DWT algorithm for Iris Recognition

Nguyen Phuc Vien[1], Nguyen Thanh Hai[1] and Ngo Duc Dat[2]

[1] Faculty of Electrical-Electronics Engineering, HCMC University of Technology and Education, Vietnam
[2] HCMC Navy Technical College, Vietnam

Abstract. This paper proposes with a Discrete Wavelet Transform (DWT) method to extract features for iris recognition. In particular, Daugman's Integro - differential operator is applied to extract iris image from human eye image and the iris image is analyzed to extract features using the DWT for iris recognition of one person. From the iris features, a threshold method is proposed to estimate similarity between irises of people for recognition of one corresponding person. Results show that contribution of this research illustrates the effectiveness of the human recognition method.

Keywords: Iris recognition, Discrete wavelet transform, biometrics, Daugman's Integro - differential operator.

1 Introduction

In recent years, man systems for human identification based on signals or images have been developed with increased reliability. In particular, different ways of identification of voices, faces, obstacles, eyes and others people have attracted researchers [1, 2]. Identification of iris part in human eye image for recognition of one corresponding person is one interesting issue.

Biometrics are the reliable and secure instrument for access control systems and physical assets provided by individual characteristics or based on physiological or behavioral characteristics [3, 4]. Related to human recognition of characteristics, particularly the physiological characteristics are iris, fingerprint, face and hand geometry or behavioural characteristics consist of voice, signature, gait and keystroke dynamics [5, 6]. Moreover, methods can be applied for biometric recognition based on properties and they cannot be forgotten or stolen like traditional authentication such as passwords or PIN's [7, 8].

To successfully perform iris recognition, iris segmentation in eye image is a very important [9]. Two methods, which are often used for iris segmentation, are Wildes method and Daugman's one. In particular, Wildes proposed the iris segmentation with two steps: firstly, eye image is converted into binary image base on gradient of intensities of the pixels in an iris image; the secondly, the iris inner and outer borders are detected using Hough transform [10]. Daugman's algorithm is an integro differential operator that allows to search over an eye image for the circular pupil and

borders of the iris image [11]. Therefore, the circular edge is detected for determining parameters of circular border.
The performance of an iris recognition system is affected by iris features. In recent decade, 2D Gabor filters developed by Daugman have been applied for filtering noises of images. Therefore, Wavelet transform algorithm are employed for feature extraction [12]. It means that this is one of the methods is applied for improvement of the human iris recognition system. Some other research results showed that the method of identifying human iris is highly accurate compared to that of biometric fingerprint identification. In particular, the structure of the human iris has 240 distinct characteristics compared to only 20 to 40 fingerprint recognition features [13]. It means that using the structure of the iris for recognition is more accurate than that of the fingerprint.

In this paper, the threshold method is proposed to estimate iris recognition of people based on eye images. In addition, this research shows statistics of many iris images of different people and between two eyes of one human for estimating the effectiveness of the proposed method. This paper is organized as follows: Section 2 describes the materials and methods related to the DWT and DIDO, in Section 3, results and discussion of iris recognition are obtained, Section 4 provides the overall conclusion.

2 Materials and Methods

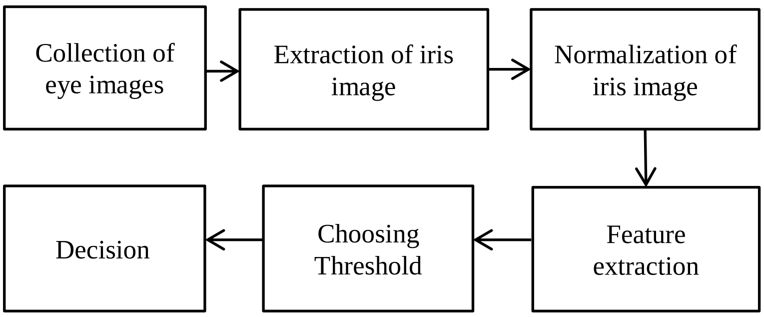


Fig. 1. Block diagram of iris recognition

The collection of eye image with iris for identification is one of the major challenges due to requiring its high-quality image and they are not obscured by human eyelashes. In addition, in this research, the eye image database with iris is obtained from the website of the organization of Biometrics Ideal Test (CASIA-Iris-Interval) and there are 249 persons with one left eye or one right eye only. Which each eye image with an iris has the resolution of 320x280 pixels. From these eye images, an iris image of each eye image needs to extract for recognition, then the methods of normalization and feature extraction for estimating and decision are employed as shown in Fig. 1.

2.1 Extraction of iris image

The algorithm of Daugman's Integro-Differential Operator (DIDO) [5] is applied to find an iris image in an eye image as described:

$$\max_{(r,x_0,y_0)}\left|G_\sigma(r)*\frac{\partial}{\partial r}\oint_{r,x_0,y_0}\frac{I(x,y)}{2\pi r}ds\right| \quad (1)$$

where $I(x,y)$ is the intensity of the pixel at coordinate (x,y) in the iris image, r denotes the radius of the various circular region with the center coordinate at (x_0,y_0), σ is the standard deviation of the Gaussian distribution, $G_\sigma(r)$ denotes the Gaussian filter of the scale sigma (σ), (x_0,y_0) is the assumed centre at the iris coordinate and s is the contour of the circle determined by the parameters of (r,x_0,y_0).

In Daugman's Operator, a Gaussian filter is employed to make smooth image and to reduce noise of eye image. In order to find an iris image in an eye image, one needs to set up parameters as described in Table 1. From these parameters, circles of pupil and iris are drawn as shown in Fig. 2. Therefore, in order to calculate the iris, the iris image needs to be normalized by using the model as shown in Fig. 3.

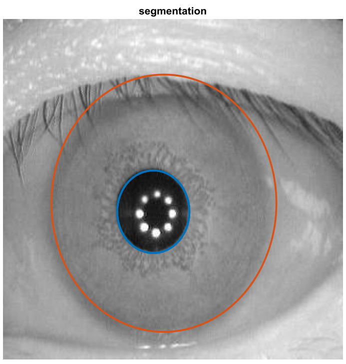


Fig. 2. Representation of finding an Iris image in an eye image

Table 1. Description of parameters of finding the iris image

	X coordinate	Y coordinate	Radius
Pupil	142	159	34
Iris	152	152	109

2.2 Normalization of iris image

After determining the iris area in the eye image, all iris images need to be resized for comparison. The spatial conflict between eye images is mainly due to dilated iris from different lighting levels. In particular, the main causes of inconsistencies include the projecting distance, the rotations of the camera and the eye in the eye socket. Thus, the normalization of iris image is necessary and the normalization process will produce the same irregularly shaped iris areas. With this iris normalization, two images with the same iris under different conditions will have the same structure at the same locations.

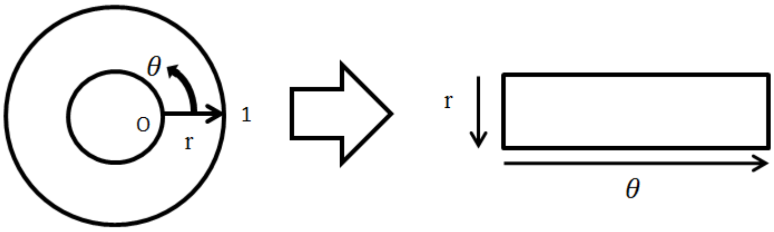


Fig. 3. Daugman's rubber sheet model

The homogenous rubber sheet model was devised by Daugman [14, 15], in which each point within the iris region corresponding to a pair of polar coordinates is (r,θ), where r is on the interval [0,1] and θ is the angle of $[0,2\pi]$. This model allows to convert an iris image into a homogenous rubber sheet image as described in Fig. 3. From this model, the rubber sheet used for remapping of the iris image can be represented as follow:

$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta) \tag{2}$$

where

$$x(r,\theta) = (1-r)x_p(\theta) + rx_l(\theta) \tag{3}$$

$$y(r,\theta) = (1-r)\,\mathrm{y}_p(\theta) + r\,\mathrm{y}_l(\theta) \tag{4}$$

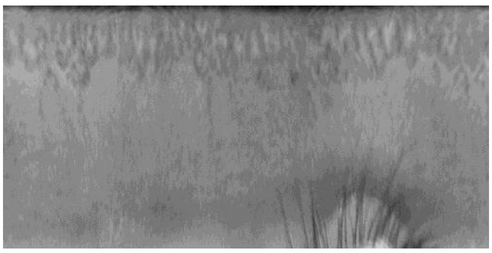


Fig. 4. Normalization of the iris image

From Operator (2), an iris image is calculated and normalized to be a rubber sheet image as shown in Fig. 4. Therefore, all iris images after normalization are calculate to extract features for iris recognition.

2.3 Discrete wavelet transform algorithm for feature extraction

The Discrete Wavelet Transform (DWT) algorithm id applied to analyze features in iris regions into components appearing at different resolutions [16]. The DWT allows to collect coefficients for extracting features of iris images. Therefore, the coefficient output of the DWT is encoded to provide a compact and distinctive representation of the iris model and its equations are described as follows:

$$W_{\phi}(j_0, m, n) = \frac{1}{\sqrt{MN}} \sum_{x=1}^{M-1} \sum_{y=1}^{N-1} I(x, y)\phi_{j,m,n}(x, y) \quad (5)$$

$$W_{\psi}^{i} = \frac{1}{\sqrt{MN}} \sum_{x=1}^{M-1} \sum_{y=1}^{N-1} I(x, y)\varphi_{j,m,n}^{i}(x, y), i = H, V, D \quad (6)$$

where I(x,y) is the normalization iris image with MxN pixels, $M = N = 2^J$, $j = 0,1,2,..., J-1$; $m,n = 0,1,2,..., 2^j - 1$. j_0 denotes the random starting scale and is commonly chosen to be $j_0 = 0$.

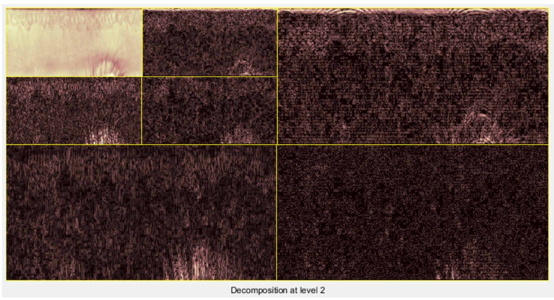


Fig. 5. An Iris image is analysed using the discrete wavelet transform.

Fig. 5 shows the result of the iris image using the DWT with Harr function, in which the approximate image contains features. After extracting features, the iris image needs to be encoded in binary. Thus, the DWT algorithm was employed at level-2 to produce three coefficient components H, V, D which can be utilized for binary coding by using the following equation:

$$\begin{cases} C(i) = 0, & C(i) < 0 \\ C(i) = 1, & C(i) \geq 0 \end{cases} \quad (7)$$

where C represents the iris feature space after the DWT, C= {LH3, HL3, HH3} after the DWT with level 3, and C(i) is the element of C.

2.4 Threshold algorithm for iris identification

From features of the iris image, the Hamming Distance (HD) indicates the number of bits that are the same between two bit patterns. Using the HD of the two bit patterns, one decision can be made whether two samples of different irises or from they are the same iris. It means that when one compares between samples *A* and *B*, the *HD*(A, B) is defined as the sum of the bits not to be the same per the total number of bits of a sample and its equation is described as follows:

$$HD(\mathrm{A},\mathrm{B}) = \frac{1}{N}\sum_{j=1}^{n} A_j \oplus B_j \tag{8}$$

in which *N* is the size of an iris feature code, *A* and *B* are denoted as different iris feature codes, A_j and B_j are corresponding bits of the iris feature codes.

For evaluating the similarity of two iris samples, the Similarity Degree (SD) method is applied and its equation is defined as follows:

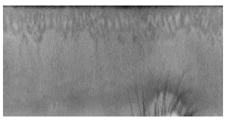
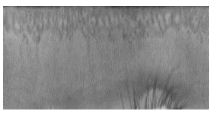
$$SD(\mathrm{A},\mathrm{B}) = 1 - HD(A,B) \tag{9}$$

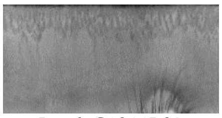
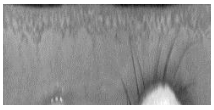
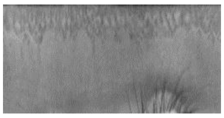
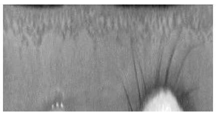
In general, the SD and HD are the same, but the SD is the same direction to the similarity of the two irises. Finally, the threshold T is employed for estimating, particularly if $SD(\mathrm{A},\mathrm{B}) \geq \mathrm{T}$, then A and B comes from an iris and else that is not.

3 Results and Discussion

In this research, each iris of one person is encoded to be S1011L08, in which S1011 is assigned a person; letters of L or R are assigned to be the left iris or right iris; 08, 09 or 02 is the number of the sample. Therefore, the algorithm was applied to calculate values of SD on the iris images and one is based on it to estimate and make decision. The results in Table 2 show that the SD value of Iris from two eyes is always less than 0.625, so the threshold T=0.625 can be installed to identify matching. In particular, the SD values, which are smaller than T, mean that two iris images are estimated not to be the same and inversely it is the same. Therefore, to be able to select an optimal T threshold, the database with different iris samples is large.

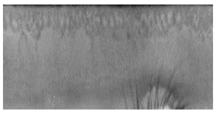
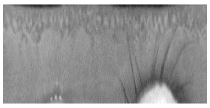
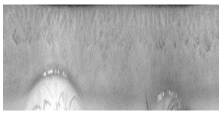
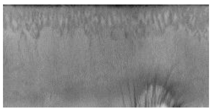
Table 2. The results of matching iris images of the left eye images between different samples

Images		Matching Results
 Iris A-S1011L02	 Iris B-S1011L09	SD=0.628

 Iris A-S1011L02	 Iris B-S1011L08	SD=0.6308
 Iris A-S1011L09	 Iris B-S1011L08	SD=0.6276

In case of two irises of different people as shown in Table 2, in which the SD values are considered differently for recognition. In similarity, Table 3. shows matching an iris image compared with that of other iris images corresponding to the different SD values.

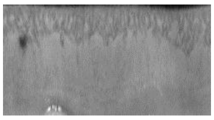
Table 3. The results of matching iris images with different people.

Image		Matching Result
 Iris A- S1011L02	 Iris B- S1019L01	SD=0.6176
 Iris A-S1011L08	 Iris B-S1019L01	SD=0.6215
 Iris A-S1011L02	 Iris B-S1016L02	SD=0.6201

In Table 4, two iris images show the difference in structure of the left and right iris images of one person corresponding to one SD value.

Table 4. The results of matching with left iris with right iris of a person.

Image	Matching Result

 Iris A- S1011L02	 Iris B- S1011R02	SD=0.6184

From the above results, with SD=0.6184 < T, it shows that there is the difference in the structure of the iris images between the left and the right iris images. Therefore, one can be based on this difference to identify one typical person with higher accuracy.

In this paper, the proposed method of iris recognition showed that using the iris structure for human recognition is useful and needs to develop in the future. In this research, the feature extraction for recognition was worked out using the DWT based on the DIDO model and its simulation results showed the effectiveness.

4 Conclusions

In this research, an iris recognition system was applied to analyze the iris features of human for recognizing a typical person. In particular, the DIDO model was used to extract iris image from eye image for feature extraction and the DWT algorithm was employed to determine the iris features for identification. The threshold method was utilized to exactly determine the iris feature for finding the corresponding person. Simulation results are that one T threshold suitably chosen allows to determine difference between two right and left irises of one person, as well as between two irises of two persons. These results mean that the proposed method is the effectiveness and the basic step for development of iris identification with more optimal methods.

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Conflicts of Interest

The authors declare that they have no conflict of interest.

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