Available online at http://www.csjonline.org/

The Caspian Sea Journal
ISSN: 1578-7899

Volume 10, Issue 1, Supplement 4 (2016) 585-589

Identification based on Iris Texture

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ABSTRACT─ The identification methods based on biometric characteristics are of great importance nowadays. The identification based on iris texture is of particular importance due to the high accuracy and very good security which can be achieved by it. So in this paper, some iris based identification algorithm is presented. In this work, processing steps of iris tissue are described that contains the images acquisition, iris isolation, normalization, feature extraction and pattern matching. For the pattern matching stage, three algorithms based on the subtraction and Hamming codes was proposed. The presented methods were evaluated on selected iris database and as a results the subtraction algorithm outperformed the others with matching accuracy of 99.8% achieved by applying on 120 iris images. The results proved that the presented matching method is appropriate enough for authentication systems.
Keywords: Biometrics based on Iris, Image Processing, Identification

Introduction

Biometrics is the identification of individuals using their behavioral and physiological characteristics. Different biometric technologies such as fingerprint recognition, iris, face, voice, etc. are used for identification purposes, which are the human behavioral or physiological characteristics. In all biometric systems, there are common parameters that define the features and capabilities of the system. The parameters are: 1.Wrong acceptance rate: this parameter determines the possibility of accepting fake user instead of the original user. This parameter must be as small as possible. 2. False rejection rate: this scale reflects the extent to which the original person is rejected mistakenly (high sensitivity). These parameters should also be low as possible. 3. The equal error rate: reduction of false acceptance rate is led to non-deliberate incrementing of false rejection rate. The point at which the false rejection rate is equal with the false acceptance rate, is called equal error rate point. The lower the value of this parameter indicates that the system has a better sensitivity and good balance. 4. The rate of false registration: the probability of error which may occur in the correct diagnosis when sampling for registration in the database. According to presented researches, one of the unique features of human is his eye. The probability of authentication error in this method is significantly 1 out of 1078. Scanning the iris also makes it possible for the system to test and compare up to 200 points of the iris. However, for the identification based on fingerprints, 60 to 70 points are examined. In the human body, iris is a complex set of muscles located on the front of the human eye which makes it is easy to be observed and measured. Iris is strongly protected by the cornea and the eyelids which result in low chance of injury throughout human lifetime [1]. The structure of Iris tissue have been described to be unchanged and stable throughout human lifetime and also with a high degree of structural wealthy and almost a little dependence on human genes which can be used as a way to identify identical twins. Iris will not change with the passage of lifetime which makes this method more suitable over other identification methods. Also after eye surgery, the patient's iris remains unchanged in most cases. This method can also be used even for the blind people as long as their eyes have iris. The use of glasses or contact lenses does not interfere in diagnosis routine, and does not cause false detection. Various researches have been done in the field of identification based on iris. Daugman, Gabor filter used for the iris feature extraction and phase information used tissue [2]. Boles and Boashah have used zero-crossing points of one-dimensional wavelet transform at different scales on the concentric circles of the iris with the pupil as a center [3].Tan and his colleagues used multi-channel Gabor filters used for feature extraction [4]. This paper is organized as follows: In Section 2, the methodology of the presented algorithm will be explained. The simulation results of the proposed algorithm are presented in Section 3, as well as accuracy comparison with various algorithms, together with a discussion of the advantages of the proposed algorithm. Finally in Section 4, a brief conclusion of this study is presented.

Methodology and the proposed algorithm

In this section, the methodology and the proposed method are going to be explained in different subsections. The overall view of this study is shown in the flowchart of Figure 1.

Figure 1. Flowchart of the presented algorithm. Different processing stages of eye's image

Isolation of iris

As it's shown in Figure 2, images of the eye not only include the area of the iris but also the pupil, eyelids, eyelashes and reflections. Thus, unwanted features should be removed, so the iris could be separated from the rest of the image.

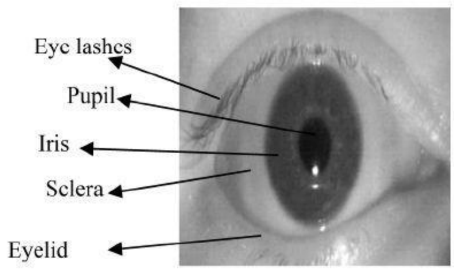

Figure 2. Different parts of the eye

Iris can be roughly considered as a circular area enclosed between two circles in which the first circle is the iris border with sclera, and the second circle is the iris border with the pupil. The areas are shown in Figure 3.

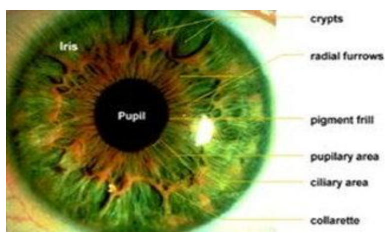

Figure 3. The location of iris between two circular boundaries

To obtain the inner and outer properties of iris, the edges of the picture must first be determined. Using Hough transform it could be determine which parts are located on the circular borders or the shapes defined by a specific parametric equation. Since the Hough algorithm is time consuming and also the center of iris are not too far from the center of the pupil, so the search area for iris center can be limited with respect to the center of the pupil. Then to remove the rest of the eyelids and eyelashes, the average value of twelve neighborhood pixels of the picture is calculated. Then, each pixel of the image is deducted of this value and compared with a certain threshold value. If the value obtained was lower than the threshold, it is considered as eyelash. Most complex tissues which have the information necessary to identify the iris are located in the areas near the center of pupil which is called collarets. After identifying the internal border of the iris and the pupil, a circle is plotted with centrality of the pupil and the certain radius from internal border. The border of this circle is considered as the outer boundary of the iris. By doing so, not only the collarets area area is extracted very well but masking the iris region by the upper and lower eyelids and eyelashes is also prevented. These steps are shown in Figure 4.

Normalization

Normalization is done after isolation of the iris. Some of the factors cause changes in the iris, which impairs the correspondence between the irises. These factors are the distance between camera and eye, pupil size changes due to change in ambient light and so on. To avoid the impact of these factors, iris is going to be normalized. In normalization stage, the iris is turned to a rectangular area with consistent dimensions. At this point, the Rubber sheet Daugman's model is used to transfer each points of iris to the related points in polar coordinates. This map is shown in Figure 5. After separation of iris's borders, the iris is normalized to a fixed size rectangular block using Daugman normalization method with equations of 1 to 3.

$$I\ (x(r,\theta\ ), y(r,\theta\ )) \rightarrow\ I\ (r,\theta) \tag{1}$$
$$X(r,\theta) = (1-r)x_p(\theta\ ) + x_s(\theta) \tag{2}$$
$$Y(r,\theta) = (1-r)y_p(\theta) \tag{3}$$

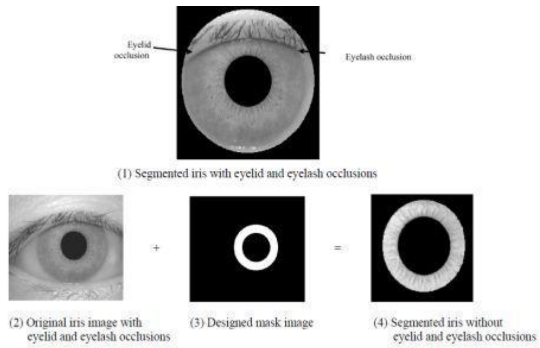

Figure 4. Proposed steps to isolate the iris

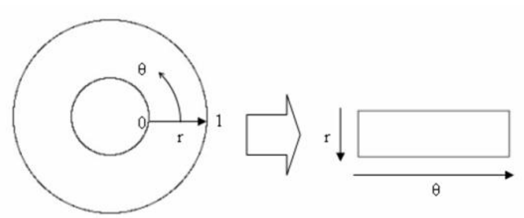

Figure 5. Mapping the iris disc on a strip with the desired dimensions

Image enhancement

Since the identification is done using patterns in the iris's tissue, the images must be of good quality in terms of contrast. Depending on the shooting conditions and the location of the light source, it is possible that ambient light is not spread uniformly on the entire surface of the iris. In this study, mean filter, histogram smoothing and then two-dimensional adaptive low-pass Wiener filtering is used to achieve the proposed method. Wiener filter eliminates the high frequency noise of image. Two-dimensional Adaptive Wiener filter which eliminates the noise, is a filter of linear filters family that will comparatively adapts itself to the local variances of the image. The functionality of filter is set so that, wherever the image variance is large, smoothing is mildly done by filter and when the variance is small, smoothing operation is carried out intensively. By using equations of 4 to 6, two-dimensional Wiener filter estimates the mean value and the variance around each pixel to perform filtering.

$$\mu = \frac{1}{nm} \sum_{n1,n2\in\eta} \alpha(n1,n2) \tag{4}$$
$$\sigma^2 = \frac{1}{nm} \sum_{n1,n2\in\eta} \alpha^2(n1,n2) - \mu^2 \tag{5}$$
$$b(n1,n2) = \mu + \frac{\sigma^2 - v^2}{\sigma^2}(\alpha(n1,n2) - \mu) \tag{6}$$

Where, V^2 is the noise variance? This value is fed to the filter if a certain noise with known variance is considered, otherwise the filter uses the average of all local variance estimates.

Feature extraction

To obtain a precise identification systems, important information contained in the iris tissue that indicate different identity between people, must be extracted from the images. In this paper ridgelet transform is used to extract the features of the iris and finally these outcomes have been examined and evaluated in terms of precision and timing. In many cases, the wavelet transform is used as the main tool to extract features. Wavelets are appropriate for zero dimension or the point singularity, but two-dimensional signals such as digital images have one-dimensional singularities. Therefore, wavelet-based techniques are less precise for detecting geometrical structures, which naturally appeared at the continuous edges of images. In other words, wavelet are not efficient enough to identify the lines and curves because of their structure. In the case of the smoothed areas which are separated by the edges, the wavelet transform could be a good choice only if these areas have little continuity; but it's not performing well in the case of images with more continuous and sharp edges. It generally can be said that the wavelet transform in two-dimensional environment, is not suitable for isolation of continuous and right edges and as a result, being continuous in line with an edge cannot be shown. To overcome this limitation of wavelet transform, the researchers have presented a new transform called ridgelet transform. This transform was based on the idea of mapping linear technique to point technique, which in turn was the basic idea of the Radon transform. [5].

Suppose that f (x) is an integral function of two variables. Ridgelet transform in R2 domain can be defined as equation (7):

$$\iint \emptyset_{a,b,\theta}(x1, x2) f(x1, x2) d_{x1} d_{x2} \quad (7)$$

$$\emptyset_{a,b,\theta} = a^{-0.5} . \emptyset(x1 \cos\theta + x2 \sin\theta - b)/a \quad (8)$$

Matching

A simple and efficient method to evaluate compliance rate is subtract or XOR. Given that the noise of image has been almost eliminated, so the risk of error would be negligible. In this paper, subtract and XOR are used for matching. For this purpose, the images are subtracted pixel by pixel from each other. The only thing that can be a problem in this case is the rotation of input images. Considering the fact that the picture might be taken in different positions of eye and head, it is possible to have different direction of the head and as result, the image taken cannot aligned with image stored. In addition, the algorithm should be immutable to the transfer and scaling. These two factors are eliminated by normalization. Another method is used for performance comparison which is called "Hamming". Hamming distance is a measure that indicates the number of bits which are not similar when comparing two vectors. By using Hamming distance for comparing two models in the iris-based identification system, it can be said whether the two codes generated from the images are belonged to the certain eye or not. To compare the two codes Y and X, Hamming distance is the sum of the difference between the two bits x and y, for all the elements contained in them. [6]

Simulation results

CASIA I database [7] is used to evaluate the performance of the proposed algorithm. A typical PC using Windows 8 as its OS powered by a Pentium Corei7 processor (3GHz) was used to apply the proposed algorithm to the database and to do the whole computing process. The results of applying various algorithms on a single database, is shown in Table 1. The results proved that the differential algorithm have shown the best performance with an identification accuracy of 99.8%.

Table 1. Results of applying various algorithms on a single database

Proposed algorithms	**Accuracy rate of identification**
Subtract	99.8%
XOR	98%
Hamming code	97.57%

For better evaluation of the presented algorithm, the population of statistical society is increased to examine the stability of the proposed algorithm. The results of applying subtract algorithm on different statistical societies is shown in the Figure 6. According to Figure 6, the detection accuracy varies from 99.8% to 97% in the statistical society of 120 to 400 people respectively, which in turn indicates the relative stability of the algorithm against large communities.Finally, the performance of the proposed algorithms is compared with other methods in different literature. The results of this comparison are presented in Table 2. As can be seen, the proposed algorithm has better identification accuracy against other methods except the "Selzer".

Conclusion

One of the most important issues today, is information security and without a doubt, biometric systems are one of the most versatile systems in order to achieve this objective. Therefore, in this paper a simple and efficient method for matching images was presented to improve the identification systems based on biometrics. At first, the pre-processing steps were introduced and explained according to the proposed flowchart. Then, three different algorithms called "Subtract, XOR and Hamming" were suggested for identification. The performance of the presented algorithms was evaluated using CASIA I database. According to the results obtained, the Subtract algorithm outperformed the other methods with identification accuracy of 99.8%. Finally, for more review and accuracy, the Subtract algorithm was tested on statistical society of 120 to 400 people. Moreover, considering the changes of accuracy rate for statistical society of 120 to 400 people shown in Figure 6, it can be said that the proposed method is of good stability in spite of increasing number of statistical society. Finally, comparing the proposed algorithm with some other methods from different literatures proved the identification accuracy of presented algorithms.

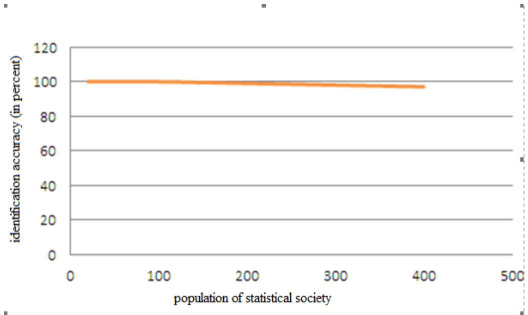

Figure 6. Identification accuracy of subtract algorithm vs. different population of statistical society

Table 2. Comparison of identification accuracy between the proposed algorithm and the algorithms of other literatures

Presented method	Accuracy rate (in percent)
Selzer[8]	100%
Amir Azizi[9]	96.5%
k. masoud[10]	95.9%
A.T zaim[11]	95%
Vladan[12]	94.7%
Proposed method (XOR)	98%
Proposed method (subtract)	99.8%

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