ABOUT THE CALCULATION METHOD OF THE COEFFICIENT THAT SHOWS SIGNIFICANCE EXTENT OF GEOMETRIC CHARACTERISTICS IN DETERMINATION OF RACIAL AND ETHNIC IDENTITY OF HUMAN

Tofig Kazimov [1], Shafagat Mahmudova [2]

[1,2] *Institute of Information Technology of ANAS, Baku, Azerbaijan*

tofig@mail.ru shafagat_57@mail.ru

Abstract

In the article, a new algorithm for finding coefficients that determine significance extent of the values of geometric characteristics that are used for determination of racial and ethnic identity of human is proposed. It is explained that the calculation of coefficients which determine the importance extent of the values of geometric characteristics is important in several respects. The determination of coefficients that indicate the importance extent of geometric characteristics causes reduction in numbers of values of geometric characteristics that don't have particular importance and in time that is spent for the identification and improvement of identification quality.

Keywords: recognition, race, ethnicity, coefficient, geometric characteristics, identification, points.

INTRODUCTION

Continuous the development of computer technology, the improvement of existing software quality instigate to revise problems and issues of computer vision. In this regard, computer recognition issue of people is of great significance and is particularly relevant. This, successively, has led to the rapid development of biometric technologies in recent years. On one hand the development of information and communication technologies in new level, on the other hand existing of serious problems related to security in political, economical, social, military and so on fields are one of the main reasons that make development of biometric technologies necessary. However biometric identification systems solve security problems to some extent, they still need to be developed theoretically and practically. Recently, the number of studies dedicated to the establishment of identification systems that based on different biometric characteristics (facial description, fingerprints, hand vessels anatomy, netted iris of the eye, etc) is rapidly increasing [1]. The issues of automatic based human face recognition (photo-portrait)

have special theoretical and practical importance [2-5]. One of them- identification systems based on geometric characteristics (characteristic features) of human face specially differ from others for its high accuracy and versatility [6]. Although currently there are significant researches in this field, the number of methods and systems that determine human racial or ethnic identity is rather few [7-8].

Among the various approaches for three-dimensional face recognition, methods based on ethnic facial features are more promising [9]. Nevertheless, ethnic features applied for three-dimensional face recognition have been little studied [10].

It is also possible to determine racial and ethnic identity of human for patterns of his fingers and palms. For this purpose opportunities of dermatoglyphics and dactyloscopy are used as well.

Dermatoglyphics is the field of science that studies the skin patterns of the palms and soles of a person. Dactyloscopy is an identification method of a person according to the finger prints on the skin, and relies on the patterns observed in individual prints. Currently, the most common applications characterize the papillary patterns of the fingerprints [11].

Experts from different scientific fields studies problem solutions in determination of racial and ethnic identity of a person. Existing problems in this field are solved by experts through the use of various methods.

For the solution of the existing problems, researches are being carried out in the fields of anthropology, ethnography, and racism included in social sciences and in the fields of biometric technologies, pattern recognition, medicine, etc included in technical sciences [12-14].

Some aspects of determination of racial and ethnic identity of a person are:

1. Skull bone based;
2. Facial image based;
3. Finger and palm pattern based;
4. Eye based;
5. Tooth based etc. [15].

Canonical correlation method, main component method, least square method, elastic model, neural network, etc are used in determination of racial identity of a person.

In authors' work [16] identification method based on geometric characteristics of face has been successfully applied for determination issues of racial and ethnic identification of a person.

In this work, method and identification algorithm that determine generalized geometric characteristics of standard image of face has been developed on the basis of the images of people having the same historical and ethnic roots. Thus, probabilities of identity are calculated through comparison of person's image with standard image of ethnic group, in order to determine ethnic group identity of any person.

In this article, calculation method of significance extent of geometric characteristics which applied in the work [17] has been used.

The determination of coefficients that show importance extent of geometric characteristics causes reduction in numbers of geometric characteristics that don't have particular importance and in time that is spent for the identification and improvement of identification quality.

In the paper [17] a new algorithm is proposed to finding the coefficients that determine importance extent of values of geometric characteristics which are used for recognition of a person on the basis of photo portraits.

Let's explain the purport of new algorithm suggested for finding of coefficient that determines significance extent of values of geometric characteristics used in determination of ethnic identity of a person.

Clusters are organized by taking the same characteristics of the geometric characteristics those belongs to the every image of ethnic group. In order to determine significance extent of values of geometric characteristics, identification process is implemented by the temporary replacement of each values of geometric characteristic of a person in cluster with the values taken from interval of each standard image and the effect of the change in recognition process is evaluated.

Mathematical statement of the problem

Initially let's explain identification process which guesses identity of a person to any ethnic groups on the basis of the images [16].

In identification systems which are established on the basis of geometric characteristics of a human face, organization of database (images) has a particular importance. Of course, the images included in database must meet the certain requirements [17]:

1. Identification marks shouldn't be covered by hairstyle, beard, mask, glasses, etc. ;

2. Image sizes (scale) should allow to easily choose the identification marks, recognition process shouldn't depend on scale;
3. Identification marks system should provide relative stability of recognition process during small change (little rotation of head, facial expression changes, etc.) of drawing perspective of image;
4. In order to provide high accuracy of identification, there should be as many identification marks as possible.

Image databases are organized in a way that to add images there is possible at any time. In order to increase effectiveness of identification, some facial expressions of human face and other features (skin color, hair color and structure, eye color and shape, etc.) are included in database such as stationary parameters.

For each ethnic group standard image is determined on the basis of particular algorithm, or rather generalized characteristic signs matrix is calculated for standard image.

Identification issue is about comparison of any images with the standard images, so it leads to finding of the smallest distance between vectors. Thus, probability of belonging of the image to the standard image of ethnic group is calculated.

On the basis of analysis of existing reference and personal experience, 30 identification marks have been described on the image. It is supposed that these marks are more invariant to the small changes (lighting, expression, cosmetics, shooting angle, age-related changes, etc.) than others.

Let's suppose that the face has symmetrical shape according to the line that divides it into two symmetrical parts and selected marks are like below (figure 1):

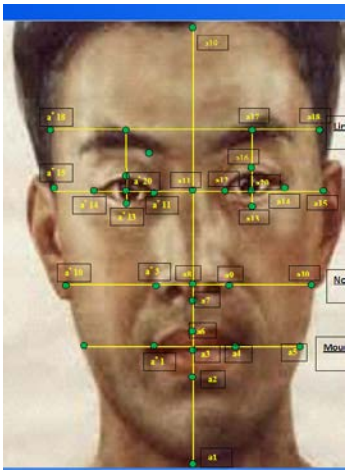


Fig. 1. Selected marks on the human face

- *a*1—tip of the chin;
- *a*2—bottom point of the lower lip;
- *a*3—center of the mouth, as the occlusion point of lips on the facial symmetry line;
- *a*4—right corner of the mouth;
- *a*5—far right point of the face on mouth line level;
- *a*6—far point of the upper lip on face symmetry line;
- *a*7—far lower point of the nose;
- *a*8—tip of the nose (on the nose line);
- *a*9—far right point of the nose on the nose line;
- *a*10—far right point of the face on the nose line;
- *a*11—middle point of the portion adjoining the centers of eye pupils;
- *a*12—left corner of the right eye;
- *a*13—point of the lower lid of the right eye laying perpendicular to the eye line passing through the pupil of
- the right eye;
- *a*14—right corner of the right eye;
- *a*15—far right point of the face on the eye line;

- *a*16—point of the upper lid of the right eye laying perpendicular to the eye line passing through the pupil of
- the right eye;
- *a*17—point of the right lid of the right eye laying perpendicular to the eye line passing through the pupil of
- the right eye;
- *a*18—far right point of the face on the brow line;
- *a*19—far upper point of the forehead on the facial symmetry line;
- *a*20—point determining the center of the pupil of the right eye.

Where

- facial symmetry line—is a line dividing the face in two symmetrical halves;
- mouth line—perpendicular to the symmetry line, passing through the center of the mouth;
- nose line—perpendicular to the symmetry line passing through the tip of the nose;
- eye line—line passing through the centers of the eye;
- browline—line passing through the points *a*17 and 17 *a*∗ .

And now let's show formation of standard image of any ethnic group and calculation method of significance extent coefficients (weight coefficients) of geometric characteristics. Let's mark out characteristic features of the images in this group with matrix of $B(b_{ij}, i=\overline{1,n}, j=\overline{1,m})$. Here b_{ij} is the j-th characteristic feature of the image of i-th person. n is the number of images of the group, m is the number of geometric characteristics of each image. If we would mark out characteristics of standard images with the vector $E(e_1, e_2, ..., e_m)$, then:

$$e_j = \frac{\sum_{i=1}^{n} b_{ij}}{n}, \quad j=\overline{1,m}, \tag{1}$$

is calculated like this [17].

Let's determine variation interval of coordinates of vector E like:

$$d_j = \frac{\sqrt{\sum_{i=1}^{n}(e_i - b_{ij})^2}}{n}, \quad j = \overline{1,m}, \tag{2}$$

$$e_j \in [\alpha_j, \beta_j]$$

$$\alpha_j = e_j - d_j, \quad \beta_j = e_j + d_j, \; j = \overline{1,m},$$

Let's mark the image which is going to be determined its ethnicity with $E^*(e_1^*, e_2^*, ..., e_m^*)$ as m-dimensional point. Then the distance S between point E and point E^* is calculated like below:

$$S(E^*, E) = \sum_{i=1}^{m}(e_i^* - e_i)^2 \tag{3}$$

Here formula (3) is used only for comparison, that's why square root sign hasn't been used.

Let's divide interval $[\alpha_j, \beta_j]$ into equal parts with step h_j.

$$h_j = (\beta_j - \alpha_j)/t, \; j = \overline{1,m},$$

$$x_{jk} = \alpha_j + kh_j,$$

t is whole number.

When we consequtively place obtained $x_{jk} \in [\alpha_j, \beta_j], (k = \overline{0,t}; \; j = \overline{1,m})$ points in plac e of $q^{th}(q = \overline{1,m})$ coordinate values of E* point, we will obtain (t+1)m quantity of numbers, which will be identified as

$$ET_{kq} \; (k = \overline{0,t}, q = \overline{1,m})$$

Let us calculate ω_j coefficient indicating $ST_{kq}(E_i, ET_{kq})$ distances between these points and E point and determining the significance degree of geometric characteristics:

$$\omega_j = \left(\frac{1}{n(t+1)} \sum_{i=1}^{n} \sum_{k=0}^{t} \frac{ST_{ki} - S}{x_{jk} - e_j} \right)^{-1}, \quad j = \overline{1,m},$$

Identification system

"Racial and ethnic" biometric identification system (REBIS) has been established based on algorithm suggested by the authors for racial and ethnic identity based recognition of humans.

Image base is organized in such way that images can be added at any time. Some facial expressions and features (skin color, hair color and structure, eye color and shape, etc.) are included in database stationary parameters in order to increase recognition efficiency

For each ethnic group standard image is determined on the basis of particular algorithm suggested in [16], or rather generalized characteristic signs matrix is calculated for standard image.

The issue of identification is led to the comparison of the image with standard images, and so to the finding of the smallest distance between vectors. Thus, probability of belonging of the image to the standard image of ethnic group is calculated.

Numerous experiments have been implemented through REBIS. For the implementation of experiments three ethnic groups- European, mongoloid and negroid have been taken in REBIS.

The view of the front page of REBIS is shown in figure 1.

Experimental trials are also implemented by the using of images of FERET database.

Automatically calculated distances in accordance with determined characteristics marks based on image of each person are included in database and saved (figure 2). This information has been included in database only once and is able to be edited [18].

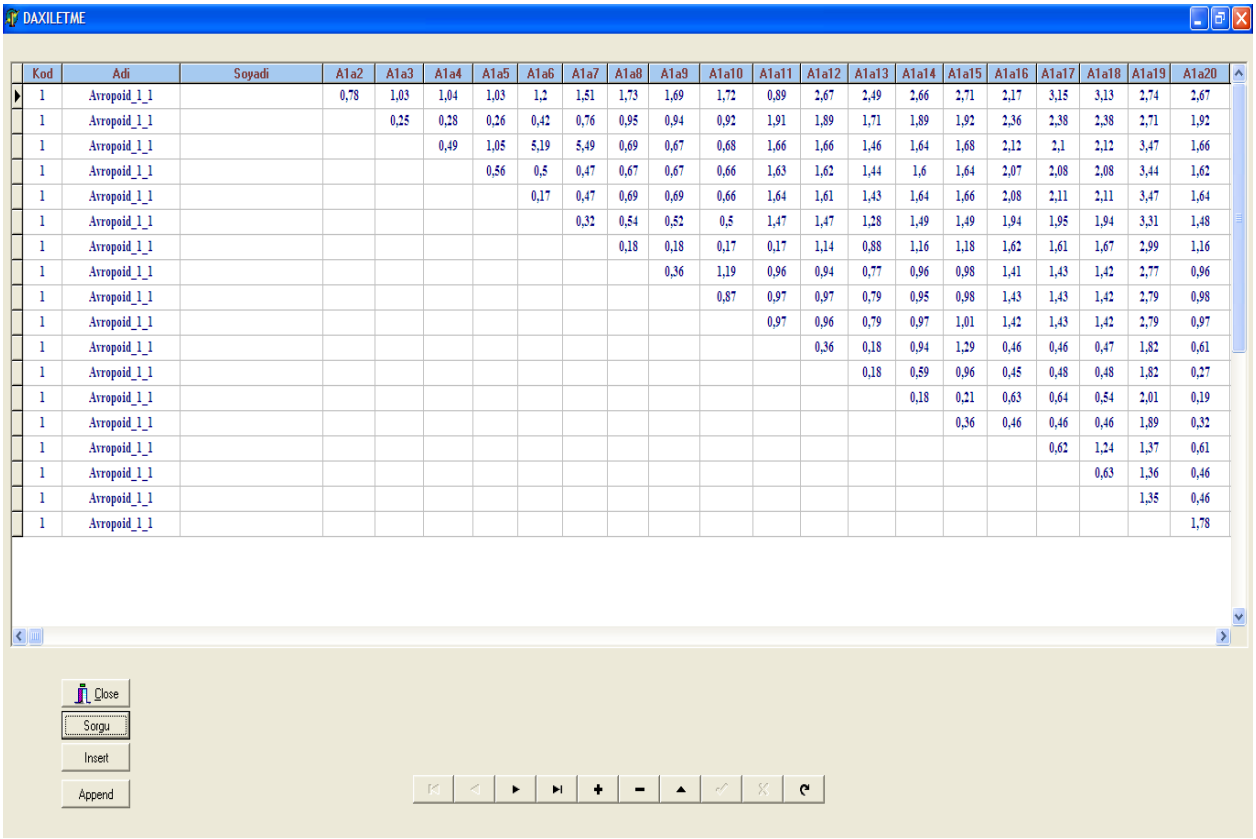
Some problems must be solved in order to get successful recognition of racial and ethnic identity of a person face on the basis of portraits:

1. choosing of anthropological marks of human face on the basis of template;

2. calculation of geometric characteristics of any human face for recognition on the basis of characteristic marks and automatic addition of it to the database;
3. recognition process should not depend on the scale of the portrait;
4. implementation of recognition process of human face and system informs user about it.

The main difference of REBIS is that it works fast on the basis of developed algorithm, utilizes portraits of database effectively and its prompt recognition. The main advantage of the suggested algorithm is that results are sustainable to changes in appearance depending on human aging. Experiments have been implemented on person portrait of more than 150 european, mongoloid and negroid race and 96-98% recognition accuracy has been achieved by the developed algorithm [19].

Through REBIS which is created for recognition of racial ethnic identity of human face, in entrance any human portrait belongs to any race is given, and as an output system determines belonging probabilities of a person to any racial-ethnic group (figure 3).



Kod	Adi	Soyadi	A1a2	A1a3	A1a4	A1a5	A1a6	A1a7	A1a8	A1a9	A1a10	A1a11	A1a12	A1a13	A1a14	A1a15	A1a16	A1a17	A1a18	A1a19	A1a20
1	Avropoid_1_1		0,78	1,03	1,04	1,03	1,2	1,51	1,73	1,69	1,72	0,89	2,67	2,49	2,66	2,71	2,17	3,15	3,13	2,74	2,67
1	Avropoid_1_1			0,25	0,28	0,26	0,42	0,76	0,95	0,94	0,92	1,91	1,89	1,71	1,89	1,92	2,36	2,38	2,38	2,71	1,92
1	Avropoid_1_1				0,49	1,05	5,19	5,49	0,69	0,67	0,68	1,66	1,66	1,46	1,64	1,68	2,12	2,1	2,12	3,47	1,66
1	Avropoid_1_1					0,56	0,5	0,47	0,67	0,67	0,66	1,63	1,62	1,44	1,6	1,64	2,07	2,08	2,08	3,44	1,62
1	Avropoid_1_1						0,17	0,47	0,69	0,69	0,66	1,64	1,61	1,43	1,64	1,66	2,08	2,11	2,11	3,47	1,64
1	Avropoid_1_1							0,32	0,54	0,52	0,5	1,47	1,47	1,28	1,49	1,49	1,94	1,95	1,94	3,31	1,48
1	Avropoid_1_1								0,18	0,18	0,17	0,17	1,14	0,88	1,16	1,18	1,62	1,61	1,67	2,99	1,16
1	Avropoid_1_1									0,36	1,19	0,96	0,94	0,77	0,96	0,98	1,41	1,43	1,42	2,77	0,96
1	Avropoid_1_1										0,87	0,97	0,97	0,79	0,95	0,98	1,43	1,43	1,42	2,79	0,98
1	Avropoid_1_1											0,97	0,96	0,79	0,97	1,01	1,42	1,43	1,42	2,79	0,97
1	Avropoid_1_1												0,36	0,18	0,94	1,29	0,46	0,46	0,47	1,82	0,61
1	Avropoid_1_1													0,18	0,59	0,96	0,45	0,48	0,48	1,82	0,27
1	Avropoid_1_1														0,18	0,21	0,63	0,64	0,54	2,01	0,19
1	Avropoid_1_1															0,36	0,46	0,46	0,46	1,89	0,32
1	Avropoid_1_1																	0,62	1,24	1,37	0,61
1	Avropoid_1_1																		0,63	1,36	0,46
1	Avropoid_1_1																			1,35	0,46
1	Avropoid_1_1																				1,78

Fig. 2. Distances in accordance with determined characteristics

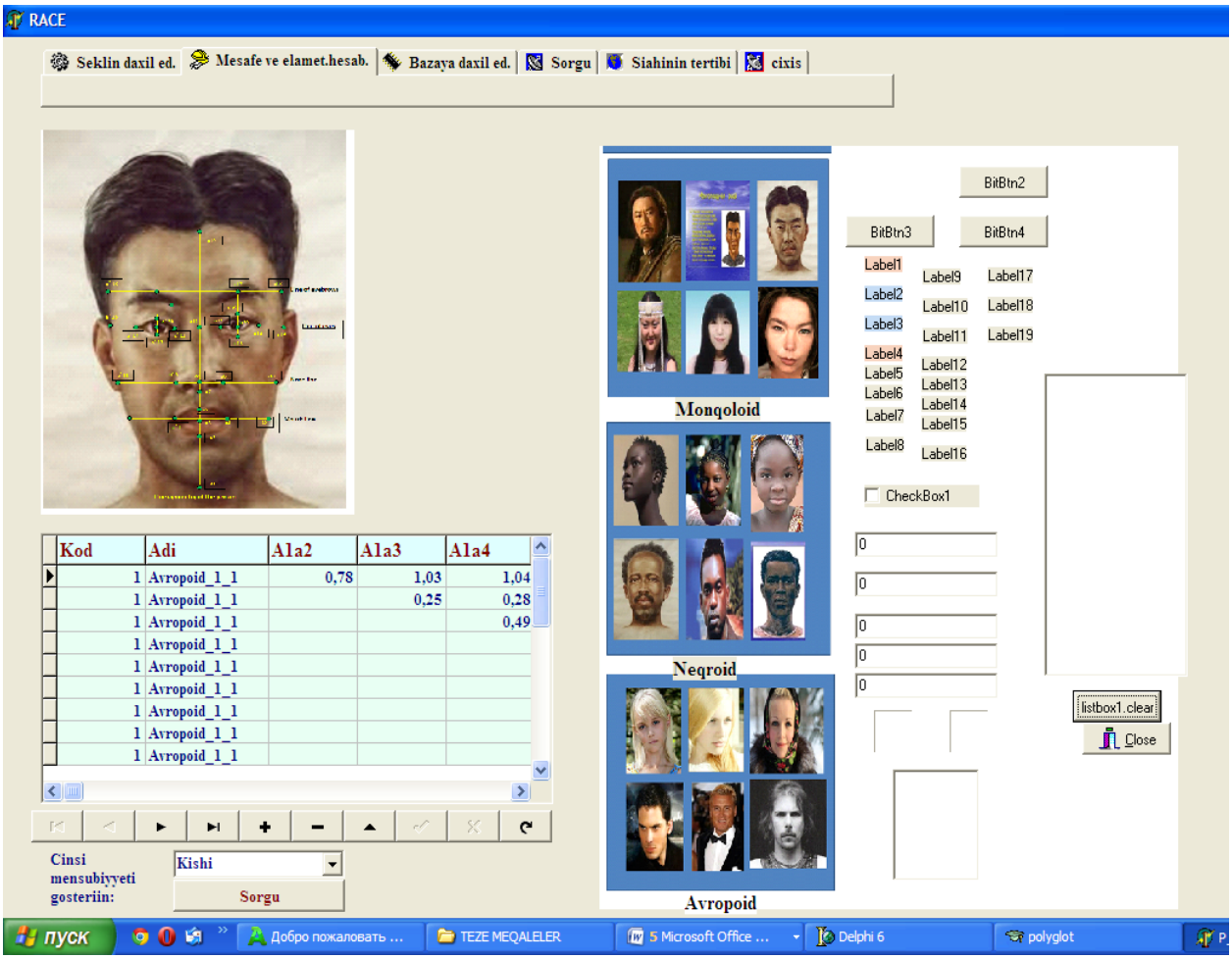


Fig. 3. Interface for recognition

Conclusion

Various professional fields (anthropology, customs, border control, security services, etc.) might be interested in theoretical and practical researches on determination of racial and ethnic identity of a person. Solution of this issue enables to reduce the time spent for the search of millions of photos stored in the database during the recognition of a person on the basis of images, as well as to decrease the scope of the search significantly.

A new algorithm for finding coefficients that determine significance extent of geometric characteristics used in determination of racial and ethnic identity of a person on the basis of portraits is suggested.

A formula is given to calculate distances between the wanted photo portraits possessing m number of geometric characteristics with the points of photo portraits in the database.

A formula is given to calculate a step in appropriate intervals of each cluster in order to determine importance degree of the values of geometrical characteristics of each photo portrait for identification.

A formula is given to calculate coefficients that indicate significance extent of values of geometric characteristics.

The given algorithm leads to the reduction in the number of values of geometric characteristics used for identification, as well as to the improvement of identification quality and to the decrease in time spent for the identification.

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