Personal Identification/Verification by Using Four Fingers

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Abstract-**This paper presents an approach to personal verification and identification based on four fingers geometry. Having been extracted, twenty four features of four fingers little ring middle index, Fingers' width and length, are classified with two different pattern recognition systems Euclidean and Absolute Distance. The algorithm has been tested on 500 pictures of 50 users. Result shows 99.811 identification rate and 0.1743% Equal error rate (EER) with absolute distance classifier. As the reported algorithm is not sensible to rotation of hand pictures are captured with a scanner without any special instrument for fixing the placement therefore the purposed method is an inexpensive and easy to use. The experimental result shows the system performance in identification and verification.**

Keywords: geometry; identification; verification; feature

I. INTRODUCTION

At present, authentication based on biometric properties plays an important role in world's society. Biometric system uses variety physical or behavioral characteristic for automatic identification and verification such as face, iris, hand geometry, voice, and signature. In recent years, hand geometry recognition becomes a very popular biometric access control and it is used in around a quarter of real world physical access control applications [1]. In literature, there are different techniques that have been introduced below for identification and verification based on hand geometry.

Anil K.Jain presented a biometric system based on 20 features of hand. Pins and mirror were used for capturing the picture. Used classifier were Absolute, Weighted Absolute, Euclidean and Weighted Euclidean. The database consists 500 pictures of 50 users. Reported FRR were 3.5% [2]. Anil K.Jain and Duta developed a verification system that aligns finger contours and measures the mean alignment error between them. The system has been tested on 200 pictures of 20 persons. The reported EER was 15% [3]. Raul Sanchez-Reillo presented a biometric system based on hand geometry identification. Pins and mirror are used for fixing the hand placement and capturing the picture of the hand's side respectively. Having been extracted, 25 features were classified with different pattern recognition system from Euclidean distance to neural network. 97% accuracy in identification was reported via GMM [4]. Javad Hashemi presented an identification system based on 31 features that include area and length of fingers and width of multiple parts. Different pattern recognition techniques such as Gausssian mixture modeling (GMM), Radial basis function neural network (RBF), Multi layer perceptron (MLP), K-Nearest neighbor and Hamming distance have been used as a classifier. Simulation result showed 90% accuracy in identification [5]. Reported verification/identification system by Ovunc Polat does not require any feature extraction stage before identification. Having been resized to 50x70, the captured images were classified through GRNN neural network. The algorithm has been tested on 200 pictures of 20 users and the success rate in identification was 85% and reported EER was 15% [6]. Marcos Faundez extracted 10 features of right hand. Used classifier was MLP network. 99.62% accuracy in identification was reported [7]. Xiaoqain Jiang purposed using SVM algorithm for classification of 15 extracted features of hand. The reported success rate was 92% [8]. Miguel Adan presented a hand biometric system for verification and recognition purposes. The system implied minimum image processing and low computational cost. Pictures of right and left hands have been used in the system. Purposed algorithm has been tested on 5640 pictures of 470 users. Reported accuracy in identification is 97.6% and EER is 1.3% [9]. Hui Yan developed a biometric system based on hand geometry, palm print and finger print. Manhattan distance has been used for classification. Simulating the algorithm on 500 pictures of 50 users showed 97% accuracy in identification .The reported EER was 1.5% [10]. S.Selvarajan purposed the usage of 14 features that are distance of 12 main points from a reference point and area and circumference of hand for identification via hand geometry. Euclidean distance has been used for classification. He reported 96% accuracy for the data base of size greater than 50 images [11].

In the reviewed algorithm there are some disadvantages. The weakness points of reviewed algorithms are:

- Image acquisition: In some researches peg or special demand has been used for image acquisition to fix the placement of the hand. The pegs will deform the shape of the hand and users might place their hands incorrectly is the weaknesses of using pegs. This system isn't easy to use.

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- Features: increasing the number of features leads to a considerable increase in computational cost. On the other hand, more memories are necessary for storing in the database.
- Classifier: The Neural Network can be used as an identification system therefore, for verification approach system; an individual neural network should be defined for each person so this way is not desirable.
- Accuracy: The reported Accuracy in biometric systems based on hand geometry is not high so hand geometry system is introduced as a median security algorithm.
- Majority of papers are sensible to rotation therefore the algorithms are not useful for the captured images that have notable rotation.

In this paper we proposed a new feature extraction method with less number of selected simple features with low computational cost. Minimum distance classification algorithm is used for simplicity. The purposed algorithm improved the system accuracy in identification and verification and overcame the rotation of hand.

II. Methodology

Hand geometry features are extracted from an image through 3 steps as follow: Image acquisition, Image pre-processing and feature extraction.

A. *Image acquisition*

Database that is available at http://www.gpds.ulpgc.es/download has been used in this paper. The database consists of 10 different acquisitions of 50 people by a desk scanner. The 500 images have been taken from the users' right hand. The user in this system can place the hand palm freely over the scanning surface; pegs, templates or any other annoying method for the users didn't use to capture their hands. The images are 256 gray levels with 120 dpi resolution.

Figure 1 shows an example of a scanned image of a hand.

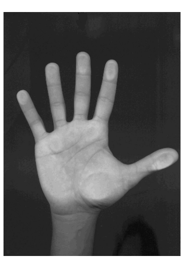

Figure 1. Scanned image

B. *Image pre-processing*

As this paper claims that can overcome rotation completely, any pin or especial instrument hasn't been used for image acquisition therefore the first step in image pre-processing is rotation cancelling that has been done in steps as follow.

As images in the data base haven't notable rotation, to show the system ability in rotation cancelling, an example image was rotated 180º (see Figure 2) and all steps are explained in mentioned picture.

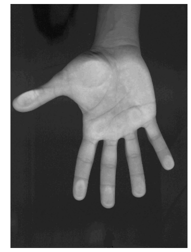

Figure 2. After 180º rotation

Step 1: First of all the gray level image is converted to a binary image. Because of the black background, there is a clear distinct in intensity between the hand and the background therefore, the histogram of the image is bimodal. The image can be easily converted to a binary image by a global threshold. Then mass centre is computed which is invariant to rotation and translation. (See Figure 3)

Figure 3. Binary image and Mass Centre

Step 2: In the next step, in order to cancel the presented noise and omit objects with area less than a predefined value, median filter and morphological opening have been used respectively. The hand contour is obtained by using Canny edge detection algorithm. The contour is shown in Figure 4.

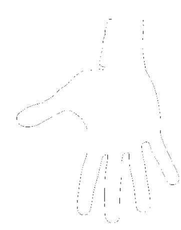

Figure 4. Contour extracted

Step 3: The border of hand is traced and pixels' coordinates are stored in a matrix then Euclidean distances between the mentioned matrix's points and mass centre are calculated and a distance distribution diagram is constructed as shown in figure 5.

The pattern in the diagram is quite similar to the shape of the hand. The local minima correspond to the valleys of the hand and the local maxima correspond to the tips of the hand (see Figure 6).

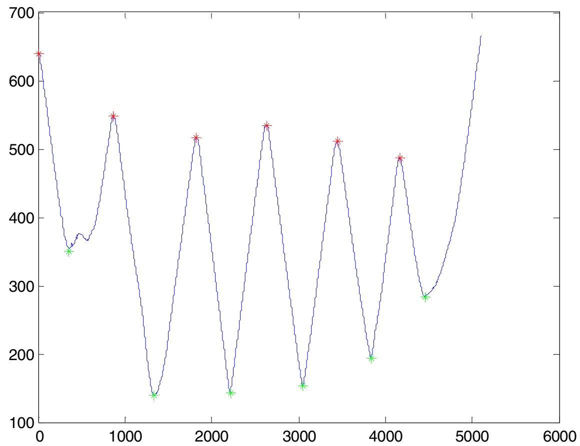

Figure 5. Location of the key-points in distance distribution diagram

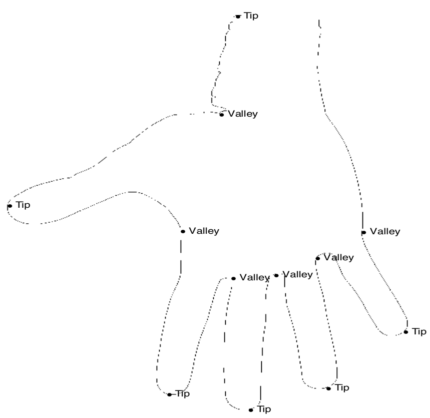

Figure 6. corresponding points of the key-points in hand contour

As it is clear in the image, with the mentioned way, we can find desire valley points although some incorrect valley and tip points are extracted too.

Step 4: The rotation angle is calculated for two fingers and mean of these two angles is reported as rotation of hand.

At first the finger baseline is created by connecting the valley points which are on both side of the particular finger. The mid-point of this baseline is used as the reference point of the finger rotation, and the axis from the reference point to the fingertip landmark is selected as the reference axis. A rotation angle is calculated with the orientation (1).

$$\theta = tan^{-1}(\frac{\Delta y}{\Delta x}) \quad (1)$$

Step 5: The image is rotated through inverse amount of calculated angle.

Based on mention method, calculated rotation angle for example image is 172.06. Figure 7 shows the image after rotation through -172.06^{o}.

It is mentionable that the reported algorithm ability in rotation cancelling has been tested for each 10 degrees between 0 and 360.

Figure 7. After rotation cancelling

C. Feature extraction

In this research 20 features are extracted from 4 fingers little, ring, middle and index finger. Having been located, 9 main points are used to extract the desired features. The following main points are located: fingers' tip, valleys between the fingers and two more points (see Figure 8).

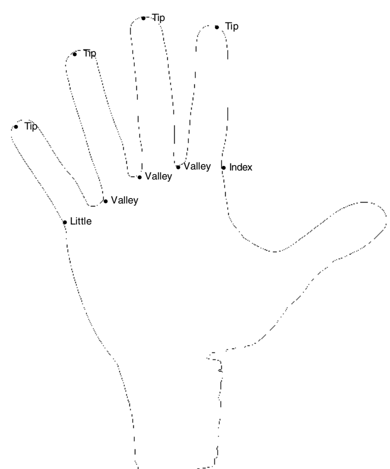

Figure 8. 9 Main Points

For extracting the 9 main points, valley between the fingers and fingers' tip, step 1 to 3 that mentioned in section 2.2 has been used. As the rotation is cancelled the exact place of wrist is clear therefore removing the incorrect valley and tip points that are in wrist is easily possible.

Two other main points that are named little and index in figure 8 should be found. For instant, to locate the little point, the outer points in the contour, with minimum distance to little-ring valley need to be found.

Once these main points are found, the geometric measurements are obtained as explained below.

Finger widths: Finger widths: Each of four fingers is measured in deferent heights (mainly 5 of them).

Finger length: In this research, Finger Length is Euclidean distance between the finger ' tip and middle points of the finger baselines. Finger baselines are obtained by connecting the valley points which are on both side of the particular finger.

Figure 9 shows the 24 extracted features of 4 fingers.

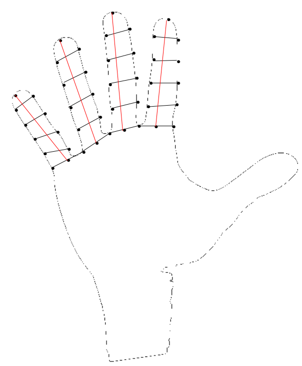

Figure 9. Extracted feature

In order to checking system ability in rotation canceling, features of entire images in the database are extracted from the images that are rotated randomly with an angle between 0^o and 360^o.

III. CLASSIFICATION

Two Types of classification, identification and verification, have been explained completely below:

A. Verification

For a verification system, an individual claims as one of the authorized users previously registered to the system. The system confirms or denies the claimer by matching the individual's extracted data with those of the claimed person which is stored in a database.

The statistical measures to be used for biometrics verification are:

FAR (False Acceptance Rate): The FAR is defined as the probability that a user making a false claim about his/her identity will be verified as that false identity.

FRR (False Rejection Rate): The FRR is defined as the probability that a user making a true claim about his/her identity will be rejected as him/her.

EER (Equal Error Rate): The EER is defined as the crossover point on a graph that has both the FAR and FRR curves plotted.

For a verification system, the optimal performance of the system is where the FRR equals the FAR. [12]

B. Identification

For identification the extracted feature vector from user is compared with the entire feature vectors in the database therefore, the Identification is a one-to-many matching process. The person whose feature vector has minimum distance with claimer person detected. The distance is compared with the threshold that is extracted from cross point of FAR and FRR. If the distance be smaller than the threshold the person identify otherwise the claimer rejected as unknown person.

In purposed algorithm, Distance functions are used for measuring the similarity between the claimer's feature vector and the feature vectors in the database as follow.

In this research, 2 distance functions are experimented.

Euclidean distance

$$D_e = \sqrt{\sum_{i=1}^{d} (y_i - f_i)^2} \quad (2)$$

Absolute distance

$$D_a = \sum_{i=1}^{d} |y_i - f_i| \quad (3)$$

Where Y = y1, y2,…,yd is the feature vector of an unknown or a claimer.

F = f1, f2, …, fd is the feature vector with "d" dimension of a registered user in the database.

As mentioned before 10 picture are exist for each registered person. 3 pictures of them are used for test. Having been extracted, features from seven other pictures are saved in the database therefore the database consist 350 feature vectors.

IV. RESULT

The performance of reported system in verification has been tested with 150 pictures that consists 3 pictures of each 50 enrolment people. FRR and FAR have been calculated for different thresholds. The best threshold is extracted from cross point of FAR and FRR. (See figure 6).

Table 1 reports the percent error in verification mode for different distance functions.

TABLE I. PERCENT ERROR FROM VERIFICATION MODE

No	Classifier	EER%		
		Mean	Min	Max
1	Euclidean	0.2194	0.0133	0.6667
2	Absolute	0.1743	0.0133	0.6667

Experimental results in identification mode are listed in Table 2. Third, fourth and fifth columns show the system accuracy in identification. As mentioned before, there are two mistakes in identification. First, the claimer rejected as unknown user. Second, the system identifies the claimer incorrectly. These mentioned errors are reported in column sixth and seventh of Table 2.

As mentioned earlier 3 pictures are used for test and seven pictures are used for storing in the database. Selecting 3 pictures from 10 pictures is possible in 120 different ways so the purposed algorithm is tested 120 times therefore minimum, maximum and mean of EER and identification are reported in Table1 and 2.

TABLE II. PERCENT ERROR OF IDENTIFICATION

No	Classifier	Identification			Rejected as unknown user	Incorrect identification
		Mean	Min	Max		
1	Euclidean	99.733	98.66	100	0.261	0.006
2	Absolute	99.811	99.33	100	0.189	0

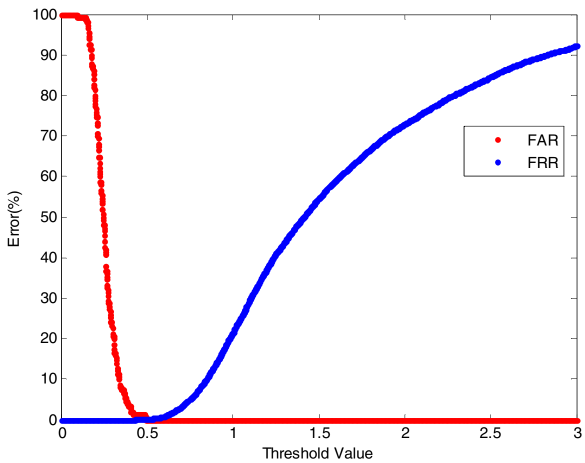

Figure 10. FAR and FRR for different threshold values

V. CONCLUSION

In this paper, we have proposed a new approach for biometric authentication that is based on four fingers geometry. As the reported method is not sensible to rotation of hand, users can place their hands freely on the scanner surface without need of pegs to fix the placement of the hand. The features used for matching are the fingers' width and length. In purposed method, distance function is used for classification in verification and identification modes. The images used for enrolment and testing are acquired from 50 users. Absolute distance gives the best performance in verification and identification, with 0.1743% EER and 99.81% accuracy in identification.

ACKNOWLEDGEMENTS

This work is supported by Iran Telecommunication Research Centre, Project number 11528/500.

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