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DEVELOPMENT OF SOFTWARE FOR FACE RETRIEVAL SYSTEMS MODELING

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The development of software for face retrieval systems modeling is studied. An overview of the state of the problem is provided. Computer modeling is shown to be required to select the most appropriate system structure, set of modules and their parameters. The basic requirements for modern face retrieval systems are determined. It is found that they provided the concept of building a software complex for FaReS modeling, which formed the basis for a new Simulink library developed by the authors. Examples of solving practical problems of facial biometrics, structure, composition and parameters of blocks of used systems are shown. Compact models of computer experiments are presented.

Keywords: object-oriented modeling, Simulink, library for modeling face recognition systems, model of compact description of computer experiment

1. Introduction

Over the past two decades powerful and affordable computing equipment for solving applied problems of retrieval and identifying people has been created. The performance of modern equipment is commensurate with the amount of data in the image database.

The human face, being its unique characteristic, is often used for identification purposes, for example, in the access control systems of different levels (from the entrance to the laboratory to cross-border control). In practice, facial images can be represented in various categories - in visible and /or infrared light, identikits, in the form of "range image" and 3D objects.

On the one hand, the presence of such categories significantly expands the field of application of facial biometrics, and on the other hand it substantially complicates the solution of applied problems.

Currently, the main studies are aimed at improving the methods of image processing, but very little attention is paid to issues related to the development and optimization of systems. This leads to the fact that a more accurate solution of the problem is provided by increasing the complexity of the system. The development of effective FaReS (Face Retrieval Systems) is a non-trivial task [1, 2] that requires not only a good knowledge of facial image processing methods, but also a lot of experience in designing and programming such systems. To solve this problem, it is advisable to use computer modeling. However, at the moment, there are practically no full software tools for modeling facial image processing systems (figure 1).

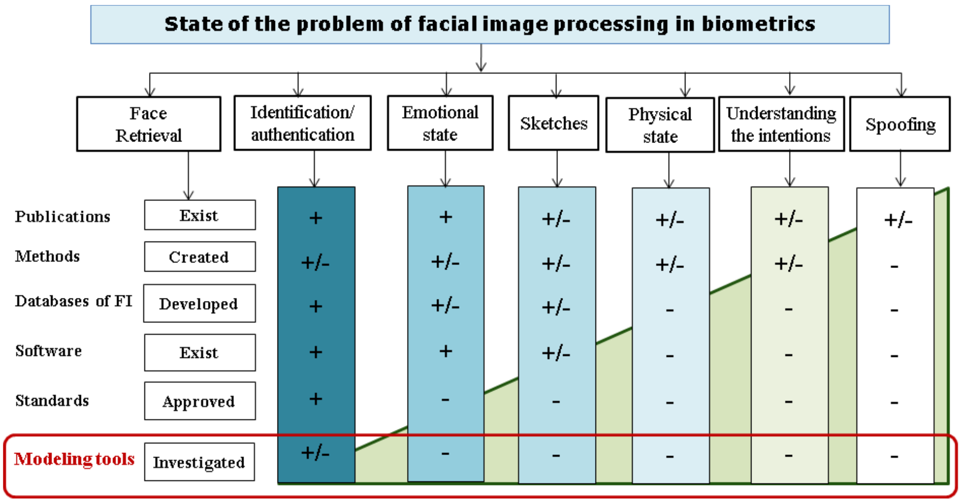

Figure 1. Methodical support of facial biometrics tasks

2. Concept of building software for modeling FaReS

One of the most important and complex stages is the formulation of the problem and the choice of an adequate solution to it. However, this requires either a great practical experience or a lot of experiments, so in practice, preference is often given to systems using universal but excessively complex and resource-intensive methods for image processing. To search for more economical and simple solutions, it is reasonable to use computer modeling at the stage of developing the concept of a future system.

One of the reasons for the lack of FaReS modeling tools is the lack of requirements for such software. The software for modeling should have a modular structure that will provide flexibility and extensibility of the system without a significant increase in labor costs for implementation. The software system should provide the ability to solve the task of each block by several methods, as well as adding new functional modules, including those developed by users. It is also necessary to synthesize a system that has a cascading, parallel or more flexible hybrid structure, it is necessary to ensure the possibility of using different information about the same person. For the implementation it is necessary to have the formation of a ready-made application for solving a specific problem, evaluation of time and computing costs, evaluation of the quality of the developed system. For research, analysis of the composition, characteristics of the feature space, data randomization, selection of optimal parameters, experimental planning, visualization of data and results, flexible reporting. A detailed list of requirements is presented on the figure 2.

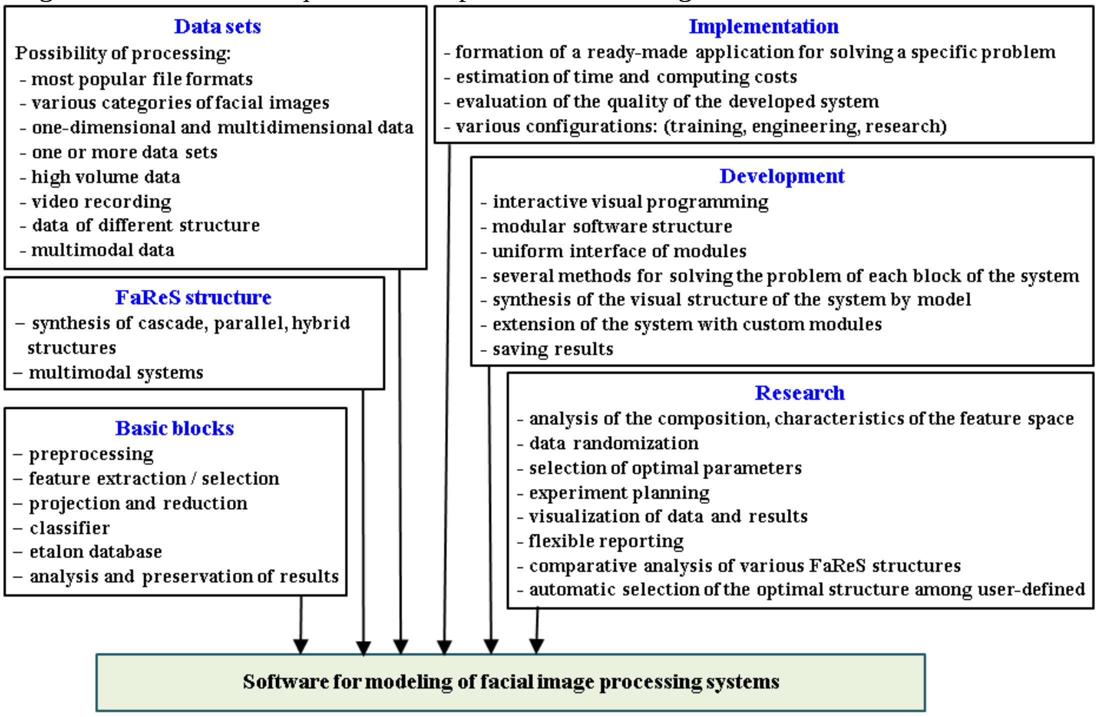

Figure 2. Concept of building software for modeling FaReS

3. Simulink library FaReS design

Three groups of modern tools are most often used for modeling: software development environments, graphic environments for simulation of FaReS, specialized software for modeling recognition systems. A key advantage for solving the problems of the facial biometry with the help of Graphical environments of simulation is the Ready-made graphical modeling environment, and for Simulink also the support of the MATLAB language [3], which allows the processing of images in terms of matrix algebra.

To solve any applied task of biometrics it is necessary to determine the architecture of the target system. To do this, you should take into account the quality of the data, the number of data sets, the dimensionality of the data, the dynamics of data changes, the purpose of the analysis. You should chose method of feature extraction/selection and feature space dimension reduction methods, and all of this defines the type of system structure.

As illustrated above, Simulink is the most appropriate option to design a simulation system, for this you are able to use blocks from standard packages but they are not enough for a full-scale simulation. Thus, it is necessary to develop new custom blocks.

To FaReS design the authors developed a Simulink library. The steps required for block creation are open the standard Simulink block library, select the Matlab function block, define the block interface, describe block behavior in Matlab language, set the sizes of input and output data streams, add a new block to the developed library.

Figure 3 shows an example of a system developed using this developed library. Each block has several parameters for tuning, setting values to which you can improve the results of the system.The parameters can be external to the block (connected as a separate block) or internal (available in the block settings). The library allows creating cascade or parallel structure (Figures 4) that provides an ability to generate systems of any complexity.

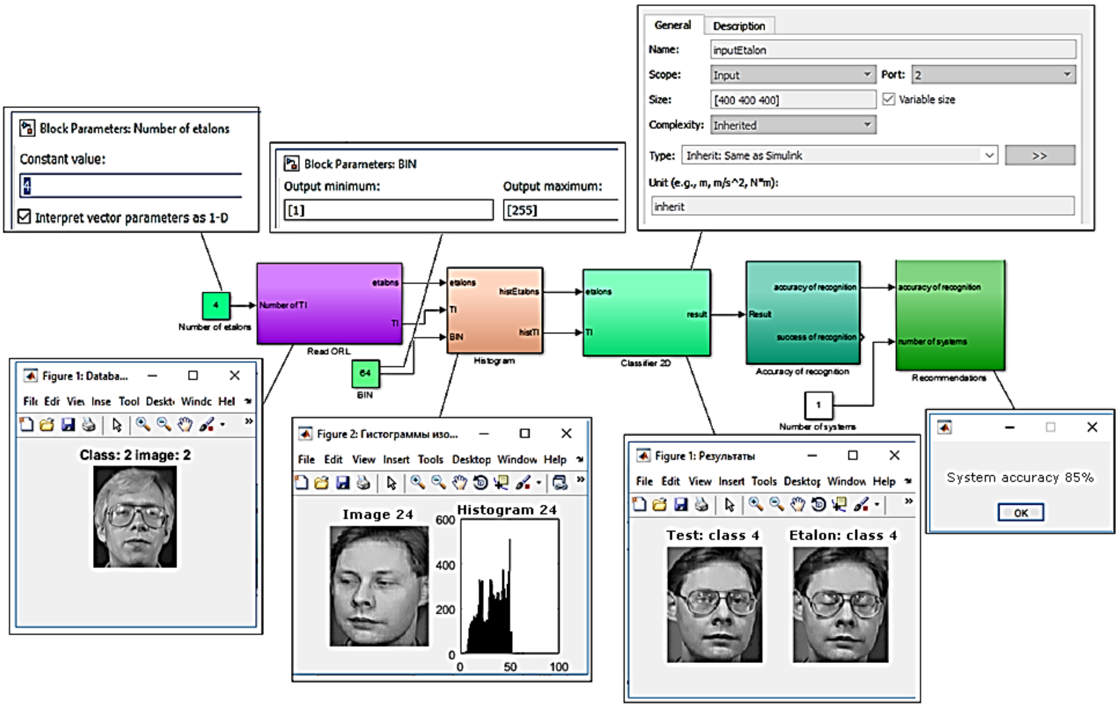

Figure 3. Example of setting parameters and workflow of facial image processing system

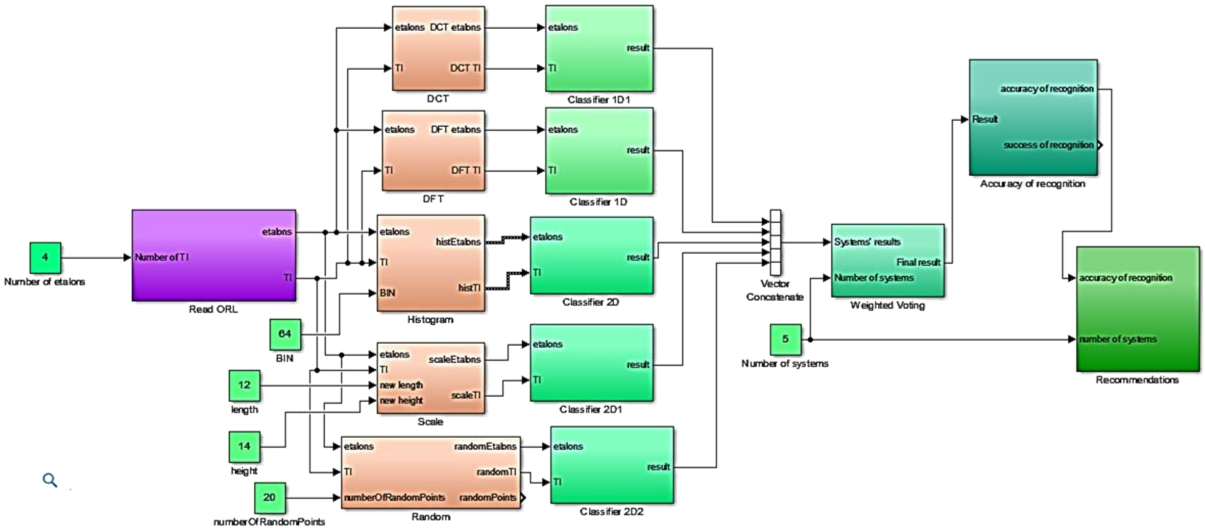

Figure 4. Example of parallel facial image processing systems

4. Model of compact description of computer experiment

For a compact description of a computer experiment, it is proposed to use a model that more clearly and fully describes the structure of FaReS, has the ability to describe parallel, cascade and combined systems [4]. A set of parameters included in the model is sufficient to perform a similar experiment by other researchers or other platforms, and also for comparative analysis during testing of simulated systems.

We define the elementary system as a combination of the image base, the block of feature extraction/selection and the classifier.

$$ES = DB\ (K/L/(Q-L) \rightarrow MOD{:}\ TV)\ \{PO/TF{:}M \times N \rightarrow d1 \times d2/SF\}[Cls/Met/rank].$$

The base of images is described by the following parameters: K – number of classes in a database; Q – number of images in a class; L – number of etalons representing the class; MOD – a sign of modification; TV – type of modification (cross-validation, randomization).

The feature extraction/selection is described by the following parameters: M – highest of facial image; N – width of facial image; TF – representation of facial image: $d1\times d2$ – dimension; PO – preprocessing; FS – feature selection.

The classifier is described by the following parameters: Cls – classifier type; Met –metrics; rank – rank of result.

The facial image processing systems description based on compact description shown in Figure 3 will be described as follows

$$\mathrm{ES} = \mathrm{ORL}\,(40/4/6)\ \{\mathrm{Hist}: 96\times 112 \rightarrow 1\times 64\}[\mathrm{CMD/L2/rank} = 1]\ .$$

The description of a simple system fits just one line, it is clear that for a parallel, cascade and more complex system structure it was also possible to give a brief definition.

The model of cascade system will be

$$\mathrm{CS} = \mathrm{ES}_1 \rightarrow \mathrm{ES}_2 \rightarrow \ldots \rightarrow \mathrm{ES}_{KS}.$$

Then the model of parallel system will be

$$\mathrm{PS} = \left\{ \begin{array}{c} \mathrm{ES}_1 \\ \mathrm{ES}_2 \\ \vdots \\ \mathrm{ES}_{KS} \end{array} \right\} : \mathrm{Fuz}\ \mathrm{ES}_{\mathrm{Itog}},$$

where KS – number of basic systems**,** Fuz – fusion (method of integration) solutions, $\mathrm{ES}_{\mathrm{Itog}}$ – system forming the solution.

The facial image processing systems description based on compact description Figure 4 will be described as follows

$$\mathrm{PS} = \left\{ \begin{array}{c} \mathrm{ORL}\ (40/4/6)\ \{\mathrm{Hist}: 96\times 112 \rightarrow 1\times 64\}[\mathrm{CMD/L2/rank} = 1] \\ \mathrm{ORL}\ (40/4/6)\ \{\mathrm{Scale}: 96\times 112 \rightarrow 12\times 14\}[\mathrm{CMD/L2/rank} = 1] \\ \mathrm{ORL}\ (40/4/6)\ \{\mathrm{Rand}: 96\times 112 \rightarrow 1\times 50\}[\mathrm{CMD/L2/rank} = 1] \\ \mathrm{ORL}\ (40/4/6)\ \{\mathrm{DCT}: 96\times 112 \rightarrow 1\times 210\}[\mathrm{CMD/L2/rank} = 1] \\ \mathrm{ORL}\ (40/4/6)\ \{\mathrm{DFT}: 96\times 112 \rightarrow 1\times 210\}[\mathrm{CMD/L2/rank} = 1] \end{array} \right\} : [\mathrm{Weighted\ Voting/rank} = 1]$$

5. Conclusion

A methodology for developing FaReS using a graphical library is proposed. It allows modeling facial image processing systems depending on the scenario of the problem being solved, the structure of the initial data, the number of data sets, the dynamics of their changes and the chosen criterion (minimum approximation error, improvement of data clustering, maximum correlation of variables in the subspace, etc.). The approach allows solving a rather wide range of facial image processing tasks and creating systems that differ in the smaller number of modules and computational complexity.

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