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Iris Recognition Using Feature Extraction of Box Counting Fractal Dimension

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Abstract. Biometrics is a science that is now growing rapidly. Iris recognition is a biometric modality which captures a photo of the eye pattern. The markings of the iris are distinctive that it has been proposed to use as a means of identification, instead of fingerprints. Iris recognition was chosen for identification in this research because every human has a special feature that each individual is different and the iris is protected by the cornea so that it will have a fixed shape. This iris recognition consists of three step: pre-processing of data, feature extraction, and feature matching. Hough transformation is used in the process of pre-processing to locate the iris area and Daugman's rubber sheet model to normalize the iris data set into rectangular blocks. To find the characteristics of the iris, it was used box counting method to get the fractal dimension value of the iris. Tests carried out by used k -fold cross method with $k=5$. In each test used 10 different grade K of K -Nearest Neighbor (KNN). The result of iris recognition was obtained with the best accuracy was 92,63 % for $K = 3$ value on K -Nearest Neighbor (KNN) method.

Keywords: Biometrics, Iris Recognition , Fractal Dimension.

1. Introduction

Biometric is a science that is now growing rapidly. The unique and distinctive characteristic of human beings makes biometrics of many researchers and academics as an effective and efficient identification system. Some biometric systems such as fingerprint recognition, face recognition and iris recognition. Iris recognition is selected by researcher because it has unique and relatively stable patterns. Several methods have been used for iris recognition systems [1]. The main differences of some iris recognition systems are the methods used that is how to extract and analyze the iris features. Iris recognition usually three main steps: iris preprocessing which consist of localization iris and normalization iris, feature extraction, and feature matching. Many experiments about iris recognition. Daugman who the first introduce iris recognition with title "High Confidence Visual Recognition of Persons by A Test of Statistical Independent"[2]. Daugman used 2-D Gabor wavelet for feature extraction and Hamming distance. In 2013, Chen et al published journal with title "Iris Recognition on Bidimensional Empirical Mode Decomposition and Fractal Dimension". Chen used Bidimensional Empirical Mode Decomposition Localization (BEMD) and Fractal Dimension for feature extraction, the result describe that fractal dimension can use for feature extraction of iris recognition [3]. Segmentation Iris consist of iris localize and iris normalize. iris localization used Hough transform. Hough transform is the method used to find the regular shape, e.g. line or circle in shape [4]. Furthermore, for normalization iris annular into a rectangular block used Daugman's rubber sheet model. Daugman's rubber sheet model is mapping every point in annular iris to pseudo-polar coordinates. The second process, feature extraction using box counting to get the fractal dimension value of the iris. Box counting method effectively is used to



calculate the dimensions of an object with an irregular shape. Iris texture is irregular, so box counting suitable for feature extraction. Feature extraction for iris recognition is finding the characteristics of the iris, which used box counting method to get the fractal dimension value of the iris. The last process, feature matching used k -fold cross-validation and K -Nearest Neighbor (KNN) method [5]. The fractal dimension value of the iris divides into two parts training data, and testing data. Then, K -Nearest Neighbor (KNN) with Euclidean distance is used to classification.

2. Method for Iris Recognition

2.1. Canny edge detection

Edge detection processes find edge from the object. Edge of the image on the border between two-pixel regions that have a contrasting color. The purpose of edge detection is to extract important feature on an image, such as lines, circles, edges. In essence, edge detection is useful to know the boundaries between an object against the background object picture [1].

The following is a Canny edge detection algorithm:

- Reduce noise image using Gaussian filter using standard devices (σ). This process aim to make thin lines of image undetect as edge.
- Calculate gradient intensity of image with determining gradient direction to particular direction.
- Non maximum suppression process to muffle undesired pixel into point edge.
- Thresholding Hysteresis Process or process of minimizing the emerging edge to produce accurate edge line. In other words, this process converts the pixel value to zero if it is deemed unfit to be an edge.

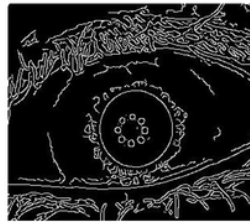


Figure 1. Result of Canny edge detection

2.2. Iris localization using Hough Transform

Hough transform is a method for finding regular shapes from the image as line, circle image, etc. The circular Hough transform can be employed to deduce the radius and center coordinates of the pupil and iris regions [4]. Hough transform process consists of 3 step. The first step is edge detection using Canny edge detection. The purpose of edge detection is to decrease points in the image. When edge point has been found, votes are cast in 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) edge point with $j = 1, 2, \dots$, which are able to define any circle according to the equation

$$(x_j - x_c)^2 + (y_j - y_c)^2 = r^2 \quad (1)$$

Here result of Hough transform

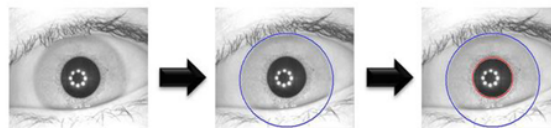


Figure 2. Process of Hough transform

2.3. Iris Normalization

Normalization of the iris dataset is the stage where the annular iris obtained from the normalized segmentation results into a two-dimensional rectangular block. The pupils of each individual are of different sizes, therefore the conversion of Cartesian coordinates to the normalization of pseudo-polar coordinates. The iris normalization function is to produce iris regions of equal size which make it easier to calculate the texture value. Daugman's model rubber sheet model or so-called Daugman's algorithm reprints every point in the iris area (between the two pupil areas and the limbus boundary) annular to the apparent polar coordinate (r, θ) where $r \in [0, 1]$ and $\theta \in [0, 2\pi]$ [4]. Reconstruction of iris regions I from Cartesian coordinates (x, y) to normalized polar coordinates (r, θ) is expressed as follows:

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

with

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

and

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

where

$$x_p(\theta) = x_{p0}(\theta) + r_p * \cos(\theta) \quad (5)$$

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

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

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

where, x_p, y_p are the coordinates of the sample point of the pupil and x_l, y_l are the coordinates of the sample point of the limbus along direction θ . x_{p0}, y_{p0} are the pupil center coordinates and x_{l0}, y_{l0} are the iris center coordinates [4].

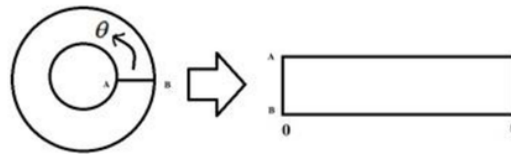


Figure 3. Result of iris normalization

Iris annular became into the rectangular block with size 64×512 . Despite all normalized iris templates being the same size, eyelashes and eyelids will still be visible on the templates, reducing iris recognition performance. Therefore, an ROI (Region of Interest) is selected to remove the influence of eyelashes and eyelids, by extracting features only from the upper half of the region 32×512 the section closest to the pupil, which provides the most discriminating information [3].

2.4. Box Counting

Fractal dimension is not like Euclidean dimension, the fractal dimension has a non-integer number of dimension. Fractal dimension is very important because it can measure the real data [6]. For example, a measure of the cloud to predict rain, a measure of soil to determine soil fertility, a measure of dust to determine air cleanliness, and so on. Many methods are used to find fractal dimensions such as Hausdorff method, Richardson method, Hurst exponent method and box-counting method. In this research, we used the box-counting method to determine iris image dimension. Calculating the dimensions of an image using the box-counting method is done by covering the object area with a square box with varying sizes [7].

This is an equation for measure fractal dimension using the box-counting method:

$$Dim = \frac{\log(N(r))}{\log(\frac{1}{r})} \quad (9)$$

where $N(r)$ is value of boxes containing the image, r is ratio of the length segment or in the word r is scale. The following is an algorithm for finding fractal dimension using box counting [6]:

1. Covering the object area with square boxes with size r bagian. r value change from 1 to 2^n , with $n = 0, 1, 2, \dots$
2. Calculate value of $N(r)$, the number of boxes containing the object.
3. Calculate value of $\log\left(\frac{1}{r}\right)$ and $\log(N(r))$
4. Creating a straight line from value of $\log\left(\frac{1}{r}\right)$ and $\log(N(r))$
5. Calculate the slope of a straight line with the following equation:

$$\alpha = \frac{(\sum_{k=1}^n xy) \left(\frac{\sum_{k=1}^n x}{n} \right) \left(\frac{\sum_{k=1}^n y}{n} \right)}{(\sum_{k=1}^n x^2) \left(\frac{\sum_{k=1}^n x}{n} \right)^2} \quad (10)$$

Where $x = \log\left(\frac{1}{r}\right)$, $y = \log(N(r))$, n = amount of data used, and α is slope which be called the fractal dimension

2.5. *k-fold cross-validation*

Cross-validation is a method to divide data into two parts, training data, and testing data. In computing, 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 [8].

2.6. *K-Nearest Neighbor*

K -Nearest Neighbor (KNN) is a classified method based on learning data that has a close distance to the object. To determine the distance between two points are used Euclidean distance, defined as follows:

$$D(x, y) = \sqrt{\sum_{i=1}^n (x_i - y_i)^2} \quad (11)$$

where D is a distance between a point on testing data x and training data y that will be classifying. Here is the algorithm of KNN method:

- a. Start
- b. Determine the number of K
- c. Calculate distance of testing data to training data using distance formula
- d. Sorting the data based on small to large from Euclidean distance
- e. Specifies the group of testing data to majority label of K
- f. Stop

3. Methodology

3.1. Data

In this study, the data of iris was chosen from Chinese Academy of Science (CASIA) interval-V4 database and randomly selected. In this experiment was used 60 images from 10 classes. Each image has resolution of 280×320 pixel in JPG format.

3.2. Procedur of iris recognition

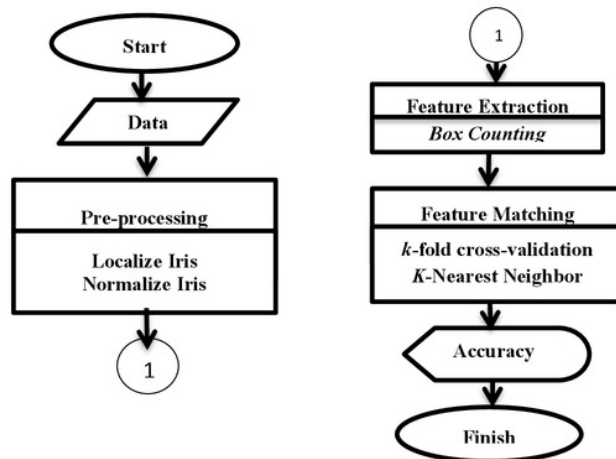


Figure 4. Flowchart of experiment

The iris recognition process begins with segmentation iris which consist of localize iris using Hough transform and normalize iris using Daugman's rubber sheet model. After segmentation process, then feature extraction with calculate the value of fractal dimension using box-counting method. Then, the next step is feature matching. The feature matching consist of two steps, that is k -fold cross validation method with $k=5$ was divide randomly into 5 sections with equal size and classification method was used in this study is K -Nearest Neighbor (KNN) with Euclidean distance.

4. Experimental result

The iris recognition process begins segmentation process consists of localizing iris using Hough transform and normalize iris using Daugman's rubber sheet model. In this experiment used 60 image *Chinese Academy of Science (CASIA) interval-V4*. This is example of segmentation process of "S1002L01.jpg".

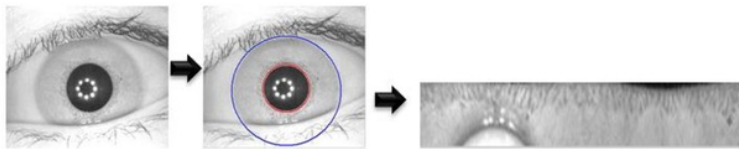


Figure 5. Example of segmentation process of "S1002L01.jpg"

After segmentation process, the next process calculated the value of fractal dimension in each image using the box-counting method. Example, iris of "S1002L01.jpg" has the value of fractal dimension equal 1.2827. In this experiment, all data have a value of fractal dimension in range 1.25523 – 1.38377. Furthermore, feature matching consists of k -fold cross-validation and K -Nearest Neighbor. It is begins that the value of 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 is classified using K -Nearest Neighbor to know which class of data and then to knows accuracy.

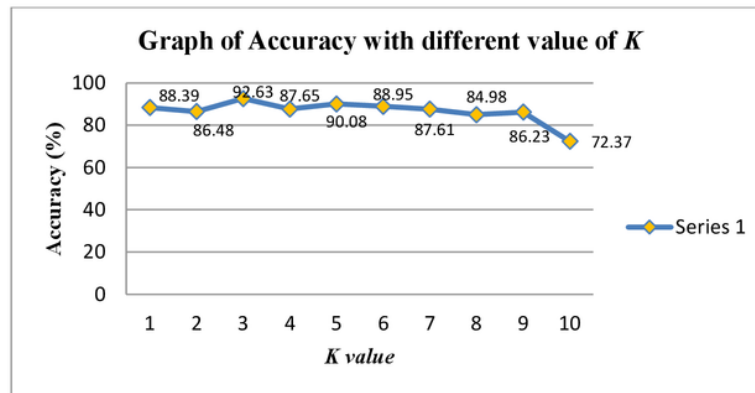


Figure 6. Graph of accuracy with different value of K

The best accuracy value is 92.63 % with $K=3$

5. Conclusion

Based on the result, it was known that fractal dimension of box counting method can be used to iris recognition. The process of iris recognition was three step: pre-processing iris consist of localize iris using Hough transform and normalize iris using Daugman's rubber sheet model, feature extraction using box counting, and feature matching using KNN and k -fold cross-validation. Iris recognition using feature extraction of box counting fractal dimension has accuracy value 92.63 % with 3-NN and 5-fold cross-validation.

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