Web Application Development for Biometric Identification System Based on Neural Network Face Recognition

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***Abstract* — The article describes the structural analysis of the developed biometric identification complex with a description of the architecture of the complex and its hardware and software components, design and development of web applications operators, as well as performance testing of important modules of the web application. Biometric identification complex under development can be applied in various spheres where access control to various important parts is required, for example in airports and its control zones. This work was supported by an internal MTUCI grant.**

Keywords— complex of biometric identification, web application design, development, template MVC, testing, Jaeger

I. INTRODUCTION

Various face recognition technologies are increasingly being developed. Developed countries as well as private companies apply these technologies to control different resources: admission to different premises, search for violators and criminals, etc. The use of detection methods in airports is of great importance. Increasing the control of standard biometric identification tools can help to correctly detect the offender and prevent illegal actions. Recognition systems can also be used for automated passport control checks (Fig. 1).

Fig. 1. Hardware component of a complex of biometric identification

The Department of Intelligent Systems in Management and Automation (ISMC) of Moscow Technical University of Communications and Informatics (MTUCI) for several years, together with undergraduates, has been conducting scientific research related to the use of machine learning in cyberphysical systems and Internet of things applications. Neural networks methods are used to develop control systems for robotic complexes or industrial devices[1,2], isolation of interfering wave components in a phased array[3], applications for communications the social sphere [4], ecology control systems[5] and medical applications [6,7].

Members of the ISMC department under the grant "Development of software for biometric identification based on face recognition for security system using neural network methods and modern software solutions" are developing a hardware-software complex of biometric identification (HSC BI) with the use of modern methods in computer vision and neural network methods of recognition of persons with the possibility of subsequent integration into the security systems [8]. Created HSC BI will provide for any set of premises access control and monitoring of the movement of people.

User-friendly operation of these systems is achieved by using fast, modern user interfaces that provide all the necessary scenarios for working with the system. Therefore, the task of creating a user interface in the form of a web application was set for the biometric identification system being developed.

II. ARCHITECTURE OF THE COMPLEX OF BIOMETRIC IDENTIFICATION

Developed HSC BI is a software-hardware complex with a distributed architecture of subsystems and modules, with the ability to run both local and on the cloud virtual or physical servers [8]. The data required for operation are stored in a relational DBMS and file storage. Hardware component of the complex is shown in figure 2. The functionality of the devices shown in the hardware component of the complex described in table I.

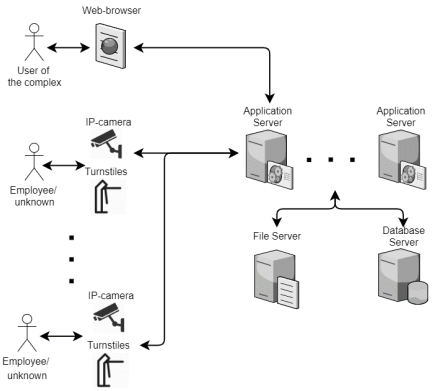

Fig. 2. Hardware component of a complex of biometric identification

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TABLE I. FUNCTIONAL DESCRIPTION OF THE DEVICES OF COMPLEX OF BIOMETRIC IDENTIFICATION

#	Device	Functionality
1	IP camera	Provide access to the video camera for the detection and identification of objects (persons).
2	Turnstiles	Provide access to the protected area.
3	Personal operator station	Used to access webinterface of the system under development and the monitoring of the proper operation of the system.
4	Application servers	Provide application detection and face recognition.
5	Database server	Provides storage for the database access information stored in the database.
6	File server	Provides storage and access to files (photos) for training/retraining neural network model and storing models from trained neural networks

The software component consists of the following subsystems and modules:

- «Detector» subsystem - connected to stream of IP-camera and use it for detection and tracking of human faces and send detected entities in the subsystem «identify»;
- «Identify» subsystem– identification of face images obtained from the «detector» subsystem using neural network models;
- module for creation backup database and file storage – create and store backup copies of the database and file storage in a local or cloud storage;
- module for retraining a neural network model – retraining a neural network model, run on demand or scheduled.

The database server used to store and access information that is stored in the system database. As a DBMS for the database was chosen as open source MariaDB.

The database contains relationships that match the following entities:

- positions existing in the University;
- faculties existing in the University.
- area, which is where the IP-camera is placed for access control;
- employees of the University.
- used IP-cameras in the complex biometric recognition.
- history of identifications carried out by complex biometric identification.

Thus, the database schema takes the form shown in figure 3.

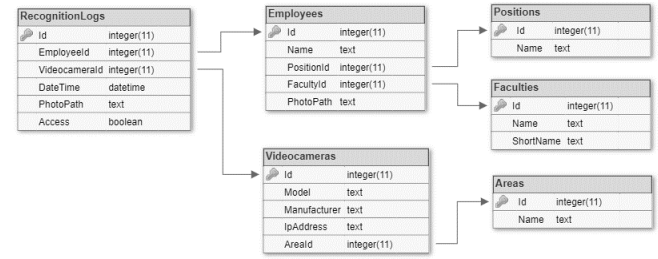


Fig. 3. The database schema of complex of biometric identification

The file server is used for storing and providing access to reading and writing photos, as well as to trained neural network models. Storing this information on a file server rather than in a database reduces both the size of the database and the time it takes to execute queries in the database. Used the tree directory of a file server shown in figure 4.

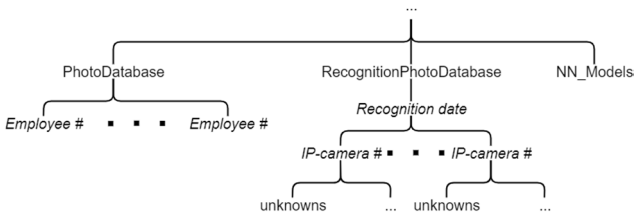


Fig. 4. The tree of directories in the file store complex of biometric identification

In the catalog PhotoDatabase placed pictures of the staff at which the learning neural network model. The directory name of an employee is a unique identifier stored in the database.

In the catalog RecognitionPhotoDatabase photos are stored produced from identification. The directory structure includes the date when the recognition was made, a unique identifier of the camera from the database and the folder unknowns, which are placed photographs of unidentified objects.

In the directory NN_Models stores all versions of files, a trained neural network. In case of unsatisfactory performance of the new model, you can replace one of the previous.

III. DESCRIPTION OF THE FUNCTIONAL REQUIREMENTS FOR THE WEB APPLICATION OF COMPLEX BIOMETRIC IDENTIFICATION

Based on the tasks implemented by complex biometric identification, the web app was based on the following requirements:

- to provide the login form to prevent leakage of information to users not having access [9].
- to provide information in real time about the recognitions during the operation of the complex, as well as provide the history of the recognitions for a certain period at a certain checkpoint and I have a IP-camera.
- to provide an interface to work with databases with ability to add/change/delete information operators have access.
- submit the following form: create new employees with the ability to add photos to train the neural network model, the change employee and his photographs, the complete removal of the employee.
- to provide an API endpoint to record the identification result of the complex to DB and save photo, which was conducted identification in the file store.

IV. Designing a web application of complex of biometric identification

Developed a web application consists of client and server, interacting with a web browser [10].

The client part is a web application used for generating requests and processing responses from the server and implements the user interface

Backend web application is used to retrieve the request from the client, search data in database and file storage, the formation of the final web page and sending it to the client.

The server part of the web application in its implementation uses the MVC pattern (model-view-controller), the scheme of which is presented in figure 5.

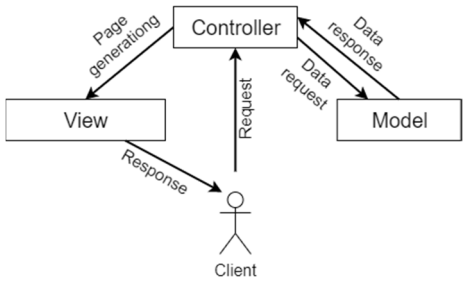


Fig. 5. Work of MVC pattern

Pattern MVC consists of the following components [11-13]:

- Model – part of the application used to display data in an object representation and its subsequent change. Often models use to maintain state in the database.
- View - used to generate and display user interface built on a data model.
- Controller – responsible for customer experience and user interface with the model and select a view to display the user interface.

To define and limit the roles of operators, the existing database schema need to be expanded by adding two new entities:

- Roles (Roles) – role of operators providing access to the resources of the web application. The entity has the following fields:
  - Id -unique identifier of the role;
  - Name – the name of the role;
  - Create – access to create records in a database;
  - Update access to update records in a database;
  - Delete – access to deleting records from the database.
- Users (Users) – operators registered in the complex of biometric identification. This entity will contain the following fields:
  - Id – unique identifier of the operator;
  - Username – the username of the operator;
  - Password – the password of the operator;
  - Email – email of the operator;
  - RoleId – the role of the operator. Is a foreign key to the field Roles.Id.

The extended database schema is presented in figure 6.

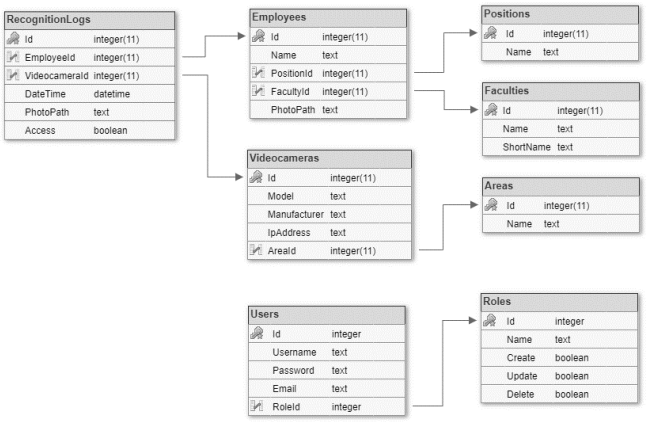


Fig. 6. The extended database schema of complex biometric identification

The web application being developed must provide an API endpoint for recording recognition results from the «Identify» subsystem. The subsystems will interact using the synchronous HTTP Protocol. Since the HTTP Protocol is a request-response protocol, after sending the request, the «Identify» subsystem will wait for a response from the web application that requests the database to search for an employee, enters the recognition result in a table, saves the photo to the file server, and generates a response. Therefore, the provided endpoint should not impair the operation of the entire complex and process the request quickly. [14-16].

V. Development of a web application of complex of biometric identification

Describes the web application is developed using programming language C# and the framework ASP.NET Core MVC [17].

To work with the database uses a technology called ORM (Object-Relational Mapping). This technology allows you to simplify working with the database using coding instead of generating sophisticated SQL query [18,19]. As a library that implements a technology ORM, you use the Entity Framework Core [20].

Components of the web application, in accordance with the MVC pattern shown in figure 7.

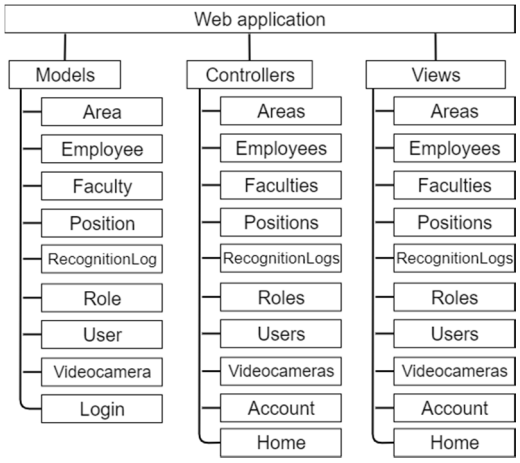


Fig. 7. Components of the web application

Developed web application runs on both desktop and mobile devices and supports the following web browsers: Google Chrome, Opera, Mozilla Firefox.

When you log in to the web application, you receive the entry form, which must be paid mail address and password of the operator. Used passwords are confidential, so if it must be protected if stored in the database. Therefore, applies the conversion to the hash SHA-1. Example conversion of passwords into a hash code with SHA-1 are shown in figure 8.

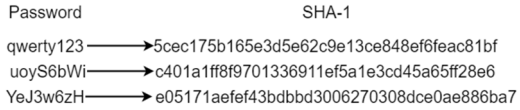
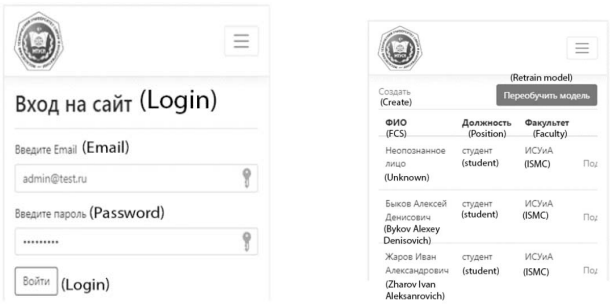


Fig. 8. Example convert the password into a hash code SHA-1

The entered data are compared with the data stored in the database, and authorize an existing user (Fig. 9).



a) b)

Fig. 9. Authorization in a web application

Web-performance models, which generates the web application, differ depending on the role. For example, the access buttons on the user interface for adding new operators or groups of operators of the complex are available only to the administrator role of the complex.

a) b)

Fig. 10. Restrict access to creating operators and groups between the administrator (a) and user (b)

Page "Recognition" shown in figure 11, provides access to results of complex biometrics in real-time. The page provides the cards last 10 recognitions, and a table with recognitions sorted by date in descending order.

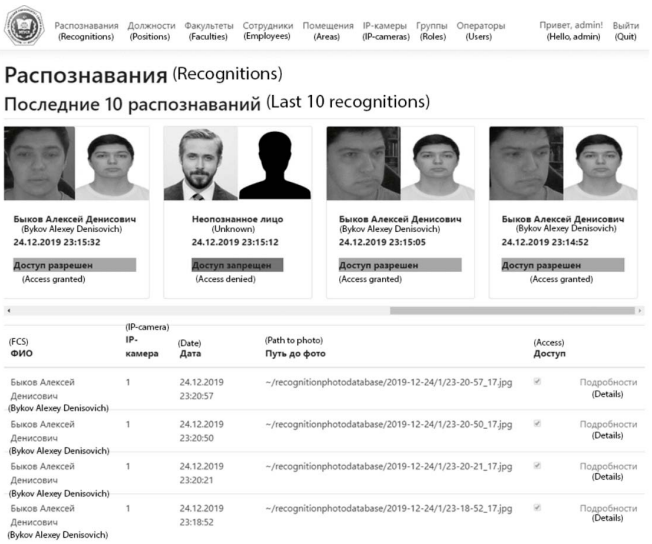


Fig. 11. Page «Recognition» of web application

Create, modify, and delete users and roles are in the "Operators" and "Group".

Pages "Positions", "Departments", "Employees", "Premises", "IP-camera" are used to display, create, modify, and delete records existing in the database.

VI. Performance Testing a Web Application of Complex of Biometric Identification

An important parameter of any web application is the processing time of the client request [14,15]. As backend for the web application communicates with other subsystems via a

synchronous Protocol HTTP, the formation of the response the web application will obviously affect the operation of the subsystem identify (when writing a result identification to the database) and on the formation of page recognitions complex for operators.

Testing the response time of the web application will be produced by the system Jaeger. Jaeger is a distributed tracking system open source, developed by Uber Technologies. This system is used for monitoring and Troubleshooting distributed systems with the following features [21]:

- the proliferation of distributed context requests between subsystems;
- monitoring of distributed transactions;
- the analysis of the dependencies of the subsystems;
- performance optimization and delay subsystems.

Testing of web application was conducted using the following equipment and software:

- CPU: AMD 2600 Ryzen 5;
- Motherboard: Gygabyte Aorus B450 Elite;
- RAM: 2x8Gb DDR4;
- SSD: 500 GB;
- OS: Windows 10 Pro 64-bit v1909
- DBMS: MariaDB 10.1.43;
- Jaeger All-In-One v1.16

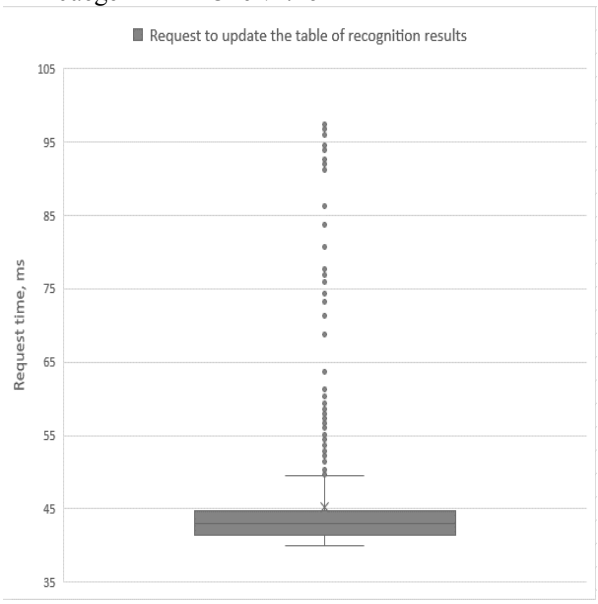


Fig. 12. Statistics processing of the request to update the page with recognition results

For the analysis of the test results were performed 1000 queries for the following methods of the web application:

- the query to update the table of recognition results (web interface);
- request for entry of the recognition result by the «identify» subsystem in the DB and save photo to file storage.

The test results are shown in figures 12-13 and table 2.

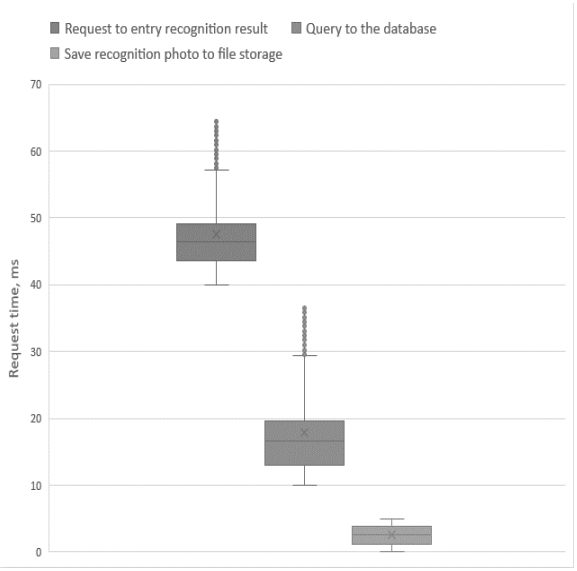


Fig. 13. Statistics processing of a request for adding a record of recognizing and saving photos in a file storage

TABLE II. THE VALUES OF THE PERCENTILES AND THE MEAN VALUE OF A SAMPLE OF 1000 QUERIES

	Request to update the table of recognitions	Request to entry recognition result	Query to the database	Save recognition photo to file storage
99th percentile	79,85	63,87	36,03	4,95
95th percentile	58,37	60,73	32,35	4,77
90th percentile	53,73	56,78	27,55	4,52
Average value	45,42	47,42	17,92	2,6

From the test results it follows that:

- large part of the requests to update the table of recognition is from 40 ms to 50 ms;
- most of the requests are for recording the results of identification runs from 40 ms to 55 ms;
- the query to the database takes 10 ms to 25 ms;
- recording time photos in the file store takes an average of 2-4 ms.

The obtained results of the web application are satisfactory in the framework of complex biometric identification and do not degrade the performance.

VII. CONCLUSION

The article analyzes the biometric identification complex being developed at the Moscow Technical University of Communications and Informatics, describes the design and development of a web application. For the web application being developed, functional requirements were put forward, which were fully met. The web application provides HSC BI operators with access to information stored in the database and allows them to change or delete it depending on the access role. We tested the query processing time of two critical methods of the web application server: a request to update the

recognition table and a request to enter identification results. The test results showed a good speed of processing requests within the framework of the biometric identification system

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