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Recognizing and Identifying Individuals' Identity by Use of Biometrics of Ear

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ABSTRACT: In comparison with other physical features, biometrics of ear has both advantages and limitations. Its small rank and its relatively simple structure brings about a controversial discussion. From a positive aspect, these features, in comparison to face recognition make it possible to have a faster processing and in comparison to fingerprinting provide an easier recognition method. From a negative aspect, the smallness of ear increases the possibility that it will be covered. In the present study, we have designed a biometric system by usage of a two-dimensional image of human ear in which moments are used to describe ear. In this system, each image of ear is described by usage of invariant moments and these moments create a seven-dimensional feature vector in the feature space which shows the image of ear. To classify the images of ear, the geometric minimum distance criterion is used and since the amounts of the moments have a widespread dynamic range, and discrepancies between the moments of low degree and high degree are very high, balanced geometric distance was used. The operation of the designed system has been evaluated based on FAR and ARR parameters as well as correct recognition rate. The results showed that the images of ears of 55 persons have led to a mean recognition rate of 70 percent which shows sustainability and effectiveness of the method in recognizing persons form their ear image under uncontrolled conditions.

KEYWORDSestablishing Identity, Ear identity Recognition, balanced geometrical distance

I. INTRODUCTION

The security systems based on biometrics are responsible for recognition or identity recognition of people upon their physiological orbehavioral features. Recently, the structure of ear has taken the attention of the biometrics researchers and organizations and some governments such as the US has invested greatly on the biometrics of ears. Among the advantages of ear structure we can refer to its fixed feature over time, lack of change in gestures such as happiness, sadness and surprise (in contrary to face), taking samples from distance without the person being noticed, and also uniformity of its color.

The image of the ear could be taken the same way as the image of face could be. Several studies have indicated that human ear is sufficiently idiosyncratic so that it could be used in the practical biometric systems. Some studies are about the usage of two-dimensional images of ears and in some others three-dimensional images have been used. The main difference of the biometric systems of ear is in analysis of the image and the method of extracting the features and creation of recognition patterns. These methods are either model-oriented or appearance-oriented. The basis of the model-oriented methods is usage of the geometry dominant to ear and place of different parts, Euclidean distance, and other geometrical relations as feature vector. The appearance-oriented methods use appearance to describe. In this study, by usage of seven invariant moments, the features of each ear image were extracted and stored. Balanced geometrical distance in the feature space has been used for the pattern matching stage.

In the method of investigation ion this study, invariant moments have been used to extract the features of each ear. These moments which are fixed in relation to displacement, rotation, and scale can be used in a two-dimensional image of ear as describer of the whole area of ear. Geometric minimum distance criterion is used to classify the feature vector which will be discussed in the following.

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II. SIMULATION

III.I.Structure of the System: Simple geometric features of an image like area, place, and direction could be calculated easily by usage of a set of linear functions of images which are called geometric moments. The geometric moment of degree (p &q) of an image is defined as follow:

$$m_{pq} = \iint x^p y^q f(x,y)dxdy \qquad (1)$$

In the above relation, $f(x,y)$ is the intensity f the image in the point (x,y) of the image sheet the moment will determine the main geometric features of image. $m_{00}$is the overall mass of the image. The image mass center is calculated as follows:

0

Image central moment is defined as follows:

$$\mu_{pq} = \iint (x-\bar{x})^p\,(y-\bar{y})^q f(x,y)dxdy \qquad (3)$$

The central moment is equivalent of the geometrical moment of the image which has been displaced so that the image mass center has been placed at the beginning. The central moments are invariant in relation to displacement of the image. Usage of moments to analyse the images and recognition of objects in images were introduced by Hu.
As it was observed in the previous part, central moment is fixed in relation to displacement of image. Finding describers for images which are fixed under the following overall conversion is of great importance.

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \alpha & a \\ b & \beta \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} x_0 \\ y_0 \end{bmatrix} \qquad (4)$$

III.II.Calculation of the Balanced Geometric Distance: Having a look at Table 1 shows that the difference between the moments of different stages is very high, especially the moments of higher stages have larger amounts. On the other hand, the moments of the higher stages have more calculating errors than the moments of the lower stages. Therefore, in the calculated geometric distance, the effects of the moments of smaller ranks will be affectless against the effects of the moments of higher ranks. To solve this problem, we use the balanced geometric distance. The balanced coefficient used for this purpose is the reverse variance of the amounts of φ_i. the balanced coefficient of each rank of the fixed moments is calculated as follows:

$$\rho_i = \frac{N}{\sum_{k=1}^{N}\left(\varphi_i^k - \bar{\varphi}_i\right)^2}\,\bar{\varphi}_i = \frac{\sum_{k=1}^{N}\varphi_i^k}{N} \qquad i = 1,2,\dots,7. \qquad (6)$$

In this formula, N is the number of the persons entered into the database of system. The balanced geometric distance between two vectors is defined as follow:

$$d(\varphi',\varphi^k) = \left[\sum_{i=1}^{7}\rho_i\left(\varphi_i' - \varphi_i^k\right)^2\right]^{1/2} \qquad (7)$$

In this part, the geometric distance of features vector of the considered person is calculated from the characteristic of all persons entered into database of the system. The geometric distance between two vectors in the characteristic space is calculated as follows.

$$D_{ij} = \left[\left(\varphi_{i1} - \varphi_{j1}\right)^2 + \left(\varphi_{i2} - \varphi_{j2}\right)^2 + \cdots + \left(\varphi_{i7} - \varphi_{j7}\right)^2\right]^{1/2} \qquad (8)$$

The characteristic vector which has the least distance with the tested characteristic vector is determined. If this minimum distance be less than a threshold default, then it is declared that these two characteristics belong to one person; otherwise, there will be no correspondence between the characteristic vector of the tested person and the characteristic vectors of the persons entered into the database of the data recognition system.

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In the next part, by usage of data set images, moments of each picture is calculated. Four characteristic vector are obtained for each person that each vector includes seven invariant moments. In order to indicate each person as a point in the seven-dimension characteristic space, the mean score of these four vectors are calculated. This vector shows the person in the characteristic space.

III.V. Error Rate of Identity Verification System: Two types of errors may occur in a biometric system in the operation phase of identity verification. In one state, the system recognizes a person not being in its database as a registered person erroneously. This type of error is called FalseAccept Rate or (FAR).

The other type of errors occur when identity verification system cannot recognize the identity of the registered person erroneously. This error is called False Reject Rate or (FRR). The quantity of these two types of errors depends upon the determined threshold for the system in that with increase of threshold, FAR is increased, and FRR is decreased. To calculate FAR, we give the ear image of a person not being registered in the biometric system to the system as input for identity verification. After calculating moments of this image, its characteristic vector is entered into the matching algorithm. In the matching algorithm, the balanced geometric distance of this vector is calculated from all characteristic vectors registered in the system. Errors occur when these distances are less than the amount of threshold determined for the system. In this case, the person's identity is verified erroneously. Initially, we should determine the amounts of threshold. For this purpose, the following linear is used:

$$th_j = d_{max} - (j+1)\frac{d_{max} - d_{min}}{T} \qquad j = 1,2,\ldots.. \tag{9}$$

In the above formula, d_{max} and d_{min} are the maximum and minimum amounts of balanced geometric distance respectively which are 15 and 0.3. T is the number of threshold which is considered 50. Now, by applying the following formula, FAR is calculated for each threshold.

$$FAR(th_j) = \frac{1}{L}\sum_{i=1}^{L} I(d_i < th_j) \qquad\qquad I(x) = \begin{cases} 1 & if\ x\ is\ true \\ 0 & otherwise \end{cases} \tag{10}$$

In the above formula, L is the number of calculated geometric distances. For calculation of FRR the same operation is made as the previous one with this difference that this time, the calculated d amounts related to distance of two feature vectors belong to one person.

$$FRR(th_j) = \frac{1}{L_1}\sum_{i=1}^{L_1} I(d_i > th_j) \tag{11}$$

Parameters of Reciever Operating Characteristics (ROC) are usually used to compare the operation of the biometric systems with each other.

III.VI. the Results of Simulation: For evaluation of the operation of the proposed biometric system, 220 pictures of 55 persons were used at the level of education. To test the system, 142 pictures of ear were used. The function of the ear biometric system is calculated by parameters of FAR and FRR and ROC diagram which is obtained from the two previous parameters. For each one of the ear pictures, these seven fixed moments are calculated by invmoments function which is written in Matlab. In Table 1, a sample of the calculated amounts has been shown for some ear pictures.

1.183610	0.122900	155.357075	17.453215	852.456803	0.462552	207.810886
1.914073	0.474886	630.533139	72.969768	15136.808143	20.341234	2442.245288
1.668754	0.255742	345.441951	40.713743	3342.816297	-8.841843	2141.846851

Table 1. Amounts of fixed moments for 3 different pictures of ear

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Four samples of ear images were used for each person entered into the simulated ear biometric system in this study. Seven fixed moments are calculated for each calculation and then, the mean score of these four seven-dimensional vectors are stored in the system database as individual's character vector. Figure 1 shows ROC diagram.

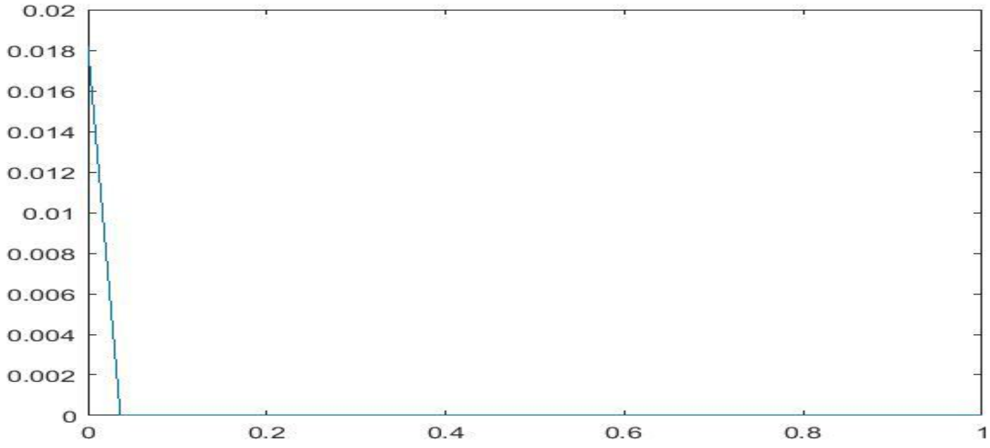

Figure 1. ROC diagram

Four seven-dimensional vectors are stored in the system database as individual's character vector. Figure 1 shows ROC diagram.

Correct recognition rate is defined as the expected proportion from the system to recognize the identity of the person who is registered in the system. The correct recognition rate depends both to threshold amount and the number of the registered individuals. 142 image samples of ears of the persons registered in the system are used to calculate the correct recognition rate. The threshold amount in the matching algorithm is 0.1 in this case, the correct recognition rate has been achieved as 70 percent.

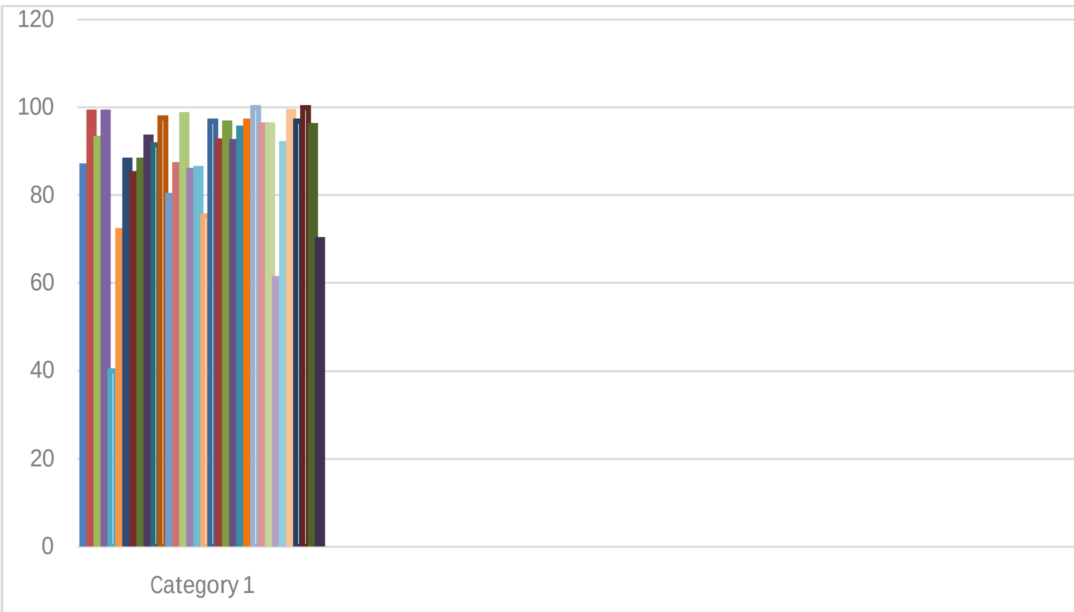

Figure 2:Diagram of Correction Recognition Rate of Moments Method

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The last bar in the diagram is related to this study which has shown that the correct recognition rate for 55 persons and 220 pictures is 70 percent.

V.CONCLUSION

The results of this study indicate that invariant moments could be used for extracting ear features. The picture of each ear is shown by usage of seven fixed moments. The advantages of using fixed moments include easy calculation of them and their invariant feature in relation to rotation, transfer and change of scales.

In order to compare the operation of the biometric system designed in this study with other biometric systems proposed in some studies, their correct recognition rate is indicated in figure 2. The last bar in the diagram is related to this study which has shown that the correct recognition rate for 55 persons and 220 pictures is 70 percent.

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