithm states that filtering the rectangle Iris by two directional filter to determine the existence of ridges and their orientation. More specifically, the result is computed by first multiplying each filter value by the corresponding input data value. Then a summation is performed, and the result is stored in a memory location that corresponds to the centroid of the filter. This process repeated for each pixel in the input data, stepping right, column-by-column, and down, row-by-row, until the filter is applied on all the pixels in the rectangle Iris. The filter processing will repeat two times on the input data one with vertical filter and the other with horizontal filter, as shown in figure 8.



(a) **(b)**

Fig. 8: a) RED vertical filter size 9*9. b) RED horizontal filter size 9*9.

The time needed for applying the RED algorithm on the two different rectangle iris is different, since the first rectangle iris template contains more pixels than the other rectangle iris template as shown in table 1. Table 1 indicates that as the size of the rectangle iris template increases the processing time for complete the RED algorithm process will increase, from table 1 the first rectangle iris that contain the iris of the lower area of eye, this iris is 90 pixel height and 240 pixel width. This rectangle iris needed 1749600 multiplication to end the RED process of size 9*9, to find the multiplication needed to complete the RED process and generated the iris template, this by multiply the height and width of the rectangle iris with the size of the filter in RED (height * width * size of filter). While the rectangle iris with size of 30*480 that contains a ring region of iris which is near to the pupil, it needs 1166400 multiplication to complete RED process of size 9*9. This result of one complete RED filter since there is two RED filters (horizontal and vertical) the multiplication process will be doubled to complete RED process, so second rectangle iris will be $1749600/1166400 = 1.5$ faster than the first one hence. (Speed = Number of multiplication of second iris template / Number multiplication of first iris template) After the rectangle Iris template is pass through two filters the horizontal and the vertical dimension will generate two images one of them the result from the vertical filter with rectangle Iris template, and the other is created from the horizontal filter with the rectangle Iris template. The vertical and horizontal templates that generated by RED algorithm for first iris template that contains the iris region of the lower part of eye, as shown if figure 9. While vertical and horizontal templates of second iris template that contains a ring region of iris near to the pupil is shown in figure 10.

TABLE I Size of rectangle iris templates

Rectangle iris	Height * width of iris generated	Multiplication need with RED process of size 9*9
Contain the lower part of eye	90*240	1749600
Contain the iris area that near to the pupil	30*480	1166400

Finally, the template is generated by comparing the results of the two different directional filters (horizontal and vertical) and writing a single bit that represents the filter with the highest output at the equivalent location [8]. The output of each filter is compared and for each pixel, a '1' is assigned for strong vertical content or a '0' for strong horizontal content. These bits are concatenated to form a bit vector unique to the "iris signal" that conveys the identifiable information. The mask also will generate at this process if any value of the resulting of the two different directional filter (horizontal and vertical) is above the threshold, this location will mark as not valid by putting 1 to it as shown in figure 11.

Fig. 9: a) Vertical template results from vertical filter with first iris template. b) Horizontal template result from horizontal filter with first iris template.

Fig. 10: a) Vertical template result from vertical filter with second iris template. b) Horizontal template result from horizontal filter with second iris template.

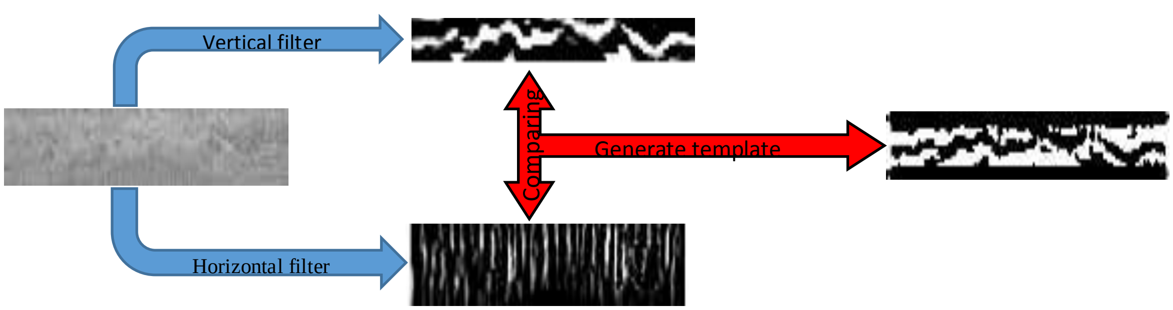


Fig. 11: Ridge Energy Direction process for generating template.

This characterization of the RED algorithm filters is applied to iris into first template 90x240 = 21,600 bits template and the other 30*480 = 14,400 bits. Therefore, the algorithm requires 21,600 iterations of this process to encode a full iris template for the first iris template. And the second iris template requires 14,400 iterations for RED process to encode a full iris template.

http://dx.doi.org/10.17758/UR.U0615001

6. Template Matching

The template can now be compared with the stored template using Hamming distance (HD) as the measure of closeness. The more the HD close to zero the more the accurate the identification. Highest closeness between matched eyes is 0.32 as indicated by Daugman [1].

$$HD = \frac{\|(Template\ A \otimes \ \ Template\ B) \cap MaskA\ \cap Mask\ B\|}{\|Mask\ A\ \cap Mask\ B\|} \tag{7}$$

Where templates A is the Iris template captured image and Template B is the iris template form the database and $\otimes$ symbol indicates the binary exclusive-or operator to detect disagreement between the bits that represent the directions in the two templates, $\cap$ is the binary AND function, $\|\bullet\|$ is a summation, and mask A is associated binary mask for captured image template and also mask B is associated binary mask for database. The denominator ensures that only required valid bits are included in calculation.

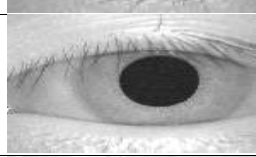
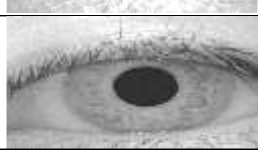
7. Result

Form the table 2 it's clear to see that the second iris template that generated by take iris that near to the pupil is more accurate than the first iris template that is generated by taking the lower area of eye. Form hence we can conclusion that the second iris template have two advantage one of them is the speed since the template that have been taken is small size and it need small time to complete the RED process as shown in table 1 the second advantage is that it's more accurate than the first iris template, since the area that near to the pupil is most the time didn't any eyelid and eyelash that considers as noise, while the lower part of the eye may contain some of eyelid and eyelash which result as error.

Table II Matching percentage between two iris templates of chosen eye from CASIA A

Iris template	Size of iris template	Correct matching
Iris template contains feature from the lower part of the eye	90*240 pixel	99.86%
Iris template contains feature from iris that near to the pupil	30*480 pixel	100%

Table III Result of Matched iris

No.	Eye chosen form CASA-VA	HD of Matched picture between half irises	HD of Matched picture between irises that near to pupil
1		0.282593	0.208889
2		0.22588	0.288958
3		0.238056	0.273264

However this noise in the second iris template doesn't have a major effect on matching process. Another reason that the lower part of the eye have HD close to zero, since the first iris template have larger size than the second one so many pixels matched with matching process.

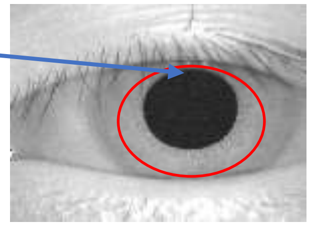


Fig. 12: Noise in iris that upper side boundary of pupil

8. Conclusion

A new developed RED algorithm method is applied for iris recognition by generating two iris templates one taking the lower part of iris and the other takes the iris that near to the pupil. This technique enhanced the RED algorithm since this part of area contains small amount of eyelid and eyelash which considered as noise. Both, the first iris template and the second iris template are generated by RED algorithm and tested on different database and no image have rejected. Table (1) shows that the first iris template needs much more time to complete the RED process than the second iris template due to the large size of the first iris template than the second template. The iris template that was taken from the boundary near the pupil have higher accuracy than the iris template that was taken from the lower part of the eye, since it have lower noise. Table 3 shows that the first iris template has much lower HD than the second iris template.

9. References

[1] J. Daugman, "High confidence visual recognition of person by a set of statistical independence," IEEE Transaction on Pattern Analysis and Machine Intelligence,, vol. 15, no. 11, pp. 1148-1161, November 1993. http://dx.doi.org/10.1109/34.244676

[2] R. P. Wildes, "Iris Recognition: An Emerging Biometric Technology," Proceedings of the IEEE, vol. 85, no. 9, pp. 1348-1363, Sep. 1997. http://dx.doi.org/10.1109/5.628669

[3] W. Kong and D. Zhang, " Accurate iris segmentation based on novel reflection and eyelash detection model," in Proceedings of 2001 International Symposium on Intelligent Multimedia, Video and Speech Processing, Hong Kong, 2001. http://dx.doi.org/10.1109/isimp.2001.925384

[4] C. Tisse, L. Martin, L. Torres and M. Robert, "Person identification technique using human iris recognition," in International Conference on Vision Interface, Canada, 2002.

[5] L. Ma, Y. Wang and T. Tan, "Iris recognition using circular symmetric filters," in National Laboratory of Pattern Recognition , Institute of Automation, Chinese Academy of Sciences, 2002.

[6] J. Daugman, "How iris recognition works," IEEE Transactions on Circuits and Systems for Video Technology, vol. 14, no. 1, pp. 21-30, 2004. http://dx.doi.org/10.1109/TCSVT.2003.818350

[7] R. W. Ives, R. P. Beoussard, L. R. Kennell, R. N. Rakvic and D. M. Etter, "Iris Recognition using the Ridge Energy Direction (RED) Algorithm," in Proc. 42nd Ann. Asilomar Conf. Signals Systems and Computers, Pacific Grove, CA, Nov. 2008. http://dx.doi.org/10.1109/acssc.2008.5074610

[8] R. N. Rakvic, B. J. Ulis, R. P. Broussard and R. W. Ives, "Iris template generation with parallel logic," in Proc. 42nd Ann. Asilomar Conf. Signals Systems and Computers, Pacific Grove, CA, Nov. 2008. http://dx.doi.org/10.1109/acssc.2008.5074753

[9] Y. Zhu, T. Tan and P. Y. Wang, "Biometrics personal identification Based on Iris Patterns," in 15th International Conference on Pattern Recognition, 2000.

[10] R. P. Wildes, "Iris Recognition: An Emerging Biometric Technology," in Proceeding of IEEE, Sep. 1997. http://dx.doi.org/10.1109/5.628669

[11] R. N. Rakvic, H. Ngo, R. P. Broussard and R. W. Ives, "Comparing an FPGA to a Cell for an Image Processing Application," EURASIP Journal on Advances in Signal Processing, vol. 2010, p. 7, 2010 http://dx.doi.org/10.1155/2010/764838