Method for optical radiation sensor signal irregularity correction in the computer microscopy system

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Abstract. The paper presents a preliminary study to adjust for the irregularity of the signal space of a sensor of optical radiation in the computer microscopy system. A method for correcting the uneven signal of the optical radiation sensor in computer microscopy systems is proposed based on the results of the research. The proposed approach will allow to correct the results of measurements of the characteristics of objects obtained by light microscopy in combination with computer data processing.

1. Introduction
The camera used in computer light microscopy systems is the primary source of information that largely determines the quality of the results of automated image analysis, on the basis of which the doctor can make diagnostic decisions (for example, the nature of the tumor – malignant or benign). Noise and signal distortion in light sensors used in an electronic camera play an important role in solving the problem of recognition of pathological cells on images of microscopic preparations in real conditions. In this regard, the problem of correction of such distortions is one of the actual problems in the field of automation of microscopic analysis [1-7].

The purpose of this work is to obtain estimates of the degree of signal distortion in the formation of images in the computer microscopy system and determination of ways to correct them.

2. Materials and methods
The method of image signal distortion estimation in the computer microscopy system is based on the registration of images with constant brightness, followed by the calculation of deviations of the brightness values in the image pixels from the actual brightness value. Registration of images at different brightness levels was performed with the installation of the microscope light control in six different positions. There were no objects of observation in the field of view of the camera, so that the image recorded the background illumination of the field of view in the computer microscopy system at a given position of the microscope light control. System for studies included automated Olympus BX43 microscope with camera Imperx IPX-4M15T-GCFB [8-12]. The images are presented in BMP format, color-coded RGB24 (over 16 million colors per pixel). To reduce the effect of noise on the result of image brightness assessment in each position of the microscope light control, a series of 288 images was shot, followed by the calculation of the averaged image. The light control of the Olympus BX43 microscope with an indication of the positions in which the series was shot is shown in Figure 1.
The average brightness of the RGB components and the standard deviation of the average brightness were calculated in each pixel for a series of 288 images.

3. Analysis of results
An example of the average brightness of the R component in a series of frames and the standard deviation of the average value in the brightness gradations obtained for the image area of 5x5 pixels is given in Table 1. Here X and Y are the integer coordinates of the pixels in the digital image.

| X   | Y  | 865    | 866    | 867    | 868    | 869    |
|-----|----|--------|--------|--------|--------|--------|
| 1060| 865| 215,71 | 0,07   | 216,36 | 0,09   | 215,47 | 0,07   | 214,99 | 0,09   | 214,35 | 0,06   |
| 1061| 866| 216,61 | 0,09   | 216,38 | 0,11   | 215,71 | 0,09   | 215,78 | 0,11   | 215,50 | 0,09   |
| 1062| 867| 215,64 | 0,07   | 215,79 | 0,09   | 215,34 | 0,07   | 215,39 | 0,09   | 214,96 | 0,06   |
| 1063| 868| 216,09 | 0,09   | 215,90 | 0,11   | 215,41 | 0,09   | 215,65 | 0,11   | 215,18 | 0,08   |
| 1064| 869| 215,17 | 0,07   | 214,94 | 0,09   | 214,42 | 0,06   | 214,34 | 0,08   | 214,33 | 0,05   |

On charts (Figure 2, Figure 3, Figure 4) dots indicate the deviation of the average brightness of the RGB components in the sample pixels from the average brightness of the whole image. The average value of brightness components of the whole image frames in the gradation of brightness is on the abscissa axis. The ordinate axis shows the deviation of the average brightness of the component in a one pixel from the average brightness of the whole image in a series of frames. Vertical segments of straight lines on the chart represent the confidence interval for the actual brightness value of the corresponding component for the confidence probability 0.95. The function represented by a straight line passing through the specified points can be used as a function of brightness correction of the components in the corresponding pixels (for each pixel, a unique brightness correction function of the components is calculated).
Figure 2. A graph of deviation of average brightness of the R component in series of frames in a single pixel from the average brightness of the whole image in a series of frames.

Figure 3. A graph of deviation of average brightness of the G component in series of frames in a single pixel from the average brightness of the whole image in a series of frames.

Figure 4. A graph of deviation of average brightness of the G component in series of frames in a single pixel from the average brightness of the whole image in a series of frames.

The results of the experiments presented in the Table 1 show that the variability of the sensitivity of the cells of the light-sensitive matrix of the camera leads to the fact that the values of the component R in the pixels of the image with uniform illumination of the field of the camera frame are significantly
different (within the region of 5x5 pixels, the differences reach two gradations of brightness). It should be noted that the signal was recorded with a coding depth of 8 bits (256 brightness gradations) for each component. Used in the system of computer microscopy camera Imperx IPX-4M15T-GCFB allows you to check in with the depth of encoding 10 bit and 12-bit (1024, 4096 gradations of brightness). In these cases, the experimental deviation of the brightness values in individual pixels with uniform illumination of the camera matrix will be 8 and 32 degrees of brightness, respectively. According to the results of the experiment, the dependence of the difference between the brightness of the component in a pixel and the average brightness of the image on the illumination level of the camera matrix was revealed. Within the error of the measurements this dependence can be described by a linear function. Using this function as a function of correcting the unevenness of the sensitivity of the matrix cells, it is possible to reduce the corresponding brightness deviations from the actual brightness value up to 6 times in individual pixels.

4. Conclusion
The paper presents an experimental study of the possibilities of correcting the signal unevenness in the space of the optical radiation sensor in computer microscopy systems. The presence of dependence of signal distortions on the level of illumination of the photosensitive matrix camera in a system of computer microscopy is revealed. A method of signal correction for individual pixels of the image is proposed. It allows to reduce the signal distortion caused by the uneven sensitivity of the cells of the photosensitive matrix of the camera up to 6 times.

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