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THE SIMILARITY OF IRIS BETWEEN TWINS AND ITS EFFECT ON IRIS RECOGNITION USING BOX COUNTING

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Abstract: One of sciences that growing rapidly is Biometric. In this world, there can't be two identical humans, even though they are twins. Every human being must have different characteristics from the others. The iris is the part of the eye that is protected by the cornea so that it has a relatively stable shape and pattern. Iris recognition is a biometric identification method based on iris patterns. Meanwhile, twins mostly have the same physical characteristics, so it is interesting to investigate how the iris between twins is related and its effect on Iris recognition. In this paper, the relationship or the similarity of iris between twins was studied using a correlation test. Meanwhile, the effect of similarity between twins on iris recognition was investigated from changes in the accuracy of iris recognition when the number of twins' iris was increased in the data. The database was taken from CASIA Interval and Casia Twin. From this research, the results showed that Iris between twins had a high level of similarity and relationship, it can be seen from the high and significant correlation value, and the number of twins' iris in the data was negatively related to the accuracy of iris recognition, namely the more iris's twins on the data, the smaller the accuracy.

Keywords: iris recognition; twins; box-counting.

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1. INTRODUCTION

One of sciences that growing rapidly now is Biometric. Biometric is a method for body measurements and calculations, most of all related to human characteristics. Biometrics has been widely used in various fields, ranging from the use to recognize a person's identity, as proof of presence, identification of a person both alive and dead, the search for missing persons, the search for criminals, and so on. Based on nature, no two people are identical, because each person must have unique and special characteristics, making researchers investigate various parts of the body that can be used in biometrics as an accurate identification. Some of the biometry used for identification are fingerprint recognition, earlobe geometry recognition, voice wave recognition, face recognition and iris recognition. Different from fingerprints and faces or other part of body that can change for one reason or another, the iris is more stable because it is protected by the eyelids. Therefore, iris recognition gives more stable and better results than others. But no less important is how to process the iris image so that the results obtained can be used as a reliable and valid recognition method. In the iris recognition system, there are several methods used to process iris images, namely how to extract and analyze iris features, this is what distinguishes one study from other studies on iris recognition. In general, the three main steps typically used in iris recognition, are: iris preprocessing which consists of iris localization and iris normalization, feature extraction to finding the characteristic of the iris, and feature matching [1]. A lot of research on the recognition of the iris has been done. Daugman is the first people who introduced iris recognition and developed the first algorithms to perform iris recognition [2], he discovered that the most unique phenotypic feature that can be obtained from a person's face is the detailed texture that forms the pattern of each iris of the eye. In his paper, he explained the method he used, feature extraction using Gabor wavelet transforms and visual recognition using Hamming distance. A new approach and algorithm were also developed by Mira and Mayer [3], an algorithm for obtaining iris boundaries from individuals by segmenting and analyzing iris patterns using morphological operators. Guodong Guo and Jones [4] said that the largely on correct iris localization determined the successful iris recognition. They presented a method based on intensity gradient and texture difference between iris and sclera or between the pupil and iris for iris localization. In 2013, Chen et al in their paper [5], described iris recognition using Bidimensional Empirical Mode Decomposition Localization for feature extraction. Chusnul and Juniati in [6], for processing the iris image, initially they processed the image to find the iris area, this process was done using Hough transform and the Daugman rubber sheet model was used to normalize the iris data set into rectangular blocks. Next, to get the characteristics of the iris, they used the box counting method to get the fractal dimension value of the iris. The accuracy obtained by using the box counting method to get the fractal dimension from the iris in the introduction of the iris was 92.63%.

Twins mostly have the same physical characteristics, and we knew that face recognition had many difficulties in determining identity in twins. So, it is interesting to investigate how the iris between twins is related and its effect on Iris recognition. Hollingsworth [7] in his research, used subjects that he called untrained human beings, which means that ordinary people do not have special abilities or knowledge about twins. He found that the subjects could group people into twin group with an accuracy of more than 81% using only iris appearance, without proximal image content such as eyelashes, eyelids, or visible tear ducts. There is not much research that discusses the Iris recognition between twins. In this paper, the relationship or the similarity of iris among twins was studied using a correlation test. Meanwhile, the effect of similarity between twins on iris recognition was investigated from changes in the accuracy of iris recognition when the number of twins' iris was increased in the data.

In this research, the initial processing or iris segmentation was done by localizing the iris from the iris image by finding a regular shape using the Hough transformation [8] then normalized the iris using a rubber sheet of Daughman, which was to change the annular shape of the iris into a rectangular shape so that it was easy further processing. The next step to get the characteristics of the iris, the box counting method was used to get the fractal dimension of the iris.

2. MATERIAL AND METHODS

This section will explain the data set and the steps of processing data, such as iris localization, iris normalization, box counting dimension and feature matching.

2.1. DATASET

The database used was two parts of CASIA-Iris V4, CASIA Iris Interval and Casia Iris Twins. The data consists of 156 iris images, namely 48 iris images of twins and 60 iris images from non-twins. The iris used is the iris from the left and right eye which were taken in balance in the amount. Each image has a resolution of 280 × 320 pixels in JPG format. Figure 1. demonstrates the right and the left eye from two person that identical twin.

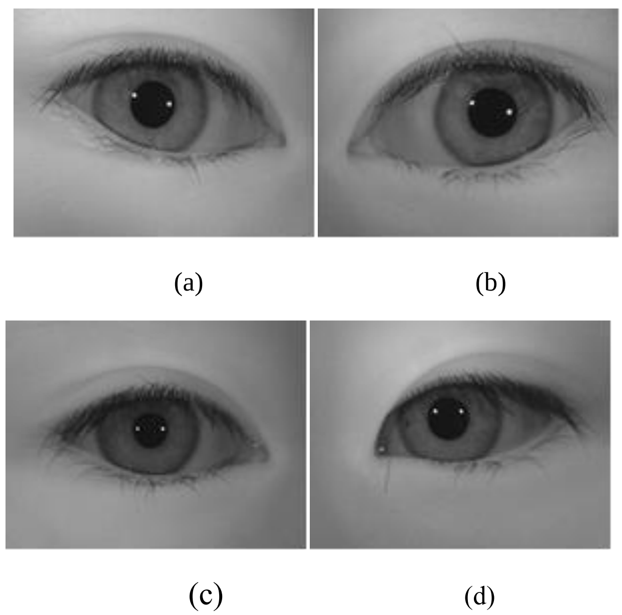

Fig. 1. An example of a pair of iris human from Casia Iris Twins. (a), (b): the right and the left eye from the first person of an identical twin. (c), (d): the right and the left eye from the second person of an identical twin.

2.2. IRIS LOCALIZATION

The process of localizing the iris image is a very important and influential step in determining the extraction of iris features. This process is carried out to get the iris image as carefully as possible and to get the minimum interference of iris images such as the presence of eyelashes or eyelids.

Hough transform is a feature extraction technique by finding imperfect or particular objects in the form of certain groups such as line, circle image with the selection process used in image analysis. The radius and the center coordinates of the pupil and iris regions can be deduced with a

Hough transform [8]. This transformation started with the Canny edge detection process which aims to find the edges of objects and reduce the points on the image. The process of detecting the edge of an object in an image can not only be used to extract the important features of an image, this process can also be used to find the boundaries of an object to be distinguished from its background [1].

The Canny edge detection algorithm contained these following steps:

a) Edge detection is sensitive to noise, so the first step is to eliminate noise in the image by using a Gaussian filter. This process aims to make thin lines undetected as an edge.
b) After having a smooth image, the next step is to calculate the gradient intensity of the image.
c) The next process is called by non-maximum suppression process. The process that turns all non-maxima to zero to reduce unwanted pixels into point edge. Finds all maxima that present in the image then keep them and removes the other non-maxima.
d) The next step is the Thresholding Hysteresis Process, the process of minimizing the edges that appear by examining the edges that have been obtained from the previous process whether they are true edges or not, to produce an accurate edge.
e) It is assumed that the edges are in the form of lines, so this last process is the removal of pixels that is deemed unfit to be an edge.

In this process, the image to be determined is given as input and the result is an edge map. The following figure shows the output of the canny edge detection process of an iris image.

Fig 2. The result of canny edge detection.

When edge point had been found, used Hough space for the parameters of circles passing through each edge point. These parameters are the center coordinates x_c and y_c , and the radius r. (x_j, y_j) is edge point with $j = 1,2, \ldots$ .which can be used to define a circle according to the equation

$$(x_j - x_c)^2 + (y_j - y_c)^2 = r^2 \tag{1}$$

Figure 3. a, b and c is a result of Hough transform.

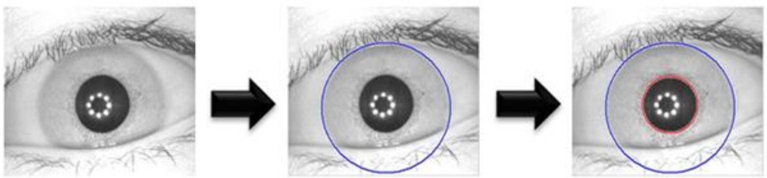

Fig 3. Process of Hough transform. (a): an image of iris, (b):an image of iris with iris circle, (c): an image of iris with iris circle and pupil iris.

2.3. IRIS NORMALIZATION

The process of normalizing the iris dataset is the stage of converting the annular iris from a ring form obtained from segmentation to a normalized rectangle. Each person's pupil has a different size, so the conversion is required from Cartesian coordinates to normalized pseudo-polar coordinates. The iris normalization function is used to produce an iris area with the same size in the form of a two-dimensional rectangular block that makes it easier to calculate the texture value.

Daugman rubber sheet model is an algorithm that changes the coordinates of each point in the iris-shaped area annular to polar coordinates (r, α) where r∈ [0,1] and α∈ [0, 2π] [8]. The process of changing iris regions I from Cartesian coordinates (x, y) to normalize polar coordinates (r, α) is expressed as follows:

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

with

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

and

$$y(r,\alpha) = (1-r)y_p(\alpha) + r y_l(\alpha) \tag{4}$$

where

$$x_p(\alpha) = x_{p0}(\alpha) + r_p * cos(\alpha) \tag{5}$$

$$y_p(\alpha) = y_{p0}(\alpha) + r_p * sin(\alpha) \quad (6)$$

$$x_l(\alpha) = x_{l0}(\alpha) + r_l * cos(\alpha) \quad (7)$$

$$y_l(\alpha) = y_{l0}(\alpha) + r_l * sin(\alpha) \quad (8)$$

Where the coordinates of the sample point of the pupil are called x_p, y_p and x_l, y_l are the coordinates of the sample point of the limbus along the direction θ. x_{p0}, y_{p0} are the pupil center coordinates and x_{l0} , y_{l0} are the iris center coordinates. The iris annular form is changed to the rectangular block form with size 64×512. When the iris image has been normalized and has the same size, it is possible that the image still has noise in the form of eyelashes and eyelids if the original image is iris covered by eyelashes and eyelids which reduces the iris recognition performance. Therefore, we need a method to overcome them. In this study, to eliminate noise in the form of eyelashes or eyelids on the iris image, the ROI (Region of Interest) of the iris was chosen, by processing only the upper part of the region in the form of 32 × 512 parts that are closest to the pupil, which provides information that is most discriminatory [7].

Fig 4. Result of normalization process.

2.4. BOX-COUNTING

Fractal theory is a modern geometry theory that facilitates the understanding of objects and natural phenomena that are irregular. One important findings of the fractal theory is the fractal dimension is different from the Euclidean dimension which is a non- negative integer, the fractal dimension can be a fraction, for example the fractal dimension of a sponge was 2.79; the fractal dimension of bread was 2.35 and so on. Fractal dimension plays a very important role in various aspects of life because it can measure the dimensions of data or real objects [9],[10].

Fractal dimension can be used to measure irregular objects, such as the soil dimensions show the degree of friability or soil texture, the fractal dimension of the sound of a musical instrument indicates the type of instrument and others [11]. In several years, the fractal dimension is also used in medical field. Safitri using fractal dimension for Classification of diabetic retinopathy with analysis of eye fundus image [9]. Juniati [12] used fractal dimensions to classify heart sound recordings with KNN and fuzzy c-means clustering method to classify a person in a healthy condition or having problems with his heart. Many methods have been produced to calculate the fractal dimensions of an object, some of which are: the Hausdorff dimension method, the Richardson dimension method which is often used to measure the dimensions of an object in the shape of a curve, for example the coastline of England. Meanwhile, the Hurst exponent method used to calculate the fractal dimensions of time series data and the method of box counting that are used to count an object in the form of images. In this study, the box counting method was used to determine the dimensions of the iris image. The method of box counting in principle is a comparison between the number of boxes (squares) that cover an image with the size of the box, where the size of a square that covers the image varies. The equation used was:

$$Dim = \frac{\log(N(r))}{\log\left(\frac{1}{r}\right)} \tag{9}$$

Where $N(r)$ indicated the number of boxes with size r that cover the image. The value of r change smaller and smaller, so that the data pair of $N(r)$ and r is obtained. Dimension fractal can be obtained from the slope of the line form by logarithmic of these pairs. When using statistical data processing, fractal box counting dimension values can be found by determining the coefficient value of the regression line equation from the data of log (N (r)) and $\log\left(\frac{1}{r}\right)$.

2.5. Feature Matching

The feature matching process is a process of finding suitable features from two similar datasets based on the concept of distance, this means that if two data distances are small then the two data are said to be similar. In this study, for the feature matching process, *K*-Nearest Neighbor (KNN) was used. For this process, the data divided into two parts, training data, and testing data using *k-fold cross-validation*. The cross-validation aims to avoid overlapping on data testing. *k*-fold cross-validation is a part of cross-validation. In *k*-fold cross-validation, the data is partitioned into *k* equally (or nearly equally). Process of testing and training repeat *k* times [13].

The next step, *K*-Nearest Neighbor (KNN) was used to classify based on learning data that has a close distance to the object and the Euclidean distance was used in this study.

3. RESULTS AND DISCUSSION

This experiment began with localization iris using Hough transform that used Canny edge detection. After that, normalization iris using Daugman's rubber sheet model was used for finding the iris region. This experiment used 60 images *Chinese Academy of Science* (CASIA) interval-V4 and 96 Images *Chinese Academy of Science* (CASIA) Twins [14]. The next process was done by calculated the value of the fractal dimension of each image using the box-counting method. The range of the fractal dimension of 156 iris images was 1.25523 – 1.3615. After the fractal dimensions of all iris images were obtained, the next process is feature matching. Feature matching consists of *k*-fold cross-validation process and *K*-Nearest Neighbor process. The values of the fractal dimension of all data divide using 5-fold cross-validation, 4 partitions were used for training data and the other one for testing data. Testing data was classified using K-Nearest Neighbor with Euclidean distance to know which class the data belong according the closest distance and then the accuracy of this iris recognition method was calculated to know how many percent of data were classified correctly.

The all process of classifying or recognizing iris is carried out in 4 different data groups. The first data was all data of 60 iris images comes from the iris of non-twins, its meant that there was no twins in the data. In the second data, the number of iris images of twins was 20% of the data. In the third data, the number of iris images of twins was 40% of the data. Meanwhile, for the fourth data, the number of iris images of twins was 60% of the data. The iris images of twins selected randomly from the data of iris twins.

From processing all data beginning with preprocessing iris images, which include iris localization and normalization of iris then feature extraction process using the box-counting fractal dimension and continued with matching features using KNN and cross-validation, the following results were obtained. For the first data group that does not contain iris images of twins, the accuracy of the iris recognition obtained was 93.33%. For the second data group that the number of iris images of twins was 20% of the data, the accuracy of the iris recognition obtained was 91.67%. For the third data group that the number of iris images of twins was 40% of the data, the accuracy of the iris recognition obtained was 75%. For the data that the number of iris images of twins was 60% of the data, the accuracy of the iris recognition obtained was 70%. From the accuracy of the different data groups, it could be seen that the amount of iris twins on the data affects the accuracy of iris recognition. The number of twins in the data is negatively related to the accuracy of iris recognition, namely the more twins the iris recognition data, the smaller the accuracy. This indicates that the presence of twins in the iris recognition data will affect the accuracy, especially if the number of twins is quite large.

For further analysis and convincing conjecture that the twins' irises are very similar in that case the fractal dimensions of the twin iris are almost the same, so that it affects the accuracy of the iris recognition, the iris relationship between twins is examined by correlation statistical tests. Pearson Correlation test was performed on twin iris data consisting of 48 twin pairs (96 iris images). The Pearson correlation value or r will be calculated, which describes the relationship between the fractal dimension of iris a person and the fractal dimension of iris of his/her twin. The left eye iris is paired with the iris of the left eye of the twin, and the right iris is paired with the right eye iris. To see whether this phenomenon is also true for non-twins, a correlation calculation is also performed to see the relationship between a person's iris and the iris of a person who is not his/her twin (randomly selected data). The data used was 48 pairs of twin iris data.

By using SPSS, it was obtained the Pearson correlation between the iris of the twins r= 0.727 with a significance value = 0.000 that less than alpha value used (0.05). This result showed that there was a positive significant relationship of the fractal dimension of iris between twins. While the Pearson correlation value of fractal dimension of iris between non-twins for the first trials was obtained r= 0.035 with a significance value = 0.814 and for the second trials, it was obtained r=0.149 with the significance value=0.313. The significance values of both were greater than 0.05 (the value of alpha) so it can be concluded that there is no relationship between iris of non-twin. This can be seen in the following Table 1 which show SPSS output table.

TABLE 1 SPSS output table of correlations.

		FracDimTwin1	FracDimTwin2	FracDimRandom1
FracDimTwin1 (N = 48)	Pearson Correlation	1	0,727**	0,035
	Sig (2-tailed)		0,000	0.814
FracDimTwin2 (N = 48)	Pearson Correlation	0,727	1	0,149
	Sig (2-tailed)	0,000		0,313
FracDimRandom1 (N = 48)	Pearson Correlation	0,035	0,149	1
	Sig (2-tailed)	0,814	0,313	

** Correlation is significant at the 0.01 level (2-tailed)

4. CONCLUSION

Iris of two twins has a high level of similarity and relationship, this can be seen from the high and significant correlation value, $r = 0.727$ which illustrates the relationship between the dimensions of the fractal iris of two twins, where this does not occur in non-twins. Because the iris relationship of twins is very high, it certainly makes sense if this affects the recognition of iris. Based on the results of the study, the number of twins in the data is negatively related to the accuracy of iris recognition, namely the more twins in the iris recognition data, the smaller the accuracy. This was evident from the results of the study as follows. For the data without twins, the accuracy of the iris recognition obtained was 93.33%. For the data group that the number of iris images of twins was 20% of the data, the accuracy of the iris recognition obtained was 91.67%. For the data group that the number of iris images of twins was 40% of the data, the accuracy of the iris recognition obtained was 75%. For the data that the number of iris images of twins was 60% of the data, the accuracy of the iris recognition obtained was 70%. Based on the results of this study, further research is needed to find other methods of iris recognition that involve twins in relatively large numbers to obtain a high degree of accuracy in iris recognition. Further research is also needed to get an important part that distinguishes the iris from two twins so that it can be used in the recognition of twins' irises.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests.

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