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Monitoring and Quality Control of Telemedical Services via the Identification of Artifacts in Video Footage

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Abstract: The current paper conducts research related to creating and implementing innovative universal software tools for operational quality control of telemedicine services using artificial intelligence technology. This paper presents the results of an analysis of trends in the development of tools for the monitoring and quality control of telemedicine services. The results of this comprehensive analysis allowed establishing the requirements (e.g., the fact that the probability of producing the incorrect results of the neural network should not exceed 20%) for the software module that provides effective monitoring and quality control of telemedicine services by identifying artifacts in the analysis of video. The study shows that the most effective approach to the integrated processing of medical video images is data mining. The paper also substantiates the prospects of neural network models within the framework of automated distributed monitoring and on-line quality control of telemedicine services using artificial intelligence technologies. It is shown that, in accordance with the current concept, the systems that provide the implementation of innovative technical solutions in the framework of such technologies, should be multi-format, flexibly configurable, and scalable complexes. A software module designed to ensure the detection of artifacts in video sequences was developed, and experiments to train the neural network included in it were successfully (the probability of producing incorrect results of the neural network was 5.49%).

Keywords: *artifacts, automated monitoring, image analysis, quality of telemedical services, telemedicine*

1. Introduction

Currently, a trend is the development of telemedicine [1–3]. Simultaneously, the underlying principles increasingly include computer, telecommunication technologies [4–6]. Within the framework of many remarkable projects implemented in various regions, the tasks related to the formalization, transmission and reception of medical data, and to the development of telemedicine informatics methods are being actively solved [7–9]. Experts are also testing promising compression algorithms and forms of information exchange [10–12]. Work related to the development of automated workstations actively carried on [13–15].

Among the various software tools developed and implemented in the field of medicine, special computer programs that enable real-time detection of some specific image fragments - "artifacts" indicating a particular critical and/or typical situation - for effective automated and proactive control of various critical situations (diseases, pathologies, medical errors, etc.) play an important role [16]. Great is the need for the use of such software products, providing the ability to identify cases of likely degradation of video images, as well as for their further improvement. This fact is obvious that there is a need to minimize the number of out-of-the-ordinary situations in the process of providing telemedical services.

The most effective modern methodological approach for the diverse processing of medical video images is data mining [17–19]. Various analytical tools are used as part of the software tools providing the solution of this task. Among them, as the results of analytical and practical research show, are the artificial neural networks that play the most important role [20–23].

The software solutions based on neural networks regularly improve with the stricter requirements to them, in particular, based on the problems arising in the process of practical application of such technologies [24, 25]. One example of the need for further work in this direction is the fact that the use of heterogeneous independently (separately) trained neural networks are unreasonable: the cost of their development and implementation become more expensive. Moreover, this may lead to medical diagnostic errors, including distortion of initial information, as well as differences in the formulation of

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diagnostic decisions by different neural networks with respect to the same patient in question [26–28].

Thus, in terms of the prospective use of neural networks within the framework of automated distributed monitoring technologies and operational quality control of information and telemedicine services using artificial intelligence technologies, it is relevant to conduct research toward the creation and implementation of more versatile software tools that allow identifying artifacts in video frames of telemedicine services in a multithreaded mode using neural networks, which reflect the aim of this work.

The following paper includes our experience in developing the requirements for such a software tool, its architecture, and the results of experiments on training and testing the neural network.

2. Trends in the Development of Tools for Monitoring Quality Control of Telemedical Services

The results of the literature review of trends in the development of tools to ensure the monitoring and quality control of telemedical services are in Table 1.

Table 1. The results of the literature review

Ref.	
[1]	This paper focuses on substantiating the relevance of the development of information technologies and telecommunication systems to ensure increased efficiency of clinical care. The aim was to conduct a comprehensive review of the existing and potential capabilities of telemedicine. The authors of the paper, along with an analysis of the broad possibilities of this intensively developing technology, discussed the problems associated with it.
[2]	This study focuses on the temporary need, arising during the COVID-19 pandemic, for telemedicine service in the United Kingdom to address early medical abortion. The aim of the authors' work was to discuss, from different perspectives, including political ones, the temporary nature of the decision taken.
[3]	This work deals with the analysis of state China's policy in terms of promoting the rapid development of telemedicine to improve the capacity of primary health care and the conditions of medical care in remote areas of the country. The aim of the authors was to analyze various regulatory and other documents designed to develop policy in the field of telemedicine.
[5]	This paper focuses on an analytical study of the intensively developing scientific and technical sphere related to the interface between medicine and informatics, aimed at analyzing the promising opportunities for mutual influence of medicine and certain areas of informatics in the future. The aim was to conduct an analytical review of the range of capabilities of computer-aided design systems in medicine. The authors identified key developments that have led to the current level of development in this field. An extensive literature review based on 251 carefully selected publications is presented.
[6]	This work deals with the justification the relevance of further development of new medical informatics technologies, combine computer information structures so that knowledge about the treatment of individual diseases can be combined to provide medical care for patients with multimorbidity. The aim was to conduct a comprehensive review and analytical studies of existing and potential capabilities of the most promising modern technologies aimed at solving this problem, as well as to classify them. The authors drew attention to ten topical issues that must be considered in the development of such technologies.
[7]	This study considers the relevance of the development of telemonitoring technology, considered as a component of telemedicine. The aim of the authors was to conduct comprehensive research of reviewing the existing and potential possibilities of telemonitoring. The authors of the article along with the analysis of the possibilities of this intensively developing direction of telemedicine discussed the related problems.
[8]	This paper deals with the research of problems of protection of private information about patients contained in biomedical images in various links of the telemedicine system. The aim of the authors was to conduct a systematic analysis of the technologies to ensure the confidentiality of medical images. The authors considered this problem from the following angles: motives for using medical image privacy technology, problems with medical image privacy technology, and recommendations for further research and use of such technology. The criteria for assessing the quality of a medical image protection algorithm are summarized, including, security assessment and assessment of speed and temporal complexity.
[9]	This study focuses on the justification of the relevance of active development and implementation of

telemedicine technologies in many areas of cardiology. The aim was to show, using the contributions of the Italian Society of Cardiology's Working Group on Telecardiology and Informatics, some crucial points concerning the potential benefits of telemedicine support in the continuum of cardiovascular care.

[10] The work focuses on using the technology of computer modeling to solve the problems of compression of medical data and their transfer between the various links of the telemedicine system. The aim was to conduct research aimed at developing a modeling procedure to solve the problems of medical data compression, transmission and reception over the IEEE 802.11b Wi-Fi network. To solve this problem, the authors performed survey research devoted to describe the current state of the following: communication networks and services; transmission technologies; network topologies in hospitals; medical information technologies and wireless telemedicine systems; data compression algorithms and standards for data transmission via Wi-Fi.

[11] This study focuses on the problems of medical information systems in terms of providing compression and protection of medical images. The aim was to develop technologies that providing, on the basis of genetic algorithms, reliable protection of medical images, as well as their optimal compression. The paper describes a procedure that provides lossless compression of medical images. The method for watermarking often used for image protection allows a reliable procedure for embedding watermark information about the signature or text data around the area of interest of a medical image based on genetic algorithms.

[12] This work deals with the research on problems related to improving the speed of exchange of large amounts of clinical information between physicians and patients. The goal was to convert clinical data from electronic medical records to the Fast Healthcare Interoperability Resources (FHIR) repository server data format and to develop a mobile application for personal medical records, allowing patients to easily access their clinical data. The authors of this article launched such an app, which allowed them to retrieve data from the FHIR server to display patients' clinical information.

[13] This paper illustrates the value of ultrasonography using automated breast ultrasound to predict the likelihood of malignancy, which can be effectively implemented in practice as part of medical information systems.

[14] This work focuses on research into the potential uses of artificial intelligence technologies to push the boundaries of medicine to improve diagnosis, efficiency, and management. The aim behind this work was to conduct conceptual research aimed at identifying the differences between physicians and general-purpose artificial intelligence systems, as well as the prerequisites for them to work as physicians.

[15] The paper focuses on analytical research of a conceptual nature aimed at substantiating the need to develop artificial intelligence systems in close cooperation with healthcare providers and patients. The aim was to investigate the problems of knowledge automation using artificial intelligence methods in medicine and health care. The authors examined this problem in seven categories, including big data search, computer diagnostics, online consultations, evidence-based medicine, medical care, precision medicine, and drug development.

[16] This study deals with the problem of increasing the efficiency of medical image analysis. The aim was to investigate a new approach to the development of image processing methods for medical video systems, the essence of which is to provide a personalized video data processing and analysis workflow. When a physician performs a visual analysis, the personalization procedure should ensure that the image is presented in a way that is most appropriate to the physiological and psycho-visual features of the physician, i.e., the image should be comfortable for analysis. The authors of the article provide specific examples of the implementation of a personalized approach to visualization, improvement and analysis of medical video data.

[18] The paper concerns the problems of organizing the operational processing and analysis of biomedical images. The aim was to conduct a comprehensive review of methods of processing and analysis of medical images, based on the use of high-performance computing technologies. The authors of the article have formed a comprehensive reference source of these methods.

[19] This work analyzes the state and development of digital endoscopy technologies in terms of processing and automatic analysis of video signal, which is produced by an endoscopic camera. The aim was to conduct a review-analytical study, aimed at systematizing the results of very diverse research in this field. The authors of the article along with the analysis of the wide possibilities of this intensively developing direction of telemedicine described specific characteristics of endoscopic video, which should be considered at the stage of their pre-processing.

[20]	This paper focuses on the development of technologies for the analysis of moving objects in video sequences. The aim of the authors was to develop a new segmentation scheme, called Dynamic Retinotopic Self-Organizing Map (DR-SOM), based on an adaptive artificial neural network, for detecting moving objects in images. Comparison with other segmentation methods showed that the DR-SOM segmentation method proposed by the authors of this paper outperforms them under conditions of dynamic background, gradual and sudden changes in illumination.
[21]	This study focuses with the development of a technology to recognize objects from real-time images, which plays an important role in navigational surgery. The aim was to investigate the effectiveness of the computer vision system based on the convolutional neural network in solving the problems of intraoperative object detection. The authors proposed a model of the system, which allows detection objects on surgical video images with high accuracy, and experimentally confirms the possibility of using methods of object recognition based on artificial intelligence for intraoperative navigation.
[22]	This study focused on improving the diagnostic efficiency of patients with ventricular dysfunction and cardiovascular disease. The aim work was to develop a technology that allows physicians to perform more reliable and accurate measurements of the heart using a deep neural network. The EchoRCNN method proposed by the authors is a semi-automated neural network for segmenting a sequence of echocardiographic images using a combination of a convolutional neural network image segmentation structure based on the mask area and a video segmentation network based on the mask propagation of a reference. Experimental results have shown that this method can predict a guaranteed, accurate, and reliable diagnosis of cardiac function during clinical examination.
[23]	This work deals with the problem of improving the efficiency of a costly and slow procedures for diagnosing patients suffering from ulcerative colitis. The aim was to experimentally test the capabilities of a machine learning algorithm that automates this process. The authors showed that an algorithm based on deep neural networks can be effective for predicting the severity of patients suffering from ulcerative colitis from full-length endoscopy videos.
[24]	This paper focuses on increasing the efficiency of diagnostic procedures in patients suffering from ulcerative colitis by combining endoscopic and histological evaluations. The aim was to adapt the previously proposed DNUC deep neural network system to full video colonoscopy and evaluate its effectiveness in detecting histological inflammation of the mucosa in real time. The authors of the article claim, based on the results of experimental studies, that DNUC provides stably accurate endoscopic evaluation and demonstrates the potential to reduce the number of biopsies required. This system is an objective and consistent application for videocolonoscopy, which can be used in various medical conditions.
[27]	This work focuses on improving the efficiency of the simple mastoidectomy procedure concerning the implementation of robotic vision for assisted surgery. The aim was to verify experimentally the capabilities of the YOLACT architecture designed for video segmentation, where each surgical instrument and anatomical region must be distinguishable in real time. The authors noted that the YOLACT-based model in the surgical environment was successfully trained and evaluated for real-time object detection and semantic segmentation. The detection accuracy of surgical instruments and anatomical areas, respectively, were 91.2% and 56.5% on average.
[28]	This work deals with the analysis of the state and development of technologies using convolutional neural networks. The aim was to analyze the current state of research on the application of neural networks in technologies for image segmentation and pathology detection in magnetic resonance imaging of the spine. The authors of this article showed that modern convolutional neural networks can detect and segment-specific anatomical landmarks and pathologies over a wide range comparable to the skills of radiologists and experienced clinicians. With rapidly evolving network architectures and growing medical image databases, the future is likely to show growth in the development and refinement of such networks.

The analytical review allowed us to form many basic requirements for a software module that provides effective monitoring and quality control of telemedical services using the identification of artifacts in the video sequences. We present the requirements and recommendations below.

The analysis of video signals for image degradation should include real-time assessment of video frame distortion

caused by encoders and decoders, and calculates the value of the "Artefacts-Level" metric. To analyze video signals for image degradation, the software module must embrace the following points:

- Accepting input data as a transport stream represented in one of the following formats: MPEG-TS; ST 2022–6; ST 2110; SRT; NDI; HLS; RTMP; HDMI and RCA;

- Decoding the video stream is decoded into separate pictures;

- Converting each resulting picture into a matrix and sending it to the input of the neural network;

- Assessment of video frame distortion by neural network model and calculation of Artefacts Level metric with a maximum 20% probability of producing incorrect results.

Recording and storing output data (Decimal (5,2) data type), i.e., "Artefacts Level" metric values reflecting the degree of video frame distortion in percentage, caused by video coders and decoders, requires organizing the corresponding database table.

Methodological aspects of solving these tasks are discussed in the paper's following sections.

Since the proposed software module is intended for use as part of the information system for automated monitoring and on-line quality control of information and telemedicine services, then:

- Operating conditions of the developed software module must correspond to the operating conditions of the hardware on which it is installed;

- Information structures at the input of the developed program module must meet the requirements for it;

- Reliability of the software module under development has to depend on the reliability of the functioning of its components, as well as by the reliability of the supporting technical and software tools on which it is installed; the scope of maintenance work should ensure the continuous performance of the software module;

- The software module under development shall provide the unification of functional tasks, operations and interfaces.

3. Methodological Aspects of Solving the Problem of Monitoring and Quality Control of Telemedical Services

Areas of improvement, used within the various subject spheres, monitoring systems of remote information transmission paths, including television signals, are constantly evolving toward the possibility of radical changes in their architecture and revision of the classical approaches to the implementation of the solutions used. The innovative concept of TV broadcasting operators is to provide flexibility and variability in the format of the systems used, it is assumed that the support of all existing standards and protocols of broadcasting is necessary and a priority. It is also advisable to collect and analyze information from third-party devices, which in the long term provides a complete picture reflecting the quality of a particular service. Such solutions must be flexible and scalable, without which the "basis" of the concept is impossible in implementation aspects. This is critical to ensure the effective operation (in terms of providing monitoring and quality control and for telemedicine services using the identification of artefacts in video sequences) of the software tool we propose to develop: the module for detecting artefacts in video sequences (MDAV), using neural network models, the requirements for which were justified in the previous section. Its functional architecture, as well as the training procedure of the neural network model used are proposed below.

4. MDAV Functional Architecture

The developed MDAV module is a software product focused exclusively on coordinated interaction in terms of data provision with many software components and modules from the multiformat information complex of automated distributed monitoring and on-line quality control of information and telemedicine services using artificial intelligence technologies.

Fig. 1 shows a block diagram of the proposed MDAV algorithm, the main procedures of which are feeding signals of specified standards from third-party devices to the module input; sending signals in BGR format; assessing the presence/absence of an artifact in the input data; assessing the neural network's reliability in detecting an artifact.

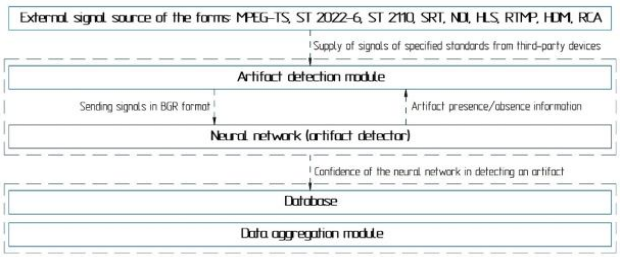


Fig. 1. Block diagram of the module algorithm for detecting artifacts in video sequences

The list of input and output data of the proposed MDAV and their descriptions are given in Table 2. The developed program complex ensures recording values of the "Artefacts-Level" metrics in the appropriate database table.

Table 2. List of input and output data for the MDAV

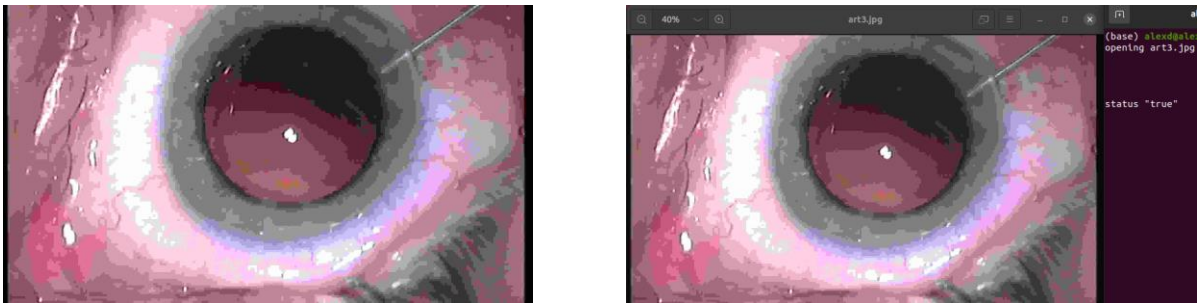
The Nature, Organization, and Preliminary Preparation of the MDAV Data		**The Format, Description and Method of Coding the MDAV Data**	
Input data	**Output data**	**Input data**	**Output data**

Input data are organized in the form of transport streams:
– MPEG-TS;
– ST 2022–6;
– ST 2110;
– SRT;
– NDI;
– HLS;
– RTMP;
– HDMI;
– RCA.
	The output data is organized as the value of the Artefacts Level metric, which evaluates the neural network's confidence in the presence of video frame distortion caused by video encoders and decoders;
	The measurement unit is %;
	datatype is Decimal (5,2)
		The artifact detector receives a BGR image in the form of a structure:
		struct BGRImage
		{
		uint32_t width;
		uint32_t height;
		uint8_t* data;
		};
		where "width" is the width of the image;
		"height" is the height of the image;
		"data" is image pixels (each pixel contains 3 channels, 8 bits per channel).
			A boolean value is generated from the output of the artifact detector:
			true, means that there are artifacts on this image;
			False means that there are no artifacts on this image.

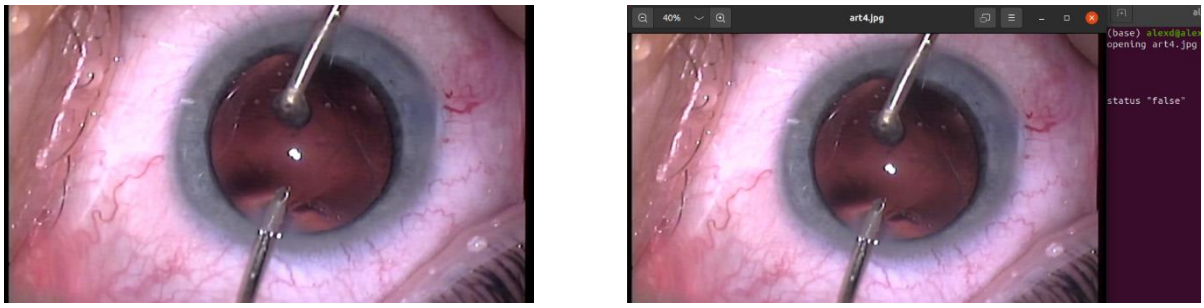
According to the developed algorithm, signals of admissible (Table 2) standards are fed to its input from third-party devices, which are not part of the MDAV. To provide further analysis with the help of a neural network, they are decoded into three-channel BGR images and converted to 224x224 resolution.

The neural network used examines the images for artifacts. A convolutional neural network of the Residual Neural Network (ResNet) type was used as a neural network to monitor video signals for image degradation caused by the appearance of foreign block structures due to interference or incorrect coding settings, which overlays the residual blocks with each other to form a network. The number of layers was 174.

The initial information for this analysis is video images, such as those shown in Fig. 2. The result of this analysis has two answers: "true" (N% confidence that there is an artifact) and "false" (M% confidence that there is no artifact). Next, the parameter N is compared with the value of the acceptable level of confidence of the neural network in artifact detection, specified by the user (hereinafter - AC). Based on the comparison result, the image is recorded as rejected (with an artifact), if N ≥ DU or, if N < DU, as acceptable (without an artifact). Subsequent actions are performed using the data aggregation module (alert service): a signal (alert) is sent about the presence of a problem.



a)



b)

Fig. 2. Images confirming the presence (a) and absence (b) artifacts

The proposed MDAV, with its basic components being the header file with module API, as well as many neural network models and dll libraries, provides a solution to the assigned task in the process of the sequential execution of the following algorithmic procedures:

Creating an artifact detector object in the video sequences, loading the neural network into RAM; the procedure is implemented using void* Create (const char* config_root_path);

Video frame processing with the result: whether or not there is an artifact on it, the procedure is implemented using bool Process (void* obj, const BGRImage& frame, float threshold = 0.95);

Destroying the artifact detector object in the video sequence, unloading the neural network from RAM; the procedure is implemented using VSDK_API bool Destroy (void* obj).

5. Training of the MDAV Neural Network Model

The goals of training the neural network model of the MDAV are as follows:

- Training a neural network designed to monitor video signals for image degradation caused by the appearance of foreign block structures, due to the presence of interference or incorrect-coding settings;

- Increase the accuracy of determining the signs of image degradation to achieve the probability of producing incorrect results of the MDAV neural network, not exceeding 20%.

To conduct training of the MDAV neural network designed to search for image degradation, a program was developed, defining technical and software training tools, describing the order and actions of training, as well as the training method, which includes

- Training methodology for the MDAV neural network designed to search for image degradation;

- Procedure for automatic calculation of classification accuracy in the process of training of the MDAV neural network;

- Procedure for calculating the actual value of the probability of producing incorrect results of the IDAB neural network.

According to the proposed methodology of training the MDAV neural network, three sets of data must be used:

- The dataset required for training the neural network (set 1 - train);

- The dataset required for validation of the neural network (set 2 - val);

- The dataset required for testing the neural network (set 3 - test).

Within the method of automatic calculation of the classification accuracy in the process of training a neural network MDAV during the training, the value of the loss function and the binary accuracy of the neural network predictions at this stage are calculated. The accuracy calculation algorithm consists of the following steps:

- Updating the weights of the neural network at each subsequent training stage;

- Passing each element 1 and 2 of the dataset to the input of the neural network;

- Calculate and save the value of the loss function;

- Comparing the response class of the neural network with the markup class:

a) If the classes match, one is added to the "count_true_gt_";

b) If the classes do not match, one is added to the "count_false_gt_."

After the algorithm has gone through the entire data set, we calculate the accuracy (*Acc* value in the log file) and the average value of the loss function (Loss value in the log file) for sets 1 and 2, respectively, according to (1) and (2):

$$acc = \frac{count\_true\_gt\_}{count\_true\_gt\_ + count\_false\_gt\_} \cdot 100\% \quad (1)$$

$$Loss = -(y \log(p) + (1 - y) \cdot \log(1 - p)), \quad (2)$$

where y is a binary indicator (0 or 1) of whether the class label is the correct classification for the observation; p is the predicted model probability; count_true_gt_ and count_false_gt_ are the match and mismatch counters of the neural network response class to the markup class.

If the value of the loss function decreases at each subsequent learning step, the learning process is correct. All calculated values are written to the training-process log file named *artifacts_resnet.log*. For further analysis of the training quality of the neural network, it is necessary to analyze this log file. As a part of the final procedure of the proposed method for training the ABM neural network, the actual AVP_{IR} value of the probability of producing incorrect results of the MDAV neural network is calculated by (3):

$$AVP_{IR} = (1 - Best\ val\ Acc) \cdot 100\ \%, \quad (3)$$

where *Best val Acc* is the best accuracy value in the process log file.

6. Results and Discussion

As part of the study, the software module MDAV designed to ensure the detection of artifacts in video sequences was developed and experiments to train the neural network included in it were carried out. According to the proposed methodology of training the MDAV neural network, three sets of video images necessary to perform training procedures at the phases of training (train) of the neural network, its validation (val) and testing (test) were used which included respectively 92416, 23654, and 24948 files with RGB images with jpg extension. Real telemedicine frames with a resolution of 720×576 pixels and the same frames subjected to multiple compression and decompression were used. The experiments were carried out using the technical and software tools of the First Moscow State Medical University named after I.M. Sechenov of the Russian Ministry of Health (Sechenov University). The training results are presented in Table 3.

Table 3. Training results of the MDAV neural network

Name	Requirements	Measured Value
Training the MDAV neural network	Training of the MDAV neural networks must be performed	The file "model.onnx" was generated, which is used for further operation of the artifact detection module. In the process of stepwise (epoch) learning, the lowest value of the loss function of 0.1479 was achieved. The loss values are shown in Fig. 3. Stepwise (epoch) learning achieved the highest value of classification accuracy over the two data sets of 0.945064. The accuracy values are shown in Fig. 4. For the training-process log file named *artifacts_resnet.log* was generated
Probability of producing incorrect results by the MDAV neural network	The probability of producing incorrect results of the MDAV neural network should be no more than 20%	5,49% (Calculation of the actual value of the probability of producing incorrect results by the MDAV neural network was performed according to the formula (3))

Therefore, the analysis of the training results of the MDAV neural network, visualized in Fig. 3 and 4, shows that during the experiments, the lowest value of the loss function 0,1479 and the highest value of the classification accuracy for the two data sets 0,945064 were achieved. The probability of producing incorrect results by the MDAV neural network was 5.49%.

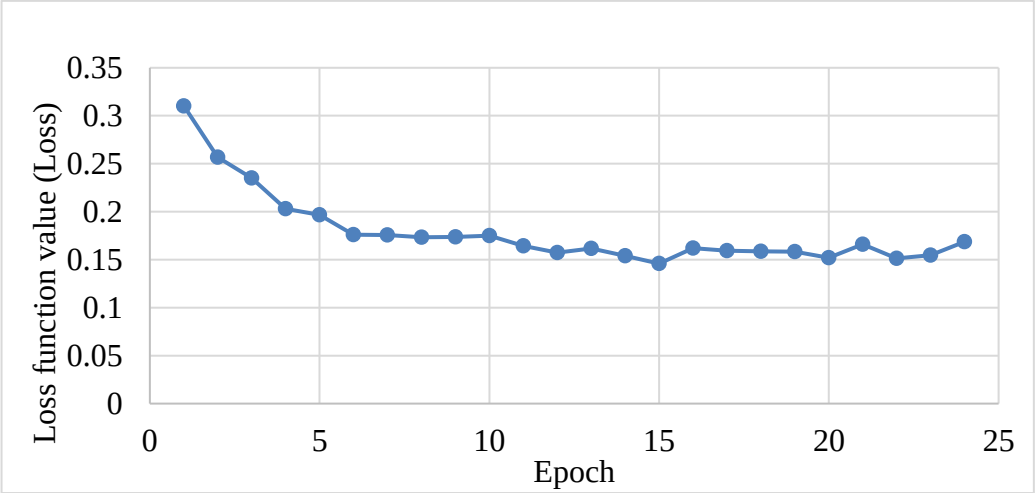


Fig. 3. Values of the loss function in the validation phase when training the MDAV neural network for image degradation classification

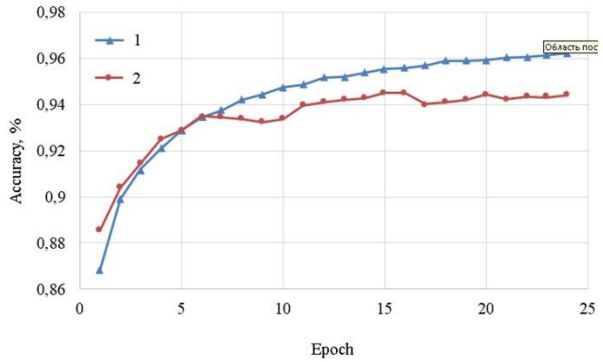


Fig. 4. Values of classification accuracy for the training phase (Train) and the validation phase (Val): 1 – the first set of data; 2 – the second set of data

7. Conclusion

The need to minimize the nonstandard situations in the process of providing telemedical services is obvious [29]. Therefore, there is no doubt about the relevance of continuous improvement of medical computer methods, hardware and software tools and technologies for monitoring and quality control of telemedical services, with the basic link being the tracts for remote transmission of various types of medical information, mainly in the form of video images and electrical signals (e.g., electrocardiograms, etc.).

Such technologies in various subject areas are regularly being improved, including the possibility of radical changes in their architecture and revision of classical approaches to their implementation. In accordance with an increasingly stable practical concept, the systems providing the implementation of such innovative technical solutions should represent multi-format, flexibly configurable, and scalable complexes to ensure effective control of the metrics of transmitted information signals. Simultaneously, in the case of providing a collection of information from third-party devices and subscriber equipment, it is possible to get a complete picture of the quality of service distribution from signal formation equipment to the customer.

The possibility of implementing an approach of this kind is relevant for the effective operation (in terms of quality monitoring and control and for telemedicine services) of our proposed software tool: a module for detecting artifacts in video sequences, using neural network models.

As part of the research performed in this paper, the software MDAV module designed to provide detection of artefacts in video sequences was developed and experiments on training the neural network included in its composition were successfully carried out. The use of such software products makes it possible, at a reduced cost of their development and implementation, to reliably detect cases of video degradation indicative of a particular critical situation in telemedicine service, which can lead, among other things, to medical and diagnostic errors due to the distortion of the original information.

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Author contributions

Aslan Adal`bievich Tatarkanov: Conceptualization, Writing-Reviewing and Editing, Supervision, Project administration **Georgy Stanislavovich Lebedev:** Formal analysis, Investigation, Writing-Original draft preparation

Elena Yuryevna Linskaya: Methodology, Software **V. Yu. Terekhov:** Validation, Data curation, Visualization.

Conflicts of interest

The authors declare no conflicts of interest.

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