Iris Recognition Analysis Using Biorthogonal Wavelets Transform for Feature Extraction

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Absrtact – **Human iris has a very unique pattern which is possible to be used as a biometric recognition. To identify texture in an image, texture analysis method can be used. One of method is wavelet that extract the image feature based on energy. Wavelet transforms used are biothogonal types, i.e. Haar and Daubechies. In this research, iris recognition based on Haar and Daubechies was done and then comparison analysis was conducted for which some conclusions taken. Some steps have to be done in the research. First, the iris image is segmented from eye image then enhanced with histogram equalization. The method used for extracting features are Haar and Daubechies (i.e. db5) wavelets transform. The features obtained is energy value. The next step is recognition using normalized Euclidean distance. Comparison analysis is done based on recognition rate percentage with two samples stored in database for reference images. As the result, the highest recognition rate is achieved using Haar with decomposition level 3 i.e. 84.375%, for which the highest recognition rate of db5 is 68.75% with decomposition level 2. The lowest recognition is achieved when db5 used with decomposition level 1, i.e. 38.231%, whereas the lowest recognition rate using Haar is 68.75% with decomposition level 1.**

Index Terms: **human iris, Haar, Daubechies, wavelet transform, Euclidean distance**

I. INTRODUCTION

A. Background

Humans as individuals, have unique characteristics and distinctive. These characteristics can be used to recognize or identify persons. This is known as biometric recognition. Iris is the part of the circle around eye pupil. Although iris has a relatively narrow region compared with entire area of the human body, iris has a very unique pattern, different in each individual and the pattern will remain stable. For those reasons, iris can be used as the basis for the recognition in biometrics [2].

Many algorithms have been applied as a method of iris recognition, such as PCA (Principal Component Analysis), ICA (Independent Component Analysis), Gabor-Wavelet algorithm [2], characterizing Key Local Variation, Laplace Pyramid, Gray Level Co-ocurrence Matrix (GLCM) [3] and others. Haar wavelet transform as a method to analyze the texture is still rarely used as a feature extractor on iris pattern. In this research, texture-based recognition methods were analyzed using the method of characterizing the Haar wavelet transform and Daubechies (db5), which then the comparison of these two types of wavelets will be conducted.

B. Research Objective

The purpose of doing this research is to create an application that can perform a comparative analysis on iris recognition rate using the Haar and Daubechies wavelets with Euclidean distance calculations. While the motivation of the research is that the iris can be used as an organ in biometric system with higher accuracy level an the fact that, up until now, there is no adequate research done for comparing these two wavelets to extract iris features.

C. Limitations

In order not to deviate far from the problems exist, the research problems are limited as follows:

1. Iris image used is the image that has been available, which is using the database of CASIA V1.0 [1].
2. Research is focused on the use of Haar wavelet transform as well as DB5 wavelet transform as feature extractor and feature used is energy
3. Recognition method used is the normalized Euclidean distance method

II. BASIS OF THEORY

A. Iris Eyes

Iris can serve as the basis for biometric systems. Each iris has a texture that is very detailed and unique to each person and remains stable for decades. The eye can not be altered through surgery without causing any damage to eyesight. Fig.1 shows the anatomy of the eye, and examples of human iris [5].

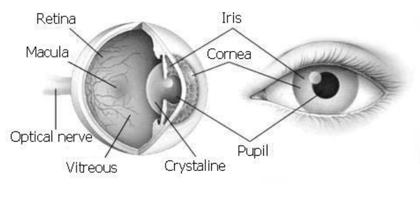

Fig. 1. Anatomy of an eye and example of iris region.

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The advantages of using the iris for reliable identification system are [2] as follows.

1. Iris is insulated and shielded from the outside environment.
2. On the iris, it is not possible to do some surgeries without causing defects in the eye.
3. Iris has a physiological response to light, which allows testing of the natural use of the possibility of fraud and faked eye lenses and so forth.

B. Wavelet Transform

Wavelets are mathematical functions that satisfy certain requirements are able to perform the decomposition of a function [7]. Hierarchically, wavelet is used to represent data or other functions. Wavelet can be used to describe a model or the original image into a mathematical function regardless of the shape of the model in the form of image, a curve or a plane. Wavelet transform is a function that converts the signals from region to region the frequency or time scale. The most appropriate wavelet transform used in image processing because there is not much information is lost during the reconstruction

Wavelet is a base derived from a wavelet basis function which is also said to be a scaling or scaling function. Scaling function has properties which can be assembled from a number of copies that have been dilated, translated and scaled. This function is derived from the dilation equation, which is considered as the basis of wavelet theory.

C. Haar Wavelet

Type of wavelet used in this research is the Haar wavelet. Haar wavelet is a compactly supported wavelets, wavelets of the oldest and simplest. Haar wavelet is in category of orthogonal. Haar wavelet is also similar with db1 wavelet (Daubechies order 1). Haar wavelet filter length is 2. Haar Wavelet scaling function is shown in Fig. 2.

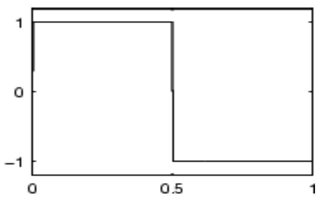

Fig. 2: Scaling function of Haar wavelet

D. Daubechies Wavelet

Daubechies wavelet has a short name db, and to order N denoted by db$N$. For order of Daubechies Wavelet N = 1 is also called Haar, Order range of Daubechies wavelet is from N = 2 until N = 45. Wavelet Daubechies length is 2N. For example db5 has a filter length 10.

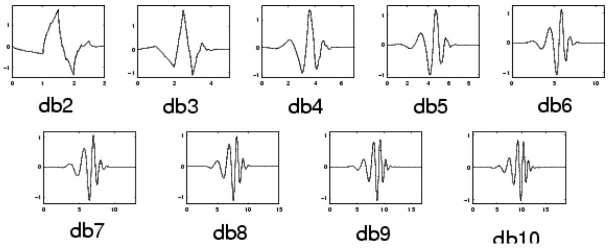

Fig. 3. Daubechies Wavelet

Fig. 3 shows the length of several types of wavelet filters of Daubechies from $N = 2$ to $N = 10$.

E. Image Decomposition

Image processing using wavelet transform is done by filtering image using wavelet filter. Result of this filtering is four image subspaces from original image. These four subspaces are in wavelet domain. Four subspaces mentioned are lowpass-lowpass (LL), lowpass-highpass (LH), highpass-lowpass (HL), and highpass-highpass (HH). This process is called decomposition. The decomposition can be continued using lowpass-lowpass (LL) as its input for getting next decomposition stages. Fig. 4 shows a decomposition image from level 1 until level 3.

Maximum level of decomposition in image processing using wavelet can be formulated as follows [4].

$$Level_{max} = \frac{\log(\text{data length}/(\text{filter length -1}))}{\log(2)} \quad (1)$$

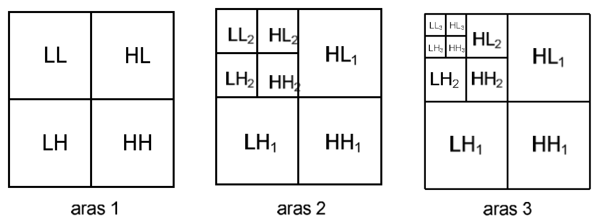

Fig. 4. Diagram of image decomposition

F. Energy Measurement in Wavelet

Energy measurement is used to calculate energies which are resulted of images as output of wavelet transform. These energies are input coefficients for Euclidean distance calculation [7].

In this research, energy can be divided into four features, those are:

1. Percentage of energy related to approximation value, E_a, is calculated based on percentage of sum-square of approximation coefficient values C_a which is divided by sum of all coefficients C (approximation coefficient plus detail coefficients).

$$E_a = \frac{\sum C_a^2}{\sum C^2} \times 100\% \quad (2)$$

2. Percentage of energy related to detail values in horizontal direction, E_h, is calculated based on percentage of sum-square of detail coefficient values in horizontal direction C_h which is divided by sum of all coefficients C.

$$E_h = \frac{\sum C_h^2}{\sum C^2} \times 100\% \quad (3)$$

3. Percentage of energy related to detail values in vertical direction, E_v, is calculated based on percentage of sum-square of detail coefficient values in vertical direction C_v which is divided by sum of all coefficients C.

$$E_v = \frac{\sum C_v^2}{\sum C^2} \times 100\% \quad (4)$$

4. Percentage of energy to detail values in diagonal direction, E_d, is calculated based on percentage of sum-square of detail coefficient values in diagonal direction C_d which is divided by sum of all coefficients C.

$$E_d = \frac{\sum C_{d2}}{\sum C^2} \times 100\% \quad (5)$$

G. Normalized Euclidean Distance

After passing through feature extraction process and parameter values are obtained, then the next stage is to calculate the nearest distance (Euclidean distance) of feature vector values of an image [5]. The closer the Euclidean distance, getting closer to a certain image. For example, values of feature vectors of first image is $A_i = (A_1, A_2, \ldots, A_n)$ and values of feature vector of second image is $B_i = (B_1, B_2, \ldots, B_n)$, then Euclidean distance between these two vectors can be expressed as:

$$D(A,B) = \sqrt{\sum_{i=0}^{n} \frac{(|A_i - B_i|)^2}{A_i}} \quad (6)$$

where:

$D(A, B)$ = Euclidean distance between iris A and B

A_i = Feature vector A

B_i = Feature vector B

n = vector length (sum of textural features) of vector A and vector B

III. Design of Research

A. Flowchart of research

Flow of iris recognition system can be depicted in a flowchart shown in Fig. 5. Broadly explained, the processes can be classified into some steps below.

1) Selecting the input image in the form of eye image.
2) Segmenting the iris for separating iris image from its eye image.
3) Normalizing the iris for getting iris image which is easier to be manipulated.
4) Extracting the features using Haar wavelet transform.
5) Recognizing using Euclidean distance calculation.
6) Doing the 4-th step using Daubechies (db5) wavelet transform.
7) Repeating the 5-th step for recognition process using db5 wavelet transform.
8) Comparing the recognition between feature extraction using Haar and db5 wavelets.
9) Taking the conclusions of point 8.

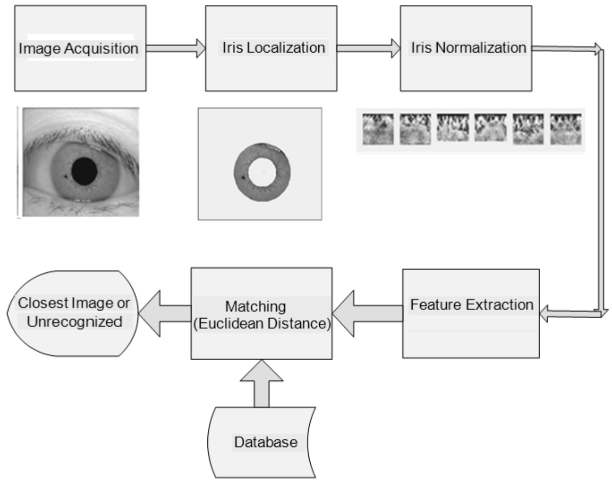

Fig. 5. Flowchart of iris recognition system using feature extraction of Haar (or Daubechies) wavelet transform.

B. Software Design

1. Iris image segmentation

In database, pupil circle and iris circle are not always perfect circle for which for getting only iris needs a complex computation. For simplified computation, it is assumed that pupil as well as iris have a perfect-circle form. First step is finding pupil circle, center point and its radius. Some subprocesses have to be done are thresholding, smoothing, and obtaining the center point of pupil and its radius using Circular Hough Transform [6].

2. Conversion of iris image into rectangular image

Pupil and iris images which are circle-form with their diameters are varied, are then converted into a fix-sized rectangular form. The size is 60×512 pixels. This conversion also for simplifying both coding as well as computation.

The presence of eyelids and eyelashes also can can disrupt the process of iris recognition and reduce the level of accuracy. Therefore, not all parts of the iris is taken. For the iris image of CASIA, the top part of the image is cut so that the bottom of the iris of the eye are taken. Image size is 60 × 384 pixels.

3. *Image Enhancement*

Iris image which has been converted into a rectangular shape has a low contrast level so that the resulting level of accuracy is less good. Therefore, the contrast then enhanced using adaptive histogram equalization. First, image is is split into 3 × 12 parts of each section measuring 20 × 32 pixels. The purpose is to obtain images with good contrast but will not damage the overall image quality.

4. *Feature Extraction using Haar and Daubechies (db5) Wavelet Transforms*

Iris image is split into 6 (six) parts (slices). Feature extraction is performed to all images which have been split before. Features obtained are energies of E_a, E_h, E_v, dan E_d.

IV. Results and Discussion

A. Feature Extraction Tests

This test uses parameter of Haar wavelet transform. Table 1 shows the energy E_a, E_h, E_v, and E_d at the 3 (three) samples of polar iris images used in the research. Wavelet type used is Haar wavelet and decomposition level is 1.

For a different image on the same slice of the iris, it does not really look any differences in the value of existing energy. However, this does not mean the combination of the characteristics of the iris (E_a, E_h, E_v, and E_d) can not be used. It is precisely that this will be observed in this research, i.e the recognition using Euclidean distance.

Table I. Energy value data E_a, E_h, E_v, and E_d for 3 (three) polar image sample using Haar filter and level of decomposition 1.

Image file	Image slice no…	Decompo-sition level	E_a	E_h	E_v	E_d	Percentage of energy
001_1_1.bmp	1	1	99,0147	0,4899	0,3786	0,1168	100
	2	1	98,5324	0,782	0,5073	0,1782	100
	3	1	98,7893	0,4912	0,5794	0,1401	100
	4	1	98,8635	0,4097	0,6082	0,1186	100
	5	1	98,9289	0,5288	0,4132	0,129	100
	6	1	98,9398	0,5535	0,3623	0,1443	100
002_1_1.bmp	1	1	99,2719	0,2793	0,3718	0,0769	100
	2	1	99,2564	0,348	0,3216	0,0739	100
	3	1	99,079	0,2836	0,5611	0,0763	100
	4	1	98,809	0,3445	0,7536	0,0929	100
	5	1	98,8761	0,3701	0,6461	0,1076	100
	6	1	98,9976	0,3461	0,573	0,0834	100
003_1_1.bmp	1	1	99,0175	0,4481	0,4239	0,1104	100
	2	1	98,976	0,4852	0,427	0,1118	100
	3	1	98,7578	0,4092	0,7307	0,1023	100
	4	1	98,879	0,4116	0,598	0,1114	100
	5	1	98,2253	0,7636	0,8301	0,181	100
	6	1	98,213	0,7259	0,8963	0,1649	100

B. Recognition Testing

The test can be divided into 3 (three) kinds of research, there are:

1. *The impacts of different decomposition level on iris recognition level*

Some tests were conducted for 128 images, originated from 64 persons. While the stored images in database are 2 samples for each person. According to Equation (1), maximum decomposition level for Haar and db5 wavelet are 5 and 2, respectively. From all allowed decomposition level tests, it can be inferred that: (a) The best recognition level for Haar wavelet is 84.375% which is achieved at decomposition level 3. While the best recognition level for db5 wavelet is 68.75% which is achieved at decomposition level 2. (b) The lowest recognition rate for Haar wavelet is 68.75% for decomposition level 1, whereas the lowest recognition rate for db5 wavelet is 38.231% for decomposition level 1. Table II shows all tests using Haar and db5 wavelet up to the maximum level achieved.

Table II. Recognition rate from different level of decomposition

Decomposition Level	**Recognition Rate (%)**	
	Haar	**db5**
1	68.75	38.231
2	76.563	68.75
3	84.375	-
4	83.594	-
5	83.594	-
Average	**79.375**	**53.491**

From Table 2 a chart showing the relationship between decomposition level (from level 1 through 5) and recognition rate using the Haar and db5 wavelets can be made. Fig. 6 shows that chart. While Fig. 7 shows the average recognition of these two types of wavelet. The average recognition rate using the Haar wavelet is 79.375%, while the recognition rate using Daubechies wavelet is 53.491%. This suggests that, in this case, recognition using Haar wavelet is better than using db5 wavelet.

2. *Effect of Number of Samples Stored*

From the test results, it was found that the use of two samples stored produces higher recognition rate than the use of one sample stored. Testing with one sample stored produces recognition rate of 81.20%, whereas test with two samples stored produces recognition rate of 85.58%. This is because the more samples stored, the more features can be extracted.

3. *Testing using outer images*

To be able to perform the test with the outer images which are not included in the database, the threshold value is implemented. Without using the threshold value, the outside image will remain recognizable as a one image in database since the recognition using nearest or smallest Euclidean distance.

In determining the threshold value, sum of two statistical parameters are used, i.e. mean and standard deviation of the results of previous tests using Haar wavelet transform with decomposition level 4 and using two samples of stored images. Threshold value obtained is the sum between the average and its standard deviation, then its value is 1.873 + 0.491 = 2.364.

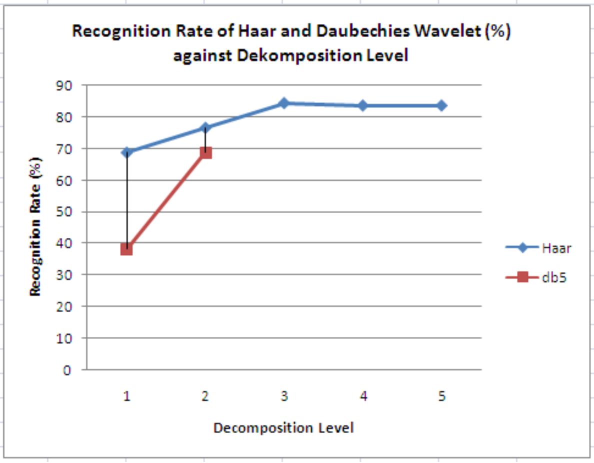

Fig. 6: Recognition rate using Haar and db5

Threshold value is then used for testing using outer test images. It is expected that the value is less than the distance of the test results. The research was done using 10 images from selected CASIA V1.0 and CASIA V3 images which are selected randomly. Test results are shown in Table III.

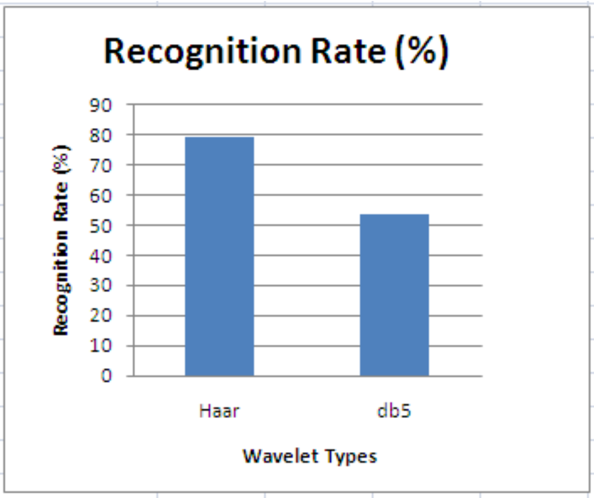

Fig. 7. Average recognition rate using Haar and db5 wavelets

Table III. Test results using outter test images

No	Image file's name	Euclidean distance	Recognized as	Note
1	001_1_2.bmp	1.8117	Iris001-2	Right
2	008_1_2.bmp	2.9612	Not recognized	Right
3	017_1_2.bmp	3.5121	Not recognized	**Wrong**
4	099_1_2.bmp	2.8431	Not recognized	Right
5	108_1_2.bmp	1.7259	Iris108-1	Right
6	S1020R01.jpg	2.6536	Not recognized	Right
7	S1210L01.jpg	2.6985	Not recognized	Right

Table III. Test results using outter test images (continued)

No	Image file's name	Euclidean distance	Recognized as	Note
8	S1228L07.jpg	2.4298	Not recognized	Right
9	004_2_2.bmp	2.2455	Iris004-2	Right
10	005_2_3.bmp	1.9825	Iris005-2	Right

V. Conclusions

From results of tests and analysis, some conclusions can be drawn are:

1. For a different image on the same slice of the iris, it does not really look any differences in the value of existing energy. However, the combination of the characteristics of the iris (E_a, E_h, E_v, and E_d) is used to recognize irises. The best recognition rate for the Haar wavelet is 84.375% which is occurred in the application of decomposition level 3. Meanwhile, the best recognition for the DB5 was 68.75% which is occurred at the level of decomposition 2.
2. The lowest recognition rate for the Haar wavelet is equal to 68.75% for decomposition level 1. As for the wavelet db5, the lowest recognition rate is 38.231% at the level of decomposition 1.
3. The use of stored samples of the two images produces a greater recognition rate that is equal to 85.58% compared with the use of only one stored image which has a recognition rate of 81.20%.
4. Testing of outter images of the iris which is not stored in the database with threshold of 2.365, the rate of recognition is 81.48%.

Acknowledgment

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