New Verification Method Based on Rotation Invariant Moments

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Summary
In this paper, we propose a new verification method based on the retinal images. In this algorithm, we use rotation invariant moments extracted from the retinal images. Then, we use them for verification. Experimental results on database, including 120 retina images obtained from 40 subjects of DRIVE database and 80 subjects from STARE database, show the average true verification accuracy rate equal to 99.39 percent for the proposed algorithm.

Key words:
Verification method; retinal images; rotation invariant moment; DRIVE and STARE database

1. Introduction

Reliable and accurate identification and verification is an important issue for security systems and recent advances in technology and increasing demand for security require the use of reliable biometric systems. Some biometric characteristics of a person for identification and recognition are finger print, hand geometry, face, voice, iris and retina. Each biometric pattern has its strengths and weaknesses and the choice depends on the application. In Fig. 1 some of the well know biometric patterns are illustrated. Among these methods retina has high level security for identification and verification. Retinal recognition is robust against imposture and has a very low false acceptance rate and false rejection rate [1]. Depending on the application context, a biometric system may operate either in verification mode or identification mode. In the verification mode, the system validates a person's identity by comparing the captured biometric data with the own biometric template(s) stored system database. In such a system, an individual who desires to be recognized, claims an identity, usually via a PIN (Personal Identification Number), a user name, a smart card, etc., and the system conducts a one to one comparison to determine whether the claim is true or not.

In the identification mode, the system recognizes an individual by searching the templates of all the users in the database for a match. Therefore, the system conducts a one-to-many comparison to establish an individual's identity (or fails if the subject is not enrolled in the system database) without the subject having to claim an identity [2].

The first identification system using commercial retina scanner called EyeDentification 7.5 was proposed by EyeDentify Company in 1976 [3]. In following we review verification and identification methods based on retinal images.

Farzin et al. [3] proposed a novel method based on the features obtained from human retinal images. This system is composed of three principal modules including blood vessel segmentation, feature generation and feature matching. Blood vessel segmentation module has the role of extracting blood vessels pattern from retinal images. Feature generation module includes optical disc detection and selecting circular region around the optic disc of the segmented image. Then, using a polar transformation, a rotation invariant template is created. In the next stage, these templates are analyzed in three different scales using wavelet transform to separate vessels according to their diameter sizes. In the last stage, vessels position and orientation in each scale are used to define a feature vector for each subject in the database. For feature matching, they introduced a modified correlation measure to obtain a similarity index for each scale of the feature vector. Then, they compute the total value of the similarity index by summing scale-weighted similarity indices. Experimental results on a database, including 300 retinal images obtained from 60 subjects, demonstrated an average rate equal to 99 percent for the identification system.

Xu et al. [4] proposed a new method for recognition. They used the green grayscale ocular fundus image. The skeleton feature of optic fundus blood vessel using contrast-limited adaptive histogram equalization is extracted at first step. After filtering treatment and extracting shape feature, shape curve of blood vessels is obtained. Shape curve matching is later carried out by means of reference point matching. In their method for recognition, feature matching consists of finding affine transformation parameters which relates the query image and its best corresponding enrolled image. The computational cost of this algorithm is high, because a number of rigid motion parameters should be computed for all possible correspondences between the query and enrolled images in the database. Experimental results on a database including 200 images resulted in zero false recognition against 38 false rejections.

Ortega et al. [5] used a fuzzy circular Hough transform to localize the optical disk in the retina images. Then, they

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defined feature vectors based on the ridge endings and bifurcations from vessels obtained from a crease model of the retinal vessels inside the optical disk. For matching, they used a similar approach as in [4] to compute the parameters of a rigid transformation between feature vectors which gives the highest matching score. This algorithm is computationally more efficient with respect to the algorithm presented in [4]. This method used only for verification.

Tabatabaee et al. [6] presented a new algorithm based on the fuzzy C-means clustering algorithm. They used Haar wavelet and snakes model for optic disc localization. The Fourier-Mellin transform coefficients and simplified moments of the retinal image have been used as extracted features for system. The computation cost and implementation time of this algorithm is high and the performance of the algorithm has been evaluated using a very small database including only 27 subjects.

Shahnazi et al. [7] proposed a new method based on the wavelet energy feature (WEF) which is a powerful tool of multi-resolution analysis. WEF can reflect the wavelet energy distribution of the vessels with different thickness and width in several directions at different wavelet decomposition levels (scales), so its ability to discriminate retinas is very strong. Easiness to compute is another virtue of WEF. Using semi-conductors and various environmental temperatures in electronic imaging systems cause noisy images, so they used noisy retinal images for recognition. In existence of 5db to 20db noise, the proposed method can achieve 100% recognition rates on a database including 400 images

Oinonen et al. [8] proposed a novel method for verification based on minutiae features. The proposed method consists of three steps: blood vessel segmentation, feature extraction and feature matching. In practice, vessel segmentation can be viewed as a preprocessing phase for feature extraction. After segmentation, the next step is to extract the vessel crossings together with their orientation information. These data are then matched with the corresponding ones from the comparison image. The method uses the vessel direction information for improved matching robustness.

In this paper, we propose a new method based on the moments extracted from the retinal images and they are invariant under the actions of rotation and translation and other linear transformations. Because of not using preprocessing algorithms such as retinal image segmentation and optic disc detection, the implementation of the proposed algorithm, is very fast.

The rest of this paper is organized as follows. In section 2 we introduce the Hu moments, section 3 contains feature extraction, section 4 is devoted to verification method and experimental results and concluding remarks are given in the last section.

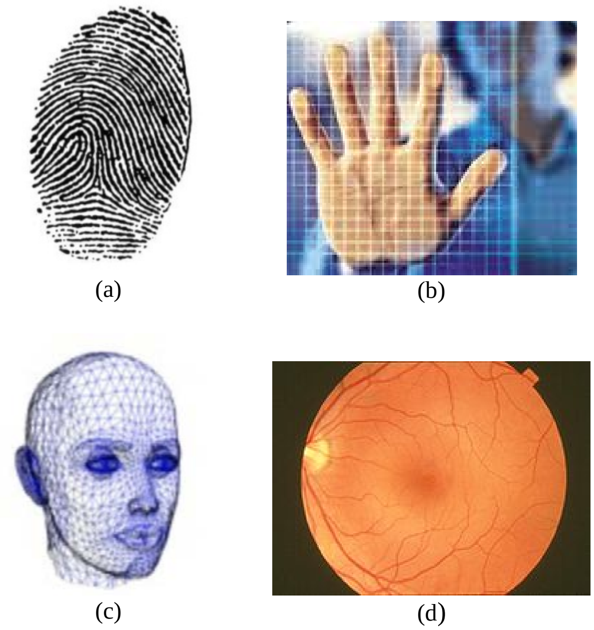

Figure 1. biometric characteristics for identification: (a) finger print, (b) palm, (c) face, (d) retina [3].

2. HU MOMENTS

One of the most important features that can be used in pattern recognition are statistical features, statistical features can help us to generate new set of patterns with less difficulty. Hu [9] introduced mathematical foundation of two dimensional invariant moments for applications of visual information processing. The most important characters of these moments are that they are invariant under translation, rotation, orthogonal transformations and also under general linear transformations. The results show that recognition schemes based on these invariants could be truly position, size and orientation independent, and also flexible enough to learn almost any set of patterns. In following section we introduce Hu moments and for verification, we use these features.

Let I(x,y) be a continuous image function. Its geometric moment of order p+q is defined as [1, 9, 10]:

$$m_{pq} = \iint_{-\infty}^{\infty} x^p\, y^q I(x,y)dxdy \qquad (1)$$

Geometric moments provide rich information about the image and are popular features for pattern recognition. The information content of moments provide an equivalent representation of an image, in the sense that an image can be reconstructed from its moments, now the central moment can be expressed:

$$\mu_{pq} = \iint_{-\infty}^{\infty} (x-\bar{x})^p \, (y-\bar{y})^q I(x,y)dxdy \qquad (2)$$

In last equation $\bar{x}$ and $\bar{y}$ are given by:

$$\bar{x} = \frac{m_{10}}{m_{00}}$$
$$\bar{y} = \frac{m_{01}}{m_{00}} \qquad (3)$$

The normalized central moments can be expressed:

$$\eta_{pq} = \frac{\mu_{pq}}{\mu_{pq}{}^{\gamma}} \qquad (4)$$

Where:

$$\gamma = \frac{p+q}{2} + 1 \qquad (5)$$

These moments are rotation invariant. Based on the last equations, the Hu moments are defined as a set of seven moments that are invariant under the actions of translation, scaling and rotation. These are:

$$p+q=2$$
$$\phi_1 = \eta_{20} + \eta_{02}$$
$$\phi_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2$$
$$p+q=3$$
$$\phi_3 = (\eta_{30} - 3\eta_{12})^2 + (\eta_{03} - 3\eta_{21})^2$$
$$\phi_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{03} + \eta_{21})^2$$
$$\phi_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{03} + \eta_{21})^2] + (\eta_{03} - 3\eta_{21})(\eta_{03} + \eta_{21})[(\eta_{03} + \eta_{21})^2 - 3(\eta_{30} + \eta_{12})^2] \phi_6 = (\eta_{20} - \eta_{02})[(\eta_{30} + \eta_{12})^2 - (\eta_{03} + \eta_{21})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{03} + \eta_{21}) \phi_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{03} + \eta_{21})^2] + (\eta_{30} - 3\eta_{12})(\eta_{03} + \eta_{21})[(\eta_{03} + \eta_{21})^2 - 3(\eta_{03} + \eta_{21})^2] \qquad (6)$$

In this paper we use only ϕ_1 for human verification.

3. FEATURE EXTRACTION

To extract features for verification using the Hu moments, the central moment for image I(x,y) will be simplified to:

$$\mu_{pq} = \sum_x \sum_y (x-\bar{x})^p \, (y-\bar{y})^q I(x,y)dxdy \qquad (7)$$

Therefore, using the last equation, we can extract ϕ_1 from our retina images. These features are in the range of [0 1] and for increasing the distance between the features and finally improving the efficiency of our algorithm, we map these features to large scale, therefore we can express:

$$c = \tan(\exp(\phi_1)) \qquad (8)$$

Now we map c to large scale and we have:

$$e = map(c) = 10^7 c \qquad (9)$$

4. VERIFICATION METHOD

Now for an individual who desires to be recognized, and claims an identity, at the first we extract feature c from his/ her image, then we calculate e and we compare it with the feature of person in dataset that the testing person claimed his/her identity. Therefore, using the result of comparing and predetermined thresholding, we can accept or reject the claim.

$$dist = abs(e - e_i) \qquad (10)$$

$$dist < thresholding \Rightarrow verify\ the\ claim$$

In the above equation, e refers to feature of testing person and ei refers to the feature of person that the testing person claimed his/her identity. The amount of threshold for this algorithm is 5.

a. Experiments

The proposed method is applied to a dataset containing 40 retina images from DRIVE database [11] and 80 images from STARE database [12] for testing our verification algorithm. For testing our algorithm, we organize 3 experiments. In the first experiment, we rotate the testing images (query images) 5 times, in the second experiment we rotate the testing images 10 times and in the final experiment we rotate the testing images 20 times. Therefore, the number of dataset images for testing are 600, 1200, 2400 images and these are the largest datasets for testing and evaluating the human verification algorithms based on retinal images. In the first step, we extract the feature of each testing image. Then, if the difference between it and the feature of the person that testing person claimed his/her identity, is lower that the predetermined threshold, we accept his/her claim. In Fig.2, we see some of retinal images which are used in the proposed algorithm.

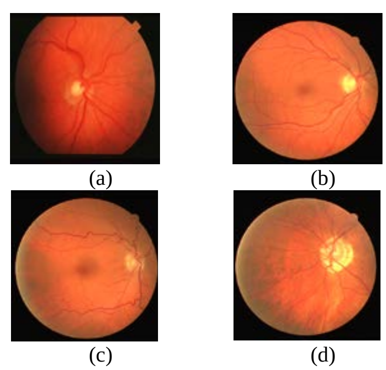

Figure 2. some of retinal images in dataset

Table I shows the results of four experiments and also the mean of results.

Table I. Experimental results

Times of rotation	***5***	***10***	***20***	***Mean***
Accuracy	99.66 %	99.30 %	99.38%	99.39%

The average accuracy rate for proposed algorithm is 99.39%. The performance is evaluated in terms of false rejection ratio (FRR) and equal error rate (EER) according to the distribution of nonmatching distance by selecting a proper distance threshold, which is shown in Fig.3.

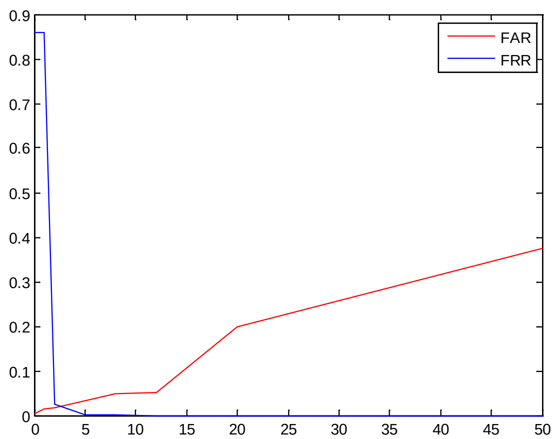

Figure 3. FRR and FAR diagram for experiment with 5 times rotation

In Fig. 4, the ROC curve shows that in a very small false acceptance rate, we have large values of genuine acceptance rate for identification. For comparing our algorithm with other algorithms, in table II the results of other algorithms are shown.

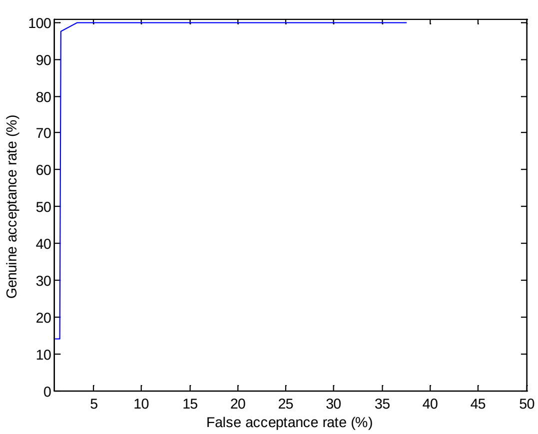

Figure 4. ROC curve

Table II. Comparing the results of different algorithms

Algorithms	***Number of Images***	***Result***	***Recognition time***
Farzin [3]	300	99%	-
Xu [4]	-	98.5%	4.63 min
Ortega [5]	90	100%	-
Oinonen [8]	233	100%	-
Proposed method	2400	99.39%	0.2 sec

5. CONCLUSION

In this paper, we propose a new human verification method based on the rotation invariant moments of retinal images, most of algorithms are used for identification, therefore propose a new verification method is an important issue for other application. The proposed algorithm has high accurate rate and is very easy, so the datasets which are used for testing are the largest datasets among the datasets which are used for verification methods in other papers and thanks to avoiding preprocessing algorithms, the proposed algorithm is faster than other algorithms. The accuracy of the proposed method for human verification is 99.39%.

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