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COMBINED IDENTIFICATION METHOD BY RECONSTRUCTION AND ANALYSIS OF FACE 3D STRUCTURE

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ABSTRACT

The process of limited access systems developing is associated with user's identification problem. In this paper solution of the problem is provided, which consists in using face geometry parameters. Implementation of combined identification method, which uses 3D face structure reconstruction and analysis, is considered. Hybrid approach is used for 2D and 3D analysis of video-frames and it helps to reduce hardware requirements and also retain method operability. A set of classification methods is considered for achieving the best accuracy for solving an identification problem. Experimental research is provided for performance confirmation and method operability quality estimation.

Keywords: identification, 3D-recognition, face geometry, 3D-reconstruction.

1. INTRODUCTION

In the development of systems with limited access, the task of identifying users arises, for the solution of which a combined method based on an analysis of the three-dimensional structure of a face obtained from two-dimensional images is proposed. Consider the implementation of a modified version of this method, in which the binary classification by the nearest-neighbor method is used for the identification stage [1, 2]. The efficiency of the proposed solution is also evaluated.

The experiments were carried out in the MATLAB R2016b software environment, which has a developed mathematical library, a language oriented to work with mathematical calculations, and a wide range of tools for displaying the results of experiments. These factors allow us to accelerate the processes of development, debugging and evaluation of the efficiency of the proposed method and its algorithmic implementation.

2. MODELS AND METHODS

Let us consider some functional features of the proposed modification of the combined method [1, 6, 9, 10]. The main changes have affected the identification phase, which consists in comparing the face descriptor generated for the current session with those available in the database. The descriptor represents a set of three-dimensional Characteristic Points (CP) of the face [1]. For determine the positions of eyebrows, eyes, nose, mouth and chin 28 points are used. In this case, the two-dimensional coordinates of CP are localized by analyzing the face image [4, 5, 6, 7].

Thus, to solve the identification problem, a descriptor comparison mechanism is needed. To build it, we use a binary classification of distance vectors between the corresponding points of two descriptors (the classification function in Figure-1). The output parameter of the classifier is a Boolean value that determines the belonging of these descriptors to one person.

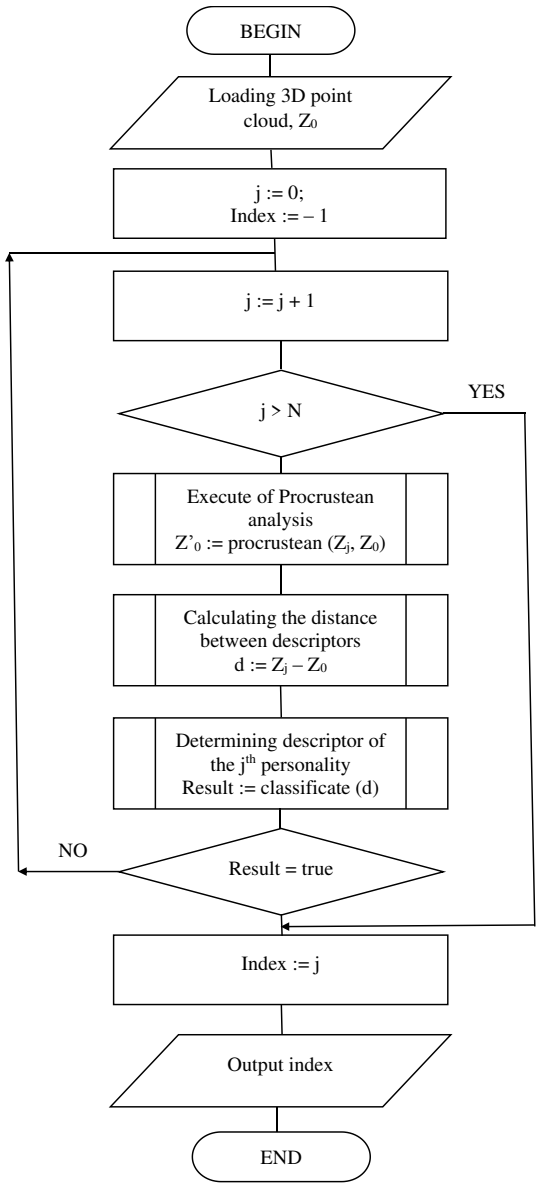

Figure-1. Algorithmic structure of the identification stage.

The algorithmic structure of the identification phase is shown in Figure-1, where Z is the array of descriptors in the database, and N is the size of this array. The output parameter is the index of the desired descriptor, if the identification process is successful. Otherwise, the method returns -1.

3. MAIN RESULTS

To determine the classification method, which has the highest accuracy of work in solving the problem, a computer experiment was conducted, during which the training of a set of 23 classifiers proposed by the MATLAB system was carried out [3]. To eliminate re-training, cross-validation with five folds was used [2]. For the experiment, a training sample was formed, representing the distance vectors between the corresponding points of the descriptors being compared [1]. For the formation of a sample, a database of photographs of individuals from different angles was used [4].

In Figure-2 represents a part of the training sample in the form of a set of polygonal lines corresponding to the distance vectors between the corresponding points of the descriptor pairs.

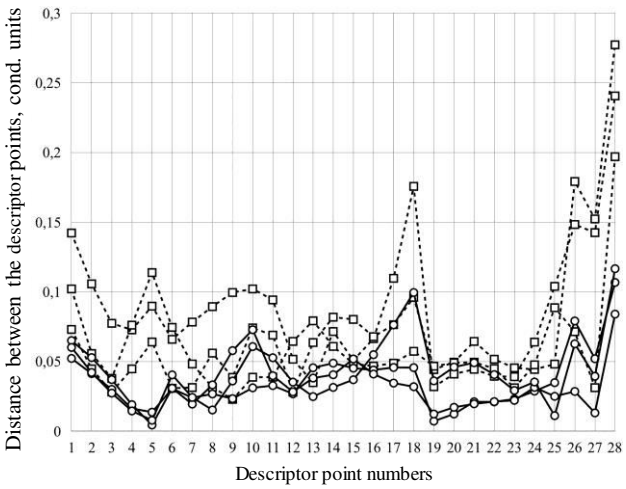

Figure-2. The values of the distances between the points of the descriptors of the training sample.

The dashed line with square markers denotes broken lines constructed for pairs of descriptors pertaining to one person. For the remaining pairs, the broken lines are indicated by a solid line with markers in the form of circles.

From the ones shown in Figure-2 of the results of the experiment shows that the greatest difference between descriptors is observed in the region of the mouth and chin (points 26 - 28), which is due to different height of faces, as well as facial expressions.

Among the trained classifiers of the highest accuracy (86.4%), the nearest-neighbor method, ensembled by random subspaces, was achieved [2]. This approach is preferable in problems with a large number of signs of a relatively small number of objects under study.

4. CONTROL DESIGN

To study the main characteristics of the chosen classifier, a matrix of inaccuracies was constructed [8], presented in Figure-3.

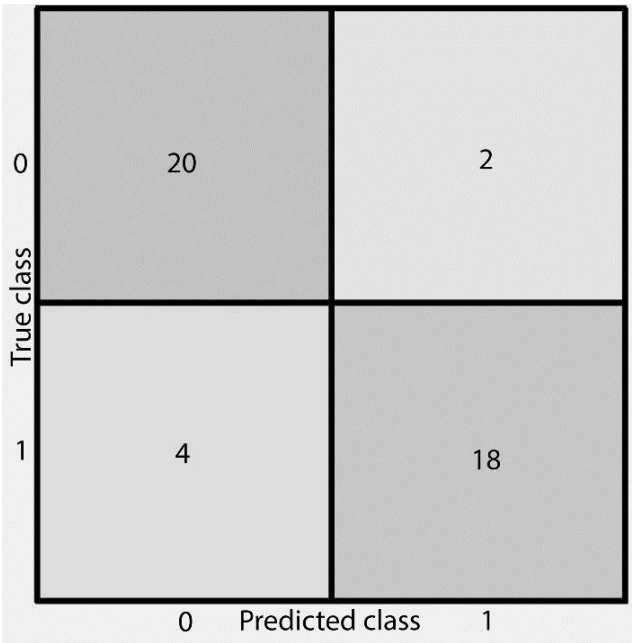

Figure-3. Matrix of inaccuracies.

It can be seen from the matrix that when recognizing the descriptors of the training sample, four errors of the first kind and two errors of the second kind were admitted from 44 experiments, which gives an overall recognition accuracy of 86.4%. The results of the evaluation of this parameter for each class are presented separately in Figure-4.

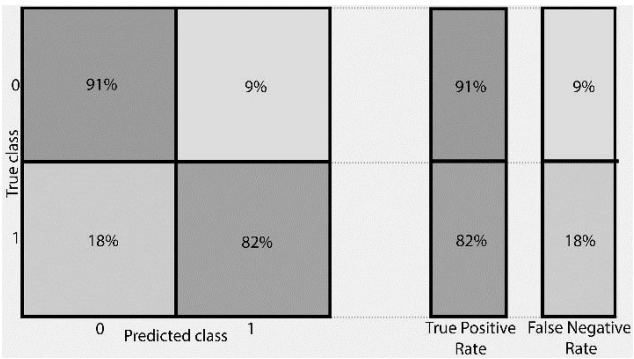

Figure-4. The accuracy of the classification and the percentage of false-negative recognition results for the designated classes.

As can be seen from the values in the figure, the comparison of descriptors relating to different personalities is successful in 91% of cases; otherwise the accuracy is 82%. However, a lower accuracy of recognizing descriptors pertaining to one person provides fewer errors of the second kind and a higher completeness

of recognition of this class, the results of calculations of which are shown in Figure-5.

Figure-5. The completeness of classification and the percentage of false-positive results of recognition of the designated classes.

From the values shown in the figure, it is clear that the predictions for descriptors pertaining to different people are correct in 83% of cases, for the other descriptors this parameter is 90%. Thus, in the implementation of identification, there is a probability of 90% that the person selected by the method from the database is the right decision.

Also, to evaluate the quality of the classifier, a Receiver Operating Characteristic (ROC) was constructed, the graph of which is shown in Figure-6.

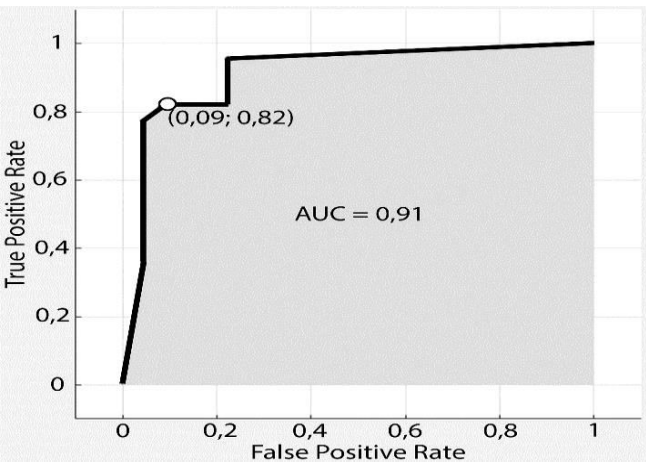

Figure-6. ROC for the selected classifier.

The ROC shows the dependence of the classification accuracy on the probability of a second-kind error. The area under the graph determines the value of the quantitative characteristic of the ROC curve and is 0.91, which allows us to conclude that the classifier in question is working. In the learning process, the point (0, 09, 0, 82) on the curve is chosen as the value at which the highest classification accuracy is achieved, from which it follows that the probability of a false-positive response of the system is 0.09 with an accuracy of 0.82.

5. CONCLUSIONS

The results of the research confirmed the practical feasibility of using a combined method of personality identification, combining two-dimensional and three-dimensional analysis in the processing of incoming frames from the video stream, which reduces the hardware requirements for the analysis of the three-dimensional structure of the face.

The efficiency of the solution is confirmed by the performance indicators used in practice, evaluated in a series of computational experiments: the overall accuracy is 86.4%. The False Acceptance Rate (FAR) is 0.09 with a False Rejection Rate (FRR) of 0.18.

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