System for constructing virtual slides for cytological diagnostics

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System for constructing virtual slides for cytological diagnostics

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Abstract. A system of virtual cytological slides formation using a robotic scanning microscope with X40 lens are discussed in the paper. Series of digital images with different focus are provided in each of the positions of the object table. Panorama is formed by the frames which are combined by reference points allocated as a result of digital processing. A software module has been developed to adjust the results of the program combination. The proposed solution is used in practice.

1. Introduction
Cytological examination is a highly specialized, complete, recognized worldwide method of morphological verification of the diagnosis, and at the same time it is one of the least automated and standardized types of laboratory diagnostics.

Information technologies are actively developed and successfully introduced into the practice of a cytologist, which is largely facilitated by the rapid development and spread of computer information systems, the appearance of scanning microscopes [1-5].

The purpose of this work is to create tools for the formation and correction of the results of scanning cytological preparations using computer microscopy for cytological diagnosis.

2. Approach to the formation and correction of the results of the assembly of panoramas.
To obtain a digital image larger than one field of view of the microscope, a slide scanning system is required. Modern technical solutions to this problem are presented in two directions-specialized devices for scanning slides with slides and classical light microscopes of transmitted light with a camera installed on them and equipped with a motorized object table with an automated scanning control system and a control computer [6-8].

In the present work, a robotic scanning microscope with x40 lens is used to obtain the initial image, which corresponds to the x400 optical magnification (with x10 eyepieces). With the help of automatic motion control of the microscope stage, the slide is putted in the positions necessary for the formation of the panorama. Images are taken by an electronic camera mounted on a microscope, with the
transmission of digital images to a computer. At the same time, in each of the positions of the subject table, a series of digital images with different focus is shot. As a result of digital processing of the obtained series, several actions are performed depending on the type of slide:

1. the most sharply focused image is selected if it is obtained in a thin place of the slide;
2. a sharp image is formed from the obtained series by means of algorithms for increasing the depth of field;
3. the resulting series is stored for further processing.

From the images obtained from the first and second stage, a panorama is formed based on the search for similar areas and the search for "special points".

For images during the third stage, a panorama is formed as well as for the two previous stages, only the user can view the images in layers (at different steps of the micro-screw along the "Z" axis).

The problem of combining the boundaries of two adjacent frames, if sharp frames at different focusing heights are found in the corresponding layers, at this stage is solved by controlling the position of the micro-screw step along the "Z" axis, and the closest to the compared image is selected.

![Diagram](image)

**Figure 1.** An example of the formation of multilayer structures of slides prepared by the method of liquid-based Cytology.

To visualize the panorama of the slide, the images obtained in different positions of the slide under the microscope lens are programmatically combined by reference points allocated as a result of digital processing.

The program allows to download the original images in the form of a catalog, then automatically assemble first a single-level panorama (one level on the "Z" axis, images or sharp, corresponding to a thin place, or collected with the application of the algorithm to increase the depth of field), then a multi-level panorama. The data structure for the download provides for naming files with a size of 2048x2048, indicating the offset of the frame in the panorama relative to the upper left corner of the panorama in the file name. The coordinates of the offset are specified in the file name as follows: "y=0" and "x=0" for the first frame, the second for "y=0" and "x=2048", etc. Example of the formation
of multilayer structures of slides prepared by the method of liquid-based Cytology, is shown in Figure 1.

To adjust the assembly results by levels corresponding to different positions of the microscope micro-screw on the z axis and individual frames, a program in C++ has been developed using the Qt library in the QtCreator development environment, which allows automating the process of assembling panoramas. An example of the program interface for the formation of panoramic images is shown in Figure 2.

![Example of the program interface for generating panoramic images](image)

According to the test results of the program, it is noted that for images with a large number of objects, the panorama assembly is performed correctly in automatic mode. If the objects on the frames are few, then the automatic assembly of the panorama requires subsequent "manual" correction. Further development of the developed program will be aimed at solving this problem.

3. Conclusion
The paper proposes an approach to the formation of single-level and multi-level panoramas in computer microscopy. The tools for adjusting the result of combining individual frames are proposed. This decision is used in practice.

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