A method for estimating the accuracy of measurements of optical characteristics of the nuclei of blood cells in the diagnosis of acute leukemia

E V Polyakov and V G Nikitaev
National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoe highway 31, Moscow, 115409, Russia
E-mail: VGNikitayev@mephi.ru

Abstract. The work is devoted to investigation of the random component of the measurement error of the nuclei structure characteristics, which are used in the method of structural elements to measure the differences of blood cells of different types. This method is realized in information-measuring system of the analysis of micropreparations of blood cells in the diagnosis of acute leukemia and its variants.

1. Introduction

Application of computer microscopy for different stages of diagnosis of acute leukemia - detection of single cells during the leukocyte count, the differential diagnosis, counting myelogram in the analysis of the bone marrow allows to clarify the morphological characteristics of lymphoid elements. That is considerable interest at the present stage of research [1-9].

The problem of automating of the microscopic analysis is timely in view of the complexity and difficulty of the analysis that requires experience and high qualification of doctors. It should be noted, that the evaluation of stained preparations by light microscopy is among the main research, especially in the diagnosis of malignant tumors, particularly acute leukemias [1].

It must be emphasized that the development and implementation of information-measuring systems for the automation of microscopic analysis requires a complex multi-factor experiments. The analysis of the external influencing factors and the search for new informative characteristics of investigated objects are examples of such experiments [2].

Along with this there are problems, which are important and are studied insufficiently: estimation of error of measurement of the optical characteristics of the nuclei of blood cells in the diagnosis of acute leukemia in blood and bone marrow; detection of bone marrow metastases from lymph nodes; the differential diagnosis in acute lymphoblastic leukemia; assessment of the impact of errors, artifacts, the shooting conditions for the classification of hematopoietic cells; identification of correlation between the structure of the blasts and their immunophenotypical status [1-4].

These tasks are the subject of current research on automation of diagnostics of acute leukemias.

The aim of paper is evaluation of the random component of measurement error of characteristics of structural elements in the problem of separation of blood cells by type in the diagnosis of acute leukemia.

The method for estimating parameters of the texture of cell nuclei based on feature extraction, reflecting the structure of chromatin was applied in this work [1]. The binary morphology procedures
were used for the calculation of the quantitative values of chromatin structure. The obtained quantitative values form the feature space for classification.

We used micro specimens with hematological disease acute leukemia in the experiment. Search and survey of the blood cells of two types - blast and lymphocyte were carried out in the study of the specimens. Each image was processed. As a result the nucleus of the cells were allocated. The blood cells type defining, quality assessment of specimens and the search of the cells were carried out by a medical expert.

2. Experimental study
The study was conducted in several stages. In the first step, we assessed the significance of the signs of the structural elements of the cell nuclei of blasts and lymphocytes obtained from blood specimens. The evaluation was carried out using the criteria of importance defined by the formula:

\[ I = \frac{(\bar{X}_b - \bar{X}_l)}{\sqrt{2(S_b + S_l)}} \]

where \( \bar{X} \) – the arithmetic mean, \( S \) – the standard deviation, index \( b \) denotes the characteristics of the blast, \( l \) – the lymphocyte.

![Figure 1. Illustration of finding significant characteristics of the structural elements for carrying out the separation of blood cells by type.](image)

In the second step, we assessed the influence of random error on the measurement of characteristics of structural elements. The above-mentioned procedure was carried out with application of system of computer microscopy, here we calculated features for 255 images of one blast, and therefore a non-blast (lymphocyte) cells. The average value characteristics \( \bar{X} \) and the standard deviation \( S \) were calculated to assess the impact of the random component in the experimental study for the following structural elements: square - \( S \); the average radius - \( R_b \); the average diameter - \( D_b \); root-mean-square radius - \( R_{rms} \); root-mean-square diameter - \( D_{rms} \). Figure 1 shows the steps of the experiment on which the letter \( X \{1, \ldots, n\} \) noted one of the characteristics of the structural element, which is presented in the work. A more detailed description of the symptoms is in paper [1]. Random component of the error was estimated, absolute error \( \frac{\Delta X}{X} = 1.6S(X) \) was calculated and relative error values \( \frac{\Delta X}{X} \) was calculated. The data are presented in table 1.

**Table 1.** Estimation of random error for the characteristics of the structural elements.

| Features       | Blast       | Lymphocyte | I   |
|----------------|-------------|------------|-----|
|                |             |            |     |
3. Conclusion
Significance characteristics of the structural elements of the nuclei of the blood cells was proposed. The random component of the measurement error of characteristics of the structural elements was calculated on experimental data for a series of images cells for device used. The effect of the random component should take account in measurement systems creating for the diagnosis of acute leukemias on the basis of pattern recognition. The data obtained have practical importance for their use in separation of cells by type in computer microscopy for diagnosis of acute leukemia.

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