Modelling the influence of noise of the image sensor for blood cells recognition in computer microscopy

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Abstract. The first stage of diagnostics of blood cancer is the analysis of blood smears. The application of decision-making support systems would reduce the subjectivity of the diagnostic process and avoid errors, resulting in often irreversible changes in the patient's condition. In this regard, the solution of this problem requires the use of modern technology. One of the tools of the program classification of blood cells are texture features, and the task of finding informative among them is promising. The paper investigates the effect of noise of the image sensor to informative texture features with application of methods of mathematical modelling.

1. Introduction

One of the relevant problems of medicine is blood cancer. The first step in the diagnosis of these diseases is the analysis of blood smears. The effectiveness of existing automated hematology analyzers is still not high enough, so their work must be supplemented by microscopic analysis of blood smears and aspirates of bone marrow [1]. Usually this work is done by a skilled doctor of clinical laboratory diagnostics. Such a study is time consuming, requires a large exertion, and the result is subjective, depends on the skill of the doctor and sometimes incorrect [2].

The use of modern computer technology can help in solving this problem, and would serve as a useful tool [3-5]. The application of decision-making support systems would reduce the subjectivity of the diagnostic process, and as a result avoid errors, resulting in often irreversible changes in the patient's condition [6].

Software for classification of pathological cells used texture features. Note that the input images for analysis system are distorted by noise [7]. In this regard, it is necessary to assess the degree of influence of noise on texture features and how it affects on the results of classification of cell types[8].

In order to study the influence of this factor in different ranges of values texture features we proposed to use the method of mathematical modeling. A mathematical model of image formation of the nuclei of the blood cells was offered for reflecting the different nature of the structure of chromatin to various cell types [9]. It was a result of analysis of real images of different types of blood cells [10].

2. Materials and methods

The following model of image of the blood cell nucleus was proposed. Image field is covered with a conventional grid, a step which is set as parameter, circles are in the nodes with random brightness, the center of which is deviated from the node to a random value. The radius of the circles, their brightness and distance along the axes x and y are normally distributed, their mean value and standard deviation
are specified as model parameters. Areas of intersection are colored by weighted sum of brightness of the circles [11].

As noise models was used values of a random variable, distributed according to the normal law. The model is described by the equation:
\[ g(x, y) = f(x, y) + \eta(x, y), \]
where \( f(x, y) \) is original image, \( g(x, y) \) is the noisy image, \( \eta(x, y) \) is additive noise and independent of the signal with Gaussian probability density function. The value of the mathematical expectation of the noise was equal to zero, and the standard deviation value is specified as a model parameter in the present study.

It is possible to create images with texture typical for the structure of the chromatin of the nuclei of various types of blood cells by using the proposed model. This achieves compliance as visually perceived images of the model and the real blood cells and measured on these images quantitative texture features.

Texture features “energy”, “inertia moment”, “maximum probability”, “local homogeneity”, “entropy” were used. They are computed on basis of normalized matrix of spatial adjacency (Haralik matrix).

The image model generation was produced for sampling images with random values of model parameters. That provided the variation of the values of texture characteristics in each of the cell types. Noise with varying degrees of intensity was added to images on the next stage of the modeling. The intensity of the noise was set to the standard deviation for the normal distribution with zero expectation. The noise standard deviation was from the series of values: 0, 2, 4, 6, 8, 10, 12, 14, 16, 18 gradations of brightness.

Examples of real and model images for blast and lymphoid cells are shown on figure 1.

3. Results and discussion

The sample contained 100 images for each noise level and the cell type. The results are shown in graphs of the dependencies of the values of the texture features from the noise standard deviation. The chart shows the results for the two types of cells – blasts and lymphoid blood cells. Each class for the noise level is represented by three points – the average value of the texture attribute and the range limits, which are specified by double value of the standard deviation of the feature for the sample at some noise level.

The analysis of the experimental data revealed that the best separation in the classification of cell types makes use of the texture feature "energy". Graphs of the texture feature "energy" depending on the noise level for the two types of blast and lymphoid cells are shown on figure 2.
It can be seen from the graph in figure 2, that the value of the texture feature "energy" decreases with increasing intensity of the noise simultaneously for both cell types, while the differences between them are also reduced. And when the level of noise standard deviation is above 10 brightness levels the differences between two cells type are fully absent.

4. Conclusion
On the results of the model experiment we can draw the following conclusions:
- if we have noise rise, texture characteristics of chromatin in images of the nuclei of the blood cells become less distinguishable for different types of cells, and the value of texture features begins to describe not the structure of chromatin, but it describes noise texture in the image of the nucleus of the blood cells;
- the blood cell images obtained in the systems with various kind of image sensors with different noise levels in the image is not correct to compare the value of texture features (images of the same cell photographed in different systems will have different texture features);
- the parameters of the classifier based on the measurement of texture features should be configured for a specific system, because these parameters depend on the noise level in the image, and when you will replace the image sensor in the computer microscopy system, you should check the change of the noise level in the image, as the change in intensity requires a change of the parameters of the classification of blood cells, and characteristics of classification accuracy of the blood cells will be changed too.

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