FOSFI – THE SYSTEM FOR FACE IMAGE RECOGNITION

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Summary

A soft/hardware system for sanctioned access by face personal identification FOSFI (Foveal System for Face Identification) is presented based on previously developed biologically plausible algorithms of image description and recognition. These algorithms are related to detection of the most informative image regions, spatially non-uniform representation of visual information, and context encoding of primary features. The results of the system testing in real-life conditions have demonstrated that the system does not permit non-sanctioned access in 100% of cases while probability of false rejection of a person with a sanctioned access is less than 8%.

Introduction

Currently, in the field of biometric person identification, an approach has been developed based on developing algorithms and systems for face recognition [5]. These systems are oriented to two main application tasks. The former is related to the problems of sanctioned access when the first type recognition error (falsely positive identification) should be, at least, in 10^4 times less than the second type recognition error (falsely negative identification). The latter task is related to a search for a certain person among others when the error relation should be opposite. As a rule, one uses different algorithms for the two tasks because in the first case some measure of similarity has been searched for, while in the second case some measure of non-similarity is to be determined.

The present research dealt with the problem of face recognition in application to the task of sanctioned access.

The algorithmic basis for visual features analysis and representation in the present research is the methods and models of active visual perception developed earlier at the Institute for Neurocybernetics at Rostov State University which use visual foveal sensor with spatially non-uniform resolution [1-3]. These algorithms are based on biologically plausible principles related to detection of the most informative image regions, spatially non-uniform representation of visual information, and context encoding of primary features [3,4]. The basic features used in all algorithms are module and direction of brightness gradient [1,3].

The system schematic

To solve a problem of sanctioned access into a restricted area, a soft/hardware system was developed. The system includes the subsystem of video-input, the subsystem of image processing and template image description forming, the subsystem of archive storage and personal data input. Storage of the database of facial images and their descriptions, additional description forming and person identification were realized by means of a high-performance computer (server) in the local network.

The system has three functional modules: “Administrator”, “Security department”, and “Identification sector”.

“Administrator” has a complete access to the system tuning and image description forming for identification objects by manual and/or automatic selection of foveal sensor positioning in a face image. Besides, "Administrator" can form additional descriptions of a given person in the case of falsely negative identification, the feature marking up of a new image being stored.

While adding a new person into the database, the measure of similarity of this person description with other subjects in the database is estimated (verification of "twins" existence). If this measure exceeded an allowable limit (0.75), an addition of "twins" descriptions is made by marking up new sensor positioning points in the "twins" images until a positive distinguishing.

"Security department" forms personal information in the database and gives each subject a personal identification code which a set of template images of this subject in the database corresponds to. This user has an access to the system protocol including information about the work of access system (who and when did come through or tried to) and formation of individual messages to persons going through the access zone.

"Identification sector" realizes a visual verification of the system functioning in the access zone and allows a person to come into the protected area in the case of a false rejection. In this case, a current and template images of the person are seen on the system monitor. If an operator visually recognizes, this person, he/she sends the current image into the file of possible complimentary images.

Subsystem of image processing and recognition

The subsystem of image processing and recognition FOSFI includes two basis modules FACE FEATURE DETECTION (FFD) and FACE DESCRIPTION AND RECOGNITION (FDR) implemented as dynamically linked libraries of functions (.dll). Both modules operate with images of from 256x256 to 512x512 pixels. A facial region is not less than 25% of the image.

In FDD, the cascade method for detection of the most informative regions of a face image (eyes, nose, and mouth) has been realized [2]. The method is based on computationally simple procedures with oriented brightness edges. At the noise level up to 20%, the cascade method provides detection of, at least, two informative fragments (eyes regions) with accuracy sufficient for calculation of the rest of anthropometrical points. The method results in coordinates of the detected fragments centers and sizes. The time of detection is 100 ms on Pentium–4 with 256 Mb operative memory.

FDD provides also marking up the basic anthropometrical points used in criminalistic facial identification [6].

FDR is used to specifically describe a 2D image by a set of 49-dimension vectors [1,3] while foveal sensor positioning in the anthropometrical points. This module provides image encoding invariantly to scaling and projective transformations and to viewing point changing (up to ±25°) by forming complementary image descriptions. The processing time of image feature description forming is 0.25 s. The result of the module work in the mode of template image description forming is a specific set of 49-dimension vectors in the database. In the mode of recognition, the module forms a presented image feature description and calculates coefficient of similarity of the current description and templates ones from the database.

The algorithms for oriented edges detection used both in detection of informative regions and to specifically describe an image allows parallelizing operations. Moreover, because the FOSFI system is aimed to estimate authenticity of a given person, the processing time depends on a number of template descriptions of this person in the database only.

The system testing

The testing of the soft/hardware system including FOSFI were carried out at the Institute for Neurocybernetics at Rostov State University. During one month, while coming into the institute, employees entered individual identification code received while experimental database forming. As soon as the first digit of the code was entered, the person's face image was taken by video camera and sent to the server. The server provided the image processing and comparison of its feature vectors with the template vectors from the database corresponding to the individual code. If the coefficient of similarity exceeded an experimentally determined value of 0.75 (the correct recognition), the server sent a signal about recognizing the entering person.

Figure 1 shows an example of the subsystem "Identification sector" work in the case of the correct recognition. It can be seen that the entered image differs from the template one by size. As the testing showed, the system provided a stable recognition if the facial image size varied in a range from 0.8 to 1.3 of template image sizes from the database.

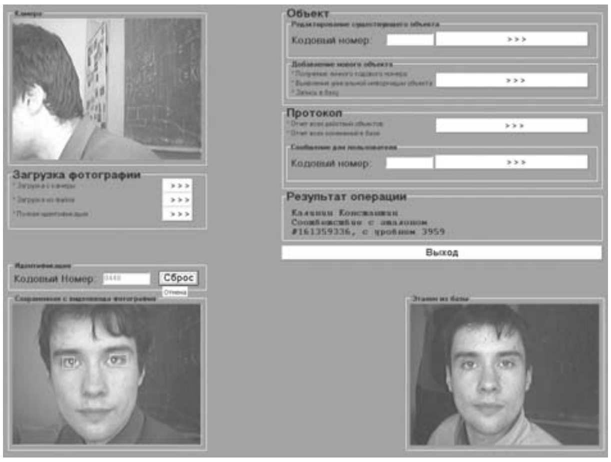

Fig. 1. An example of the subsystem "Identification sector" work. The screen is divided into 4 regions: the upper left-hand region is on line video-input window; the upper right-hand region is a service region available to the "Administrator" only; the lower left- and right-hand regions show the current and template images correspondingly.

If the similarity coefficient was less than 0.75 (the system did not recognize the current image), the template image corresponding to the personal identification code from the database was shown on the screen along with the current image and a message about the event was stored. A user of the subsystem "Identification sector" made a decision on the base of visual comparison of the two images whether the person should be allowed to enter the institute or not. At the end of each working day "Administrator" analyzed all "non-recognition" events and if necessary added a complementary description of a not recognized person into the database.

Inserting a new image into the database was carried out as follows. "Administrator" chose images to be included into the database from non-recognized images and manually marked up two basic points (centers of eye irises), the rest of the anthropometrical points was marked up automatically. If their location did not correspond to the real anthropometrical points it was corrected manually. As testing showed, in 60% of cases the automatic algorithm of marking up did not require corrections.

Figure 2 shows an example of the "Administrator" subsystem functioning in the mode of marking up a new image. The interface of this subsystem allows a user to simultaneously see the image with all anthropometrical points and the context region of a point to be marked up at the moment. Then the foveal sensor is positioned in each of these points and feature vectors are formed and stored into the database.

Fig. 2. Interface of the "Administrator" subsystem in the mode of marking up the basic anthropometrical points (black circles).

While testing the system during one month the following results have been obtained. With the database of template descriptions for 50 persons and 150 persons tested including those from the database the system provided 100% identification of "outsiders" and gave a false alarm while entering a person with a sanctioned access in 8% of cases.

It was also determined that a minimally sufficient number of the templates in the database was from 2 to 5 descriptions per person. The average image processing and recognition time, taking into account information exchange with the server, did not exceed 1 s, which corresponded to the time of walking from the video camera to the door.

Conclusion

The testing demonstrated that the developed system of personal identification by face image analysis provided a high degree of protection from non-sanctioned access. The system plausibly adapted to variations of individual person behavior in the access zone and accumulated the minimally sufficient descriptions in 15-20 entering. In comparison with the existing known systems (see, for example, www.neurotechnologija.com) the developed system has a series of advantages. In particular, for reliable recognition, it does not require an exact positioning of a person's face while video-input.

The algorithms and methods lying in the base of the recognition system demonstrated an improvement of the recognition quality in comparison with the ORL image database (www.orl.co.uk/facedatabase.html) which was used while original algorithms development. This is because of increase of image size and improvement of resolution of images to be processed.

In the future, we plan an extension of the FOSFI possibilities to solve the problems related not only to determination of a person authenticity in the access zone but also to person recognition in the case of a free behavior.

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