The influence of physical factors on recognizing blood cells in the computer microscopy systems of acute leukemia diagnosis

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Abstract. The work investigated the effect of the choice of color space component on blood cell detection based on the calculation of texture attributes of blood cells nuclei in bone marrow. The study identified the most informative color space and texture characteristics of blood cells, designed for components of these spaces. Significance ratio was introduced to assess the quality of features. We offered features that have enabled to divide lymphocytes from lymphoblasts. The selection of the features was based on the results of the data analysis.

1. Introduction

Currently, study of hematopoietic cells (blood and marrow) are performed by a doctor–laboratory assistant through visual microscopy of stained smears. Differences in the quality of smears, variability of staining cells, professionalism level of the doctor in some cases may cause discrepancy in the interpretation of results. Data objectification of cells survey may be implemented by using computerized microscopy [1-2]. Automation research allows to enter new parameters of the cells characteristics, compare data obtained in different laboratories, and thus improve the level of diagnosis of haematopoiesis diseases [3-6].

An important feature for designing systems for digital processing of blood cells images is the spatial distribution of color in the region of the cell nucleus. The camera used in the computer systems of light microscopy generates three grayscale images of the incoming light flux by dividing it into light beams of three spectral bands: R(red spectrum area), G(green region of spectrum), B(blue spectrum area). When light photons are exposed to the photosensitive element CCD camera, photons knock electrons, creating a charge that is proportional to the light flux. The amount of charge is mapped to a digital code that represents the value of a color component of corresponding zone of the spectrum for a pixel in a digital image[7]. Pixel is the smallest possible element of a digital image. Pixel is assigned a color which describes the color model RGB. This model is the base for other color models. When solving the problem of blood cells recognition in conditions of close clusters of leukocytes in feature space, study of informativeness feature calculated for components of different color spaces is actual problem.

The aim of this work is to study the dependence of the information content of texture features from region of the spectrum of visible light and to determine the suitable components of color models in the task of hemopoiesis cells recognition.
2. Materials and methods
Investigation of the effect of the choice of the spectrum band (in the visible range of the electromagnetic radiation) and components color models in the calculation of textural features from the images of the nuclei of lymphocytes and lymphoblasts in the blood cells resulting image recognition performed on blood smears of bone marrow donors and patients with acute lymphoblastic leukemia (ALL). These preparations were fixed and stained by the method of May-Grunwald-Romanovsky. Morphological examination of blood smears and bone marrow aspirates were performed in the laboratory of immunology hematopoietic of N.N. Blokhin Russian Cancer Research Center by two experts. Acute lymphoblastic leukemia diagnosis was established on the basis of morphological, cytochemical, immunophenotypic studies. Blast cells prevailed on acute lymphoblastic leukemia preparation.

Image were obtained from stained smear preparations of peripheral blood and bone marrow preparations in the system of computer microscopy: microscope Olympus BX43 with motorized stage, camera Imperx IPX-IPX-4M1ST-GCFB (hereinafter Imperx). The resulting images are described by a format BMP with a depth coding by 24 bits per pixel 8 bits per component. 14 images of donor lymphocytes and 14 images of blasts cells of acute lymphoblastic leukemia patients were obtained.

Figure 1 shows examples of images of the nucleus blast cells in the components of different colors.

![Figure 1](image)

**Figure 1.** A sample of the transformations of the three (RGB) multispectral images of the nucleus of blast cells in the components of the various color models

Images presented in figure 1 are characterized by different texture for the various components of color models. Therefore, the most informative features for the separation of blood cells and bone marrow should be looked for different color models.

3. Investigated physical characteristic
The paper discusses the characteristics of the three images for the three spectral bands. Recording is carried out with a digital camera Imperx, having three types of sensors, spectral sensitivity of which is shown in figure 2.
Images formed by these types of sensors correspond RGB color model.

4. Methodology of the experiment
To conduct the study was developed technique of the experiment, which allows to carry out a preliminary study of the impact of choice of spectral bands to the results of the classification of blood cells. Technique involves a series of steps:

1. Formation of digital sets of images of leukocytes in the computer system in the form of three microscopy multispectral images corresponding to zones R G B.
2. Image segmentation of the nucleus of cells of leukocytes.
3. Obtaining R, G, B, imaging nuclei of leukocytes, a transformation in color components models XYZ, HSL, Lab, Luv, LHC, HLS, HSV, YUV, YIQ, YCbCr, CMY. The resulting images from the components of color model are encoded 8-bit number and considered a halftone image [8].
4. Calculation textural features for halftone image. As textural features in this paper used features - energy, inertia, entropy, local homogeneity and maximum likelihood spatial adjacency matrix [9-10].
5. The index of significance of the sign was introduced to characterize the quality characteristic for solving the problem of separation of blood cells at the blasts and lymphocytes. It is calculated according to the formula

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

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

6. Search the most significant sign. The separation of leukocytes by type with using this sign.

5. Results of the study
The study calculated importance for textural features of spatial adjacency matrix, depending on the components of the color model. The figure shows the importance of the index for the different color components. The range [0, 0.4) correspond to the poor separability of different classes of cells [0,4; 0,7] - satisfactory [0.7; 1] - good, [1; + ∞) - excellent.
As a result of analysis, according to the importance of the texture characteristic of the color model components, was detected chrominance component (V) color model (YUV), for which the characteristic value is maximum.

6. Analysis of the results
To confirm the adequacy of the results of the experiment carried out the separation of the types of white blood cells and lymphocyte blast on the found significance index. Separation of lymphocytes and blasts on the component (V) chrominance color model (YUV) for texture feature "maximum likelihood" matrix of spatial adjacency performed without error.

It was determined that the spectral zone G the most significant of the three zones of the spectrum of RGB, and composite component V (linear combination of spectral RGB component) is the most significant component of the considered (figure 3).

7. Conclusion
Comparative analysis of colour models showed that for the separation of blasts and lymphocytes by types, the most important is the component (V) color-difference signal of the color model (YUV).

A further stage of the research is to study the influence of other physical factors in the system of computer microscopy in the diagnosis of acute leukemia.

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