A Wavelet Based Iris Recognition Method

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Abstract

There have been numerous implementations of security system using biometric, especially for identification and verification cases. An example of pattern used in biometric is the iris pattern in human eye. The iris pattern is considered unique for each person. The use of iris pattern poses problems in encoding the human iris.

In this paper, an efficient iris recognition method is proposed. In the proposed method the iris segmentation is based on the observation that the pupil has lower intensity than the iris, and the iris has lower intensity than the sclera. By detecting the boundary between the pupil and the iris and the boundary between the iris and the sclera, the iris area can be separated from pupil and sclera by means of the Hough transformation. A step is taken to reduce the effect of eyelashes and specular reflection of pupil. Then a four levels Daubechies wavelet transform is applied to the extracted iris image. The modified Hamming distance is employed to measure the similarity between two irises.

This research yields the identification success rate of 92.37% for the CASIA version 1.0 database. The method gives an accuracy of 87.26% for the left eyes of MMU 1 database and 94.73% for the right eyes. The time required for the encoding process, from the segmentation until the iris code is generated, is 0.85 seconds. These results show that the accuracy and speed of the method is better than many other methods.

Keywords:

biometric, iris recognition, wavelet transform

Introduction

There have been numerous implementations of security system using biometric, especially for identification and verification cases. Biometric has been used to identify a human based on the different pattern owned by the human. The uniqueness of the pattern is one advantage of biometric, since the pattern is almost impossible to be imitated by others. The main concern in biometric is finding a pattern to uniquely identify individuals. Another concern is that the pattern must not be easily changed by natural causes, e.g. temperature, climate, age, illness, etc. Some biometric patterns that have been used are finger print [1], palm print [2], and iris [3]-[11].

One of the advantages of using iris for biometric is that the iris is protected by cornea and aqueous humor. Other advantages includes, the iris pattern is fixed since a person aged 8 months and the pattern is unique, because it is determined by DNA [3]. Iris image acquisition is also fast and easy. Beside those advantages, iris recognition also have some disadvantages, e.g. a direct iris acquisition may result in erroneous data due to blinking eyes, illumination, specular reflections, patterned contact lenses, etc. In many cases eyelashes also poses problems in iris recognition. This paper presents an improvement over the method presented in [12].

The Iris Recognition Method

The processing of the iris image in the proposed method consists of four stages. These stages are image normalization, image segmentation, feature extraction and similarity measurement. In the normalization step, the iris image is converted to 256 gray level images.

The second stage is image segmentation. In this stage, two processes are carried out. Those are pupil localization and iris localization. The segmentation process is based on the observation that the pupil is normally darker than the iris and that the iris is darker than the sclera, see Figure 1. It is assumed that pupil and iris have circular shape with different centers. In many cases the upper and lower part of the iris is often occluded by eyelids.

In order to determine the pupil location, the image of an eye is divided into 8x8 regions. The mean intensity from each region is calculated and the lowest mean intensity value is used as a threshold. After that, the image of the eye is transformed into binary image using T as the threshold as in equation (1) [13].

$$g(x,y)=\begin{cases}1, f(x,y)>T\\0, f(x,y)\le T\end{cases} \tag{1}$$

The resulted image $g(x, y)$ is the binary form of the image $f(x, y)$. The result of this process is a noisy pupil mask image. The noise is usually in the form of dark areas which comes from eyelashes and or eyebrows. Since this noise usually covers less than 500 pixels, thus to remove or reduce the noise, darks areas less than 500 pixels are removed. The final result is normally one dark area which is the pupil. In the case that more than one dark object are found after noise removal, the dark object whose center is closest to the center of the image is selected as the area of the pupil. The diameter of the pupil is determined by finding the largest gradient change to the left and right of the center of the pupil. The result of this process is shown as the inner circle in Figure 1. The second process in the image segmentation is the iris localization process. Since the top and bottom part of the iris are often covered by eyelashes, the boundary of the iris is sought after along the horizontal line starting from the pupil-iris boundary. In [12] the boundaries of the iris are found by selecting the largest gradient change to the left and right of the pupil. It is observed that the diameter obtained this way sometimes is too large which is not correct. In order to reduce the error rate, a number of radial scans are carried out. These radial scans cover 15 degrees above and below the horizontal line. This process resulted in the outer boundary of the iris, shown as the outer circle in Figure 1.

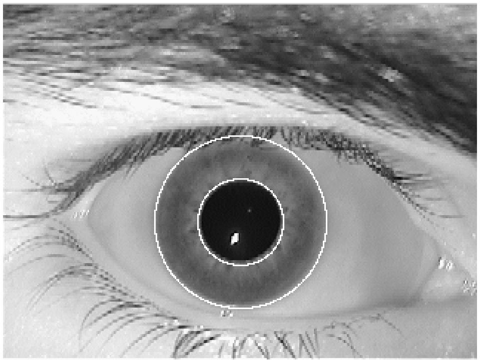

Figure 1 Example of the result of the segmentation process (the iris is the area between the inner and the outer circles).

Since in most cases the upper and lower parts of the iris area are occluded (see Figure 2), the authors decided to use only the left and right parts of the iris area for the iris recognition. This is done by cropping the iris area above the upper boundary of the pupil and the area below the lower boundary of the pupil. Example of the result of this process is shown in Figure 2.

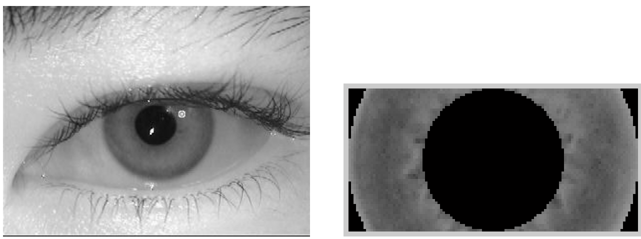

Figure 3 (Right) Example of iris where the upper part is occluded and (Left) the segmentation result

The third stage in the iris recognition is the extraction of the iris features. It is observed that the size of pupil changes in response to lighting condition. In order to reduce the effect of lighting on the size of the pupil, the segmented iris image is divided into four areas. They are upper right area, upper left area, lower left area and the lower right area. The four areas are position in such a way that pixel reading from the center of the iris outward can be carried out in a left to right and top to bottom fashion.

In order to reduce the iris code size, a one dimensional wavelet transformation is used. First, the iris area is converted into 1D form by dividing the iris area into 5x5 pixel blocks. Then the mean intensity of each block is calculated in a left to right, top to bottom fashion. Each signal is transformed using 2nd order Daubechies wavelet transformation with four decomposition levels.

In each decomposition level, the wavelet transformation divides the signal into approximation signals and detail coefficients. In this method, the 4th level approximation coefficients are used to represent the iris. To reduce the code size and the similarity measurement process, all coefficients are stored in integer form.

The final stage is matching the iris code of the unknown and the iris stored in the system. The matching is carried out by computing the distance between two iris codes. In this research, the modified Hamming distance (*HD*) is used to measure the distance between two iris codes (C_A and C_B). The Hamming distance between two binary iris codes of length *N* is calculated as

$$HD = \frac{1}{N} \sum_{i=1}^{N} C_A(i) \oplus C_B(i) \tag{2}$$

Since the iris codes used in this research is integer and the length of the codes varies, a modified Hamming distance is used to compute the distance between a pair of iris codes. The modified Hamming distance is shown in (3).

$$IRIS\_DISTANCE = \frac{1}{4} \sum_{j=1}^{M} \left(\frac{\sum_{i=1}^{N} |a_i - b_i|}{\sum_{i=1}^{N} \max(a_i, b_i)} \right)_j \tag{3}$$

where *N* is the length of the shorter of the two iris codes being measured, a_i and b_i are the i^{th} element of the iris codes, and *M* is equal to four (there are four blocks of the iris codes representing upper right area, upper left area, lower left area and the lower right area of the iris).

Results and Discussion

Experiments are carried out to test the proposed method. For this purpose the proposed method is implemented in MATLAB. The iris databases used in this experiment were taken from CASIA (Chinese Academy of Sciences Institute of Automation) version 1.0 [14] and MMU (Multimedia University) version 1 [15]. The CASIA database consists of eye images that were taken from 108 persons (seven images per-person) from two sessions, and each session were taken with an interval of one month. MMU database consist of eye images that were taken from 46 persons, ten images were taken from each person (left and right eyes). In these two databases the image are mainly eyes as shown in Figure 1.

The results of coding the iris from the two databases are shown in Table 1. For the CASIA iris database, all irises are coded successfully. For the MMU iris database, one out of 450 irises are failed to be coded. The method failed to locate the iris of Thomas (“thomasl3.bmp”). The failure is due to bright areas in the iris. The overall iris coding success rate is 99.92%. The average time required for coding is 732 ms per iris on an AMD Athlon XP 1800+ with 640 MB of RAM.

Table 1 Result of iris coding test

Database	**Number of Data**	**Number of Failure**	**Time (second)**	**Average (second)**
CASIA 1.0	756	0	573,23	0,758
MMU 1.0	450	0	309,87	0,688

The experimental result on person identification is shown in Table 2. In this experiment, the method gives an accuracy of 86.11% for the CASIA iris database. For the CASIA database the second session data is used as query and the first session data is used as the system database. The proposed method yields accuracies of 80% and 91.11% for the left and right eyes of the MMU iris database. For the MMU database the first and second image acquisitions are used as queries and the third, fourth and fifth are used as the system database. The overall accuracy is 85.74%.

Table 2 Iris identification result

Database	Number of Query	Number of persons identified	Number of person correctly identified
CASIA 1.0	432	108	93
MMU 1 Left	89	45	36
MMU 1 Right	89	45	41

Table 3 shows the results of iris identification methods proposed by other researchers when tested using the CASIA iris database version 1.0. Please note that the results from Daugman [3], Masek [7], and Wildes [4] are obtained from Proença and Alexandre [16]. The experimental results shows that the proposed method is superior to methods proposed by Masek[7], Daugman [3], Maimuna [11] and Harjoko et.al. [12], however the accuracy of the proposed method is inferior compared to the methods proposed by Wildes [4] and Selzer [10]. In term of speed however, the proposed method is much more efficient than Selzer’s method which requires 4-9 seconds to encode one iris of the CASIA database (the proposed method requires only 0.732 second).

Table 4 shows the results of the verification test of the proposed method. The verification test shows that the optimum threshold for the proposed algorithm is 0.1208 where the false acceptance rate (FAR) and the false rejection rate (FRR) are equal.

Conclusion

An iris recognition method is proposed in this paper. The proposed method consists of 4 stages and has successfully encoded the CASIA iris database version 1.0 and the MMU iris database version 1.0 with a success rate of 99.92%. The proposed method gives an overall accuracy of 85.74% which is higher than a number of existing iris recognition method.

Table 3 Result of other research using CASIA 1.0

Researcher	**Parameter**	**Identification Rate**	**Notes**
Selzer [10]	*Threshold* = 120	100 %	-
Wildes	*Hysteresis thresholds*, hi= 44, low=39, Dimension of Gaussian Kernel = 5	86,49 %	Coded by Proença and Alexandre [16]
Harjoko et.al.	Minimum Pupil size=500, multiple scan, Daubechies	85.74%	-
Harjoko et.al.	Minimum Pupil size=500, single scan, Coiflet	84,25%	-
Masek	Dimension of Gaussian Kernel =5, Kovesi Parameter = 39,34	83,92 %	Coded by Proença and Alexandre [16]
Daugman	-	54,44 %	Coded by Proença and Alexandre [16]
Maimuna [11]	-	5,98%	The test use only 117 images as database and 89 images as query.

Table 4 Results of verification test

Threshold	**FAR**	**FRR**	**|FAR-FRR|**
0.0700	0.555	0.084	0.470
0.0900	0.428	0.166	0.261
0.1000	0.382	0.207	0.175
0.1100	0.326	0.245	0.081
0.1150	0.308	0.263	0.044
0.1200	0.288	0.281	0.007
0.1205	0.284	0.282	0.001
0.1208	0.283	0.283	0.000
0.1210	0.282	0.284	0.001
0.1300	0.236	0.312	0.075
0.1500	0.172	0.366	0.193
0.2000	0.067	0.472	0.404

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