Approach to building knowledge bases in information-measuring systems diagnostics of acute leukemias

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Abstract. The paper describes an approach for the formation of the reference base of peripheral blood cells and bone marrow in information-measuring systems of acute leukemia diagnostics. The proposed approach has allowed to create a system, that is enable peer evaluation of blood cells needed for the training of recognition systems when carrying out microscopic studies.

1. Introduction
The current stage of development of measurement technology for diagnosis and condition monitoring of objects of different nature is characterized by an increasing complexity of tasks and intensive implementation of intelligent technologies in the measurement process. Expert systems are foundation of intelligent technologies. They are based on accumulating experience and knowledge of highly qualified experts.

One of the areas of works in the field of creation and development of expert systems that can accumulate the experience and expertise of highly skilled physicians is the diagnosis of acute leukemia.

The basic idea of these systems is to use the knowledge and experience of specialists of high qualification in the subject area by less skilled specialists, while addressing emerging problems.

The problem of the development of a knowledge model based on standard samples of micro specimens of blood and bone marrow remains unexplored area at present. Thus the knowledge base has special importance, if it is built on unique standard samples of large medical center in the end of expert measurements.

Knowledge base and database images are some of the key elements of building a modern decision support complex for medical diagnosis. Such complexes should include clinical system, research system, education system, information and telemedicine system on a single hardware and software platform[1].

Example of the use of software systems for the diagnosis of acute leukemia is intelligent system of decision support in the diagnosis of acute leukemia using microscopic images of blood cells presented in[2].

Evaluation of the effectiveness of a medical decision support system is given in [3]. Over 96% accuracy in the diagnosis of acute lymphoblastic leukemia was obtained for a sample of 180 images. Also method was proposed for allocation of several leukocytes in the field of view with an accuracy over 93%. The method was tested on 98 different sets. Diagnostic system was proposed for the
detection of acute lymphoblastic leukemia (ALL) based on the analysis of shape and texture and two-dimensional classifier according to the method of support vectors [4]. In general the accuracy of the developed system is more 89% for the best combination of characteristics. A common disadvantage of these systems is the small volume of the experimental sample for confirming of the statistical significance of the results.

There is a need in the reference images for the development of methods and tools of medical decision-making systems and to verify the adequacy of the developed methods at the present stage of development of computer vision systems, particularly in the diagnosis of acute leukemia. The necessity of development of such systems is due to the lack of large digitized databases of images, lack of description of cells images[5-8].

The aim of this work is to develop an approach to form a base of knowledge in information-measuring systems of acute leukemia diagnostics.

![Image](image.png)

**Figure 1.** Example of the markup of images to generate the reference sample images.

2. **Materials and methods**
   The evaluation of performance of approach was evaluated by doctors of clinical diagnostic laboratory of N. N. Blokhin Russian Cancer Science Center. The images sample was formed from smears of peripheral blood of 10 donors and 6 patients with acute myeloid leukemia.

   Images of lymphocytes and blasts were performed on stained preparations in the system of computer microscopy (Automated Olympus BX43 microscope with camera Imperx IPX-4M1ST-GCFB). Images were saved in BMP format, color-coded RGB24 (more than 16 million colors).

3. **Results**
   Program was developed to generate the reference database which was built on the receipt of opinions from several experts and on the basis of collective opinion formation samples for research. Block diagram of the operation of the program is shown in Fig.2
Figure 2. The block diagram of the program of knowledge building of the types of images in the diagnosis of acute leukemia.

The proposed solution is implemented with use of the library in Qt5 and C++ programming language. Interface for the markup of image obtained from the preparation is shown in Fig.1.

The applicability of the proposed approach was studied. 492 image frames were listed in the knowledge base. a few blood cells could be on one image frame. Bone marrow preparations of patients with acute myeloid leukemia variant M5B were used. Cells in images were marked. There were 939 monoblast, 423 promonocyte, 27 lymphocytes, 12 segmented neutrophils, 6 myelocytes, 3 eosinophiles, 1 normoblast and 1 promyelotic.

4. Conclusion
The decision support system for the diagnosis of acute leukemias was developed. The importance of this system is determined by the necessity for the doctor-diagnostician to be able, in difficult cases, refer to the "reference view" - reference database. The developed system forms this opinion on base experts knowledge about the images of blood cells and bone marrow. The system allows the doctor to get an expert opinion of leading experts to determine the types of cells. In addition the system provides for computer recognition system developer the ability to generate samples for testing the developed system with simulating different levels of difficulty for the diagnosis of acute leukemia.

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