Software for Anthropometric Analysis of a Person Face*

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Abstract. An accurate and quick assessment of psychological characteristics of a person is relevant in many areas of human activity, for example, in psychological research, education, coaching, career guidance, recruitment, etc. Scientific studies show that a face represents not only basic information about a person (age, race, etc.), but also some information about his state of health or individual psychological characteristics. In this study, a hypothesis was put forward that type of thinking expresses on facial features. This hypothesis was considered on the example of first and fourth year students of educational programs in the field of information technology. Hypothesis testing was carried out using digital facial anthropometry methods. Therefore an application that performed anthropometric analysis of faces was developed. A database of students faces images was collected, the processing of which was carried out as follows. First, the program forms a collective image - an average model of a fourth-year student. After this, the models of first-year students faces were compared with this model-sample. The program gave out the percentage of the models similarity as a result of comparison. Analysis of the obtained results showed the presence of similar facial features in first and fourth year students. The results of the study show possible directions for further work on testing the hypothesis about the relationship between the type of thinking and facial features of a person.

Keywords: digital facial anthropometry · face model · facial anthropometric points · OpenCV · facial landmark detection · software development · individual psychological characteristics

1 Introduction

One of the important and relevant trends in today's biometric technology field is scientific research on methods for automatically recognizing the psychophysical state of people by their faces [1]. Assessment of individual psychological characteristics of a person is in demand in many areas of human activity, for example, in education, coaching, career guidance, recruitment, etc [2]. Carrying out such an assessment through automatic analysis of a person's face would speed up

the process and make it more accurate, quick and objective rather than using questionnaires [3].

The development of systems for the automatic assessment of individual psychological characteristics requires joint research by specialists from the fields of psychology, mathematics and computer technology. The number of such studies is only beginning to increase, so a unified theory of how a person psychophysical state is expressed on his face has not yet been formed [1].

However, some character traits that affect the face have already been recognized. For example, while studying the 2010 World Cup American psychologist Keith Welker with his colleagues found out that the ratio of the width and height of the football players faces predicts how many goals they will score [4]. Studies have also been conducted to identify main elements of male facial attractiveness. As a result, it turned out that facial attractiveness is negatively associated with facial masculinity, and preference is not associated with facial symmetry [2].

The main research tool in the field of facial biometry is digital craniofacial anthropometry [5]. Digital facial anthropometry includes methods for automatically searching for key antropometric points coordinates on facial images, calculating various face parameters and conducting special statistical (comparative) studies on them. The coordinates of the anthropometric points represent the first level of information on the facial image for problems solved in the framework of digital facial anthropometry. The distance between the coordinates is the second level of information, and the relationship between the distances is the third [6].

Variety software packages have been developed to conduct anthropometric studies of facial images. The methods of those packages perform such functions as the search for faces and anthropometric points, the recognition of expressed emotions, and anthropometric comparison of facial images. Examples of such packages are Luxand FaceSDK and Portret Client 5.0. However, most of those programs are commercial solutions. In addition, scientific research, which includes anthropometric analysis of people's faces, often requires the creation of specific programs that meet the needs of the study. In this regard, opensource software from the OpenCV and Dlib libraries has gained great popularity. These libraries contain agorithms for detecting faces and searching for coordinates of 68 anthropometric points on faces [6].

As part of the study, the issue of registering the relationship between the type of thinking and facial features of a person through automatic analysis of the facial image was considered. If this relationship exists, then people of the same profession should have some similar facial features. This hypothesis was examined in database of faces images of first and fourth year students of educational programs 090301 "Computer Science and Computer Engineering" and 090304 "Software Engineering".

The hypothesis was tested using digital facial anthropometric methods for the implementation of which a program was developed. Creating an application includes forming a list of criteria for analyzing people faces, choosing the tools of implementing the application, as well as drawing up requirements for image databases that the program will work with.

2 Face analysis criteria

Creating systems for automatic analysis of a person's face requires the development of new computer technologies and methods for processing facial images. The main issue consists in insufficient progress of methods for describing and reading information on faces. Thus, it was necessary to compile a list of face parameters that will be taken into account in the framework of this study, as well as methods for their calculation.

19 basic anthropometric parameters were selected to compare faces, that involved 34 key points of the face 1. The distance between the centers of the eyes is the basis in relation to which all face parameters are determined.

Fig. 1. Used anthropometric points.

The selected characteristics describe both the sizes of the face elements and the distances between them:

1. The face width at the eye line level.
2. The face width at the level of the nose.

3. The face width at the level of the lips.
4. The distance from the chin to the eye line.
5. The width of the right eye.
6. The height of the right eye.
7. The width of the left eye.
8. The height of the left eye.
9. The distance from the center of the right eye to the upper point of the right eyebrow.
10. The distance from the center of the left eye to the upper point of the left eyebrow.
11. The distance from the center of the right eye to the tip of the nose.
12. The distance from the center of the left eye to the tip of the nose.
13. The width of the nose.
14. The height of the nose.
15. The distance from the chin to the middle of the lip closing line.
16. The width of the lips.
17. The height of the lips.
18. The distance from the lower point of the nose to the edge of the upper lip.
19. The area of the triangle, the vertices of which are located at the points on the inner corners of the eyes and in the middle of the lip closing line.

3 Choice of application implementation tools

The developed program is a desktop application, which should consist of two main components: graphical user interface and back-end (main) part. It was necessary to choose means of implementation: a programming language and libraries for working with images and creating a graphical shell of the program.

The application is implemented in the C++ programming language. The OpenCV library version 4.0.1 was chosen as a library for working with images. It contains all the necessary methods for image processing, face detection and searching for coordinates of 68 anthropometric points. The Qt framework version 5.12, which provides a whole set of tools for GUI design, is used to develop a graphical interface.

4 Requirements for facial images base

An important condition for the correct study conduct is that all facial images must comply with a single standard. All input images of the program must meet some requirements. Thus a list of requirements was defined, according to which and database of faces images was formed:

1. Each image is a full-face photograph of one person.
2. The image size is not less than 240x320 pixels and does not exceed 250x350 pixels.
3. The face occupies at least 80 % of the image size.

4. The background in the image is uniform.
5. Elements of the face are not covered by hair or glasses.

When the input image meets these requirements, it undergoes a series of basic transformations that preserve the parallelism of lines (affine transformations), such as rotation and scaling. As a result, all input images are brought to a single standard:

1. The centers of the eyes are on the same line parallel to the horizontal border of the image.
2. The distance between the centers of the eyes is 60 pixels.
3. The line of the face symmetry passes through the middle of the image.
4. The center of the left eye is 91 pixels from the vertical border of the image.
5. The eye line is at distance of 145 pixels from the upper border.

The standard [7] was considered in compiling the conditions for the format of images used in the application.

5 Description of the developed application

The photo processing of students faces was carried out as follows. First, the program forms a collective image - an average model of a fourth-year student. A set of images meeting the requirements is fed to the program input to create this model-sample. Each image is brought to the standard, then all necessary anthropometric measurements are carried out. The obtained values are accumulated and averaged after processing all the images. Figure 2 shows the result of the program after the formation of the fourth-year student face model-sample.

Having calculated average face model-sample, user is able to compare the models of first-year students faces with this sample. Figure 3 shows the program after comparing the face of a first-year student with a fourth-year student model. The program gives differences for each of the parameters and a final percentage of the models similarity.

Based on the results of testing the application, measurements of the processing time of one image were taken:

1. Download and image verification for compliance with the requirements: 386 $\pm$ 22 ms.
2. Image processing to bring to standard: 39 $\pm$ 2 ms.
3. Counting face parameters: less than 1 ms.

The values were obtained when the program was running on Windows 10 64-bit. The hardware consisted of an Intel (R) Core (TM) i3-6006U CPU (2.0 GHz) and 6 GB of RAM (1333 MHz).

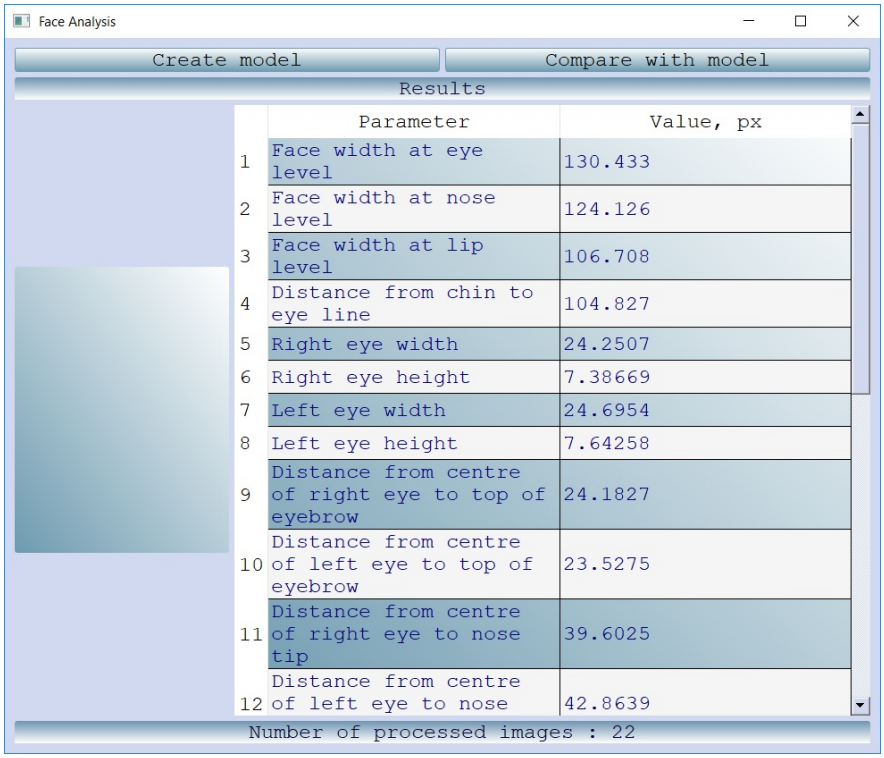
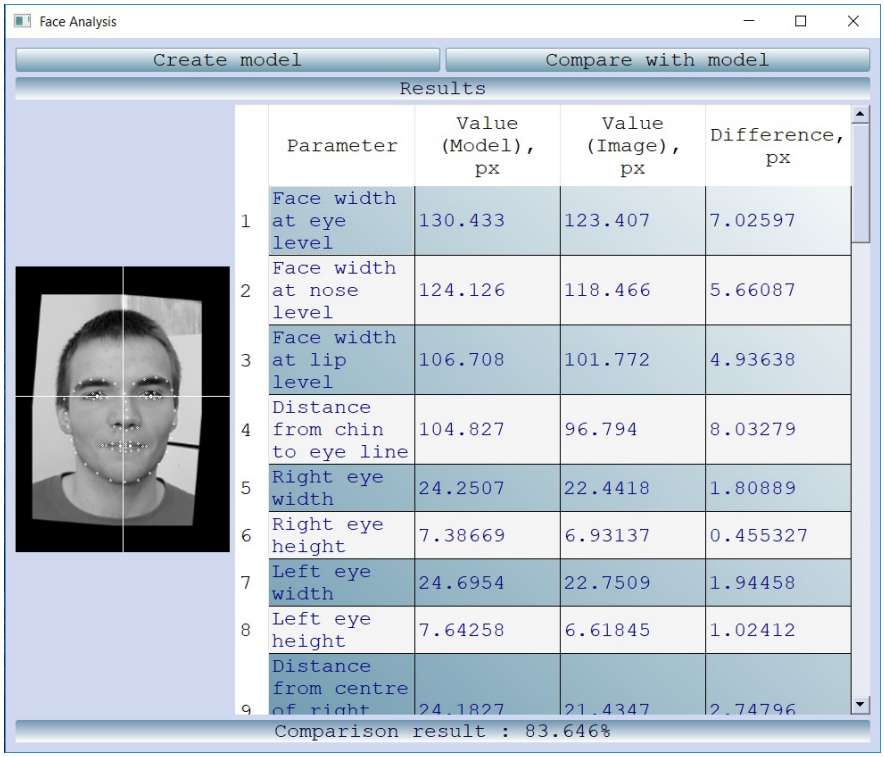


Fig. 2. Display the formation results of the average face model-sample.

6 Results of processing the generated face image databases using the application

There's no doubt that the parameters of a person's face depend on the amount of hereditary traits, gender, as well as age-related changes. Therefore, the group of students participating in the experiment was composed in such a way as to exclude the influence of these factors. The study was conducted for a group of students of the Caucasian race aged 18 to 23 years. Analysis of the students faces was also carried out separately for boys and girls. The experiment was attended by 49 first-year students, 9 out of them are girls and 40 are boys, and 36 forth-year students, 14 out of them are girls and 22 are boys. The study aroused great interest among students. The processing of personal data was carried out with the consent of students.

An analysis of the obtained results showed the existence of a correlation between the percentage of similarity with the model-sample and first-year student achievements. For example, a first-year student, who turned out to be the most similar to the model-sample, entered the ITMO University through the ITMO.Stars competition - the competition of unique achievements of applicants.



	Parameter	Value (Model), px	Value (Image), px	Difference, px
1	Face width at eye level	130.433	123.407	7.02597
2	Face width at nose level	124.126	118.466	5.66087
3	Face width at lip level	106.708	101.772	4.93638
4	Distance from chin to eye line	104.827	96.794	8.03279
5	Right eye width	24.2507	22.4418	1.80889
6	Right eye height	7.38669	6.93137	0.455327
7	Left eye width	24.6954	22.7509	1.94458
8	Left eye height	7.64258	6.61845	1.02412
9	Distance from centre of right	24.1827	21.4347	2.74796

Fig. 3. Display the results of comparing a face with a model-sample.

As a first year student, she successfully studies and participates in various activities of the university.

The results achieved during the study show possible directions for further work on testing the hypothesis about the relationship between the type of thinking and facial features of a person. Firstly, it is necessary to further improve the algorithm for compiling a model-sample by introducing more parameters. It is necessary to introduce as parameters the ratios of distances between the facial landmarks, for example, the ratio of the width to the height of the face. The added parameters should provide a more detailed anthropometric analysis of faces. In addition, an improved model-sample must be universal for people of different ages and races. For this, the parameters forming the model should be calculated in such a way as to exclude the influence of basic information about a person (age, race).

It is also possible to represent the face in the form of a mask graph consisting of the facial key points. The points are connected by edges if their position depends on the same facial muscle.

The scale of the experiment is definitely needed to increase by analyzing the faces of students for several specialities, as well as increasing the number of students for each speciality.

The application also requires the introduction of new functionality for the users convenience. For example, the function of saving and loading the model-sample parameters to / from a file, as well as the option of compiling a person's psychological profile should be added in the next version of the application.

Upgraded according to the above steps, this application can be used for career guidance, both for students and people who are already working in a certain field and who want to change their occupation. In addition, this development may be useful in medical institutions, for example, during therapy. Also, the results of further research may be of practical interest to the marketing sector in order to improve the effectiveness of targeted advertising.

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