Intelligent system for processing and analysis of mammograms

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Abstract. The article discusses the possibilities for the development of automated processing of mammographic images based on the principles of a systematic approach. A structural diagram of an intelligent system for processing and analyzing mammographic images is proposed, which contains three main modules: a module for forming cascading windows, a module for combining cascading windows, and a module for classification and decision making. The software was developed in MATLAB 2018b environment. The possibilities of functioning of each module are considered. Experimental testing of the software of the intelligent system for the classification of breast radiographs according to the classes “no area of interest” or “area of interest” was carried out. A criterion for evaluating the results of classification of mammographic images is selected. Experiments on control samples showed diagnostic efficiency for the classes of radiographs “no region of interest” - “region of interest” not less than 90%.

1. Introduction
Currently, the introduction of computer technology and information technology provides opportunities for the development of automated processing of X-ray images [1,2,3]. The problem of early diagnosis of socially significant diseases based on the analysis of medical images and video data is an important task [4,5].

Interpretation of X-ray images is performed by a radiologist based on visual analysis of images. It should be noted that X-ray images is a complexly structured image; their interpretation requires a high physician classification. At the same time, a specialist has to analyze a multitude of images of different types, in which the information content of X-ray images is lost due to the peculiarities of subjective visual perception [6,7]. Therefore, the problem of using artificial intelligence in the analysis and interpretation of X-ray images is urgent.

2. Materials and methods
To develop a structural diagram of an automated system for processing and analyzing mammographic images, we were guided by the basic principles of the systematic approach - versatility and modularity. The implementation of these principles provides opportunities to ensure the flexibility of the system to changes in conditions, as well as to make changes and additions [8,9,10]. MATLAB 2018b was chosen as the development environment, since it is effectively suitable for solving engineering and technical problems.
The block diagram of an intelligent system for processing and analyzing mammographic images, shown in Figure 1, contains 3 main modules: The Cascading Windows Formation Module, The Cascading Windows Combining Module and A Classification And Decision Making Module.

![Diagram](image)

**Figure 1.** Structural scheme of an intelligent system for processing and analysis of mammographic images

To start the operation of the intelligent system, a mammographic image is loaded into the program memory, which appears in the main window of the program, shown in Figure 2. In this case, the user is given the opportunity to obtain information about the analyzed image: image enlargement / reduction; moving within the entire image; measuring the distance from one selected area to another; determination of the coordinates of the required pixel and its brightness characteristics.

![Image](image)

**Figure 2.** Analysis of the image of the breast radiograph a) determination of the size between the objects in the image; b) window with information about the image

In the first module, a raster image is decomposed into a specified number of levels [4,11,12]. For this purpose, the value of the homogeneity criterion is introduced, which makes it possible to select blocks on the radiograph. Figure 3 shows the divisions of the breast radiograph with a different number of block structures. The task is to segment the radiograph into homogeneous blocks. Block homogeneity is established based on the entered threshold value (Fig. 3a). Each level of splitting contains many descendants - images, which are shown in Figures 3b, 3c. After decomposition, the resulting segments are written to the system memory.
Figure 3. Block structures of the breast radiograph: a) the window for entering the threshold value; b) hierarchy level 10; c) at level 69

In the Cascading Windows Combining Module, a search for contiguous regions is implemented and the homogeneity of each segment is calculated. If the homogeneity of adjacent segments does not differ significantly, then a decision is made to combine the segments, and the combined segments are written into memory [4,12]. Then the process of consolidation of blocks is carried out on the basis of the introduced homogeneity criterion, the results are shown in Figure 4 a.

Figure 4. The process of searching for contiguous areas: a) the process of combining segments; b) the result of segmentation
After the segmentation and enlargement of the blocks, the components of the vectors of informative features are formed based on the statistical and spectral characteristics for each block. An exploratory analysis of the texture characteristics of samples of two classes is carried out: \( C_1 \) - norm, and \( C_2 \) - neoplasm.

Statistical characteristics of the segment pixel brightness were used as the texture characteristics of the classified segments: mode (\( X_1 \)), mathematical expectation (\( X_2 \)), standard deviation (\( X_3 \)).

Next, the blocks were classified for the presence of morphological neoplasms. If a decision is made about the presence of a pathology, then the process of coloring the analyzed block with color is performed, and all pixels with coordinates falling inside the segment are shaded. After that, the obtained result is displayed on the screen, shown in Figure 4b.

After the doctor confirms the result, the program records it into the "patients" database for further processing.

3. Results and discussion

To check the performance of the classifiers, 100 images of mammograms of the mammary gland from the MIAS database [2] with confirmed diagnoses were used: 25 of them were normal images and 75 images were with morphological neoplasms. The task of the intelligent system was to carry out classification according to one of the criteria: "no area of interest"; "there is an area of interest." The intelligent system must confirm areas with morphological formations.

The table shows the number of positive and negative results of classification to one of the criteria.

| Table 1. Intelligent system test results |
|----------------------------------------|
| Condition                              | Observation result |
|                                        | Positive | Negative | Total |
| there is an area of interest           | 63       | 12       | 75    |
| no area of interest                    | 1        | 24       | 25    |
| Total                                 | 64       | 36       | 100   |

Analysis of the table shows: \( DC = 84\% \), \( DS = 96\% \), \( PZ + = 95\% \), \( PZ - = 85\% \), \( DE = 90\% \).

4. Conclusion

In the course of the study, experimental testing of the software of the intelligent system was carried out for the classification of breast radiographs according to the classes "no region of interest" or "region of interest". A criterion for evaluating the results of classification of mammographic images is selected. Experiments on control samples showed diagnostic efficiency for the classes of radiographs "no area of interest" - "there is an area of interest" not less than 90%.

References
[1] Ustinov A O 2018 Image reconstruction parameters in dual energy radiography Biomedical Engineering 52(3) 215-218
[2] Website of Public company “University of Essex” 2012 Retrieved from: http://peipa.essex.ac.uk/info/mias.html
[3] Suponnikov D A 2018 Development of a photosensitive cell of a matrix photosensor for an X-ray image detector Proceedings of higher educational institutions. Electronics 23(6) 573-585
[4] Dabagov A R 2019 Automated classification system for breast radiographs Medical equipment
6(318) 39-41

[5] Dabagov A R 2012 Electronic medicine and problems of building integrated medical information systems Biomedical radioelectronics 5(1) 40-49

[6] Tomakova R, Filist S, Veynberg R, Brezhnev A and Brezhneva A 2020 The Role of Hybrid Classifiers in Problems of Chest Roentgenogram Classification Advance in Intelligent Systems and Computing 902(42) 293-303

[7] Tomakova R A, Filist S A and Durakov I V 2018 Automatic classification software for chest radiographs based on hybrid classifiers Human ecology 6(1) 59-64

[8] Tomakova R A, Filist S A, Pykhtin A I and Ostrotskaia S V 2019 Classification on Multichannel Images Based on Cellular Processes 19th Int. Multidisciplinary Scientific Geoconference: SGEM pp145-152

[9] Egoshina I L 2018 Complexation of Optical, Ultrasond and X-Ray Images in Intraoperative Navigation Systems Bulletin of the Russian Academy of Sciences: Physics 82(12) 1542-1546

[10] Zhilyakov E G, Konstantinov I S and Chernomorets A A 2016 Decomposition of images into additive components International Journal of Imaging and Robotics 16(1) 1-8

[11] Tomakova R A, Filist S A and Pykhtin A I 2017 Automatic Fluorography Segmentation Method Based on Histogram of Brightness Submission in Sliding Window 17th Int. Multidisciplinary Scientific GeoConferences Conf. Proc vol 17 (Sofia: STEF92 Technology) pp 159-166

[12] Akimov A V and Sirota A A 2017 Synthesis and Analysis of Algorithms for Digital Signal Recognition in Conditions of Deforming Distortions and Additive Noise Radioelectronics and Communications Systems 60(10) 458-468