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Section B: Computer Science

Research Article

Contrast Modification as a Tool to Study the Structure of Blood Components

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Abstract: This paper focuses on the analysis and processing of blood microscopic images because of its importance to do a comprehensive analysis and diagnosis of human health. Due to the complexity of such work, we did explore various possible methods such as histogram equalization of brightness values (luminance), non-linear stretching of dynamic range of brightness values, masks filtering and fuzzy masking to get more accurate results. Color segmentation method has been used to analyze the structure of blood microscopic images. The results have showed that image segmentation increases when using fuzzy masking method, which in turn leads to increase and improve the analysis of blood microscopic images.

Keywords: color segmentation, histogram equalization, images contrasting, blood microscopic image, fuzzy masking, filter mask.

INTRODUCTION

Blood is a connective tissue with a complex structure in a liquid form, it consists of a liquid portion (blood plasma) and cells (erythrocytes, leukocytes, platelets) [1-2]. Structure of the human blood can vary because it closely related to his life and has many indicators that determine the state of his health.

Therefore, blood analysis considered very important for the purposes of diagnosis of human diseases. Traditionally, the morphological analysis of blood cells is performed manually by skilled people[3-4]. However, the accuracy of the calculation is highly depending on their skills. Nevertheless, the accuracy of the analysis of blood structure influences the diagnosis and determination of the kind of human disease. To avoid human being mistakes, the automation of human blood analysis become a necessity. One of such directions of the analysis is the application of a common ideology of image processing. Such studies allow conducting rapid and comprehensive assessment of the blood. It promotes the timely diagnosis of human health state, identifying and preventing the development of diseases in the early stages.

MATERIALS AND METHODS

Image analysis of medical microscopic image: An image of blood preparations is a medical microscopic image. Therefore, particular processing of medical microscopic image will be typical for images of blood preparations. M. Saha *et al.*[5], deal with the medical microscopic image segmentation to isolate the cell nucleus. S. Singh *et al.*[6], examine the possibility of applying the texture analysis methods for medical microscopic preparations. E. Ensink *et al.*[7], study the issues of threshold selection for segmentation of medical microscopic image. L. K. Jha *et al.*[8] offer to investigate blood preparations on the basis of classical pattern recognition methods. G. Apostolopoulos *et al.*[9] learn the shape blood cells[9]. S. Wienert *et al.*[10] allocate contour of blood cells for their analysis. Y. M. George *et al.*[11] suggest conducting automated segmentation of cells in cytological image under study. To implement this procedure, a special technique was used with staining of clinical specimens. Staining of blood smears allows a better look at the blood cells, but it also creates new difficulties in analyzing blood cells. Need to say that blood smear is a complex image that consists of a plurality of individual objects that may make some ambiguity while localizing nucleus. Changing the histogram of the input image in order to enhance its contrast is a necessity to analysis medical microscopic images[12-13]. Thus, it should be noted that by simply changing the brightness or by filtering, would not be feasible nor sufficient to solve arising issues with proper quality while processing medical microscopic images.

Color Segmentation as A Research Tool: Let us assume that microscopic blood image is a collection of individual objects: red blood cells, white blood cells and plasma, which is mean that the overall of microscopic blood image (D) can be represented as a set of all of its objects:

$$D = P \cup \bigcup K_1 \cup \bigcup K_2 ... \bigcup K_n \qquad (1)$$

Where

P – Blood plasma,

$\bigcup K_1$ – Aggregate of blood cells type 1,

$\bigcup K_2$ – Aggregate of blood cells type 2,

$\bigcup K_n$ – Aggregate of blood cells type n .

As each set of blood's cells ($\bigcup K_n$) may have a specific color, this makes it possible: to use the color segmentation, to calculate the proportion of cells in each group and to explore the detailed structure of the blood image. Knowing the structure of the blood image, we can talk about a degree of manifestation of human disease.

To implement color segmentation procedures, we will use the approach discussed by V. Lyashenko *et al.*[14-15]. The sequence of stages of this approach is as follows:

- Choosing markers for individual objects;
- Detecting objects. This is a standard procedure in image processing, which allows to select an area of a predetermined set of colors;
- Calculating the proportion of an object in the image.

For calculating the proportion of an object in the image, we can use the formula:

$$V_i = \frac{s_i}{S} 100\% \qquad (2)$$

Where

V_i – Proportion of i^{th} objects in the image ($i = \{P, \bigcup K_n\}$);

s_i – Area of i^{th} objects in the image ($i = \{P, \bigcup K_n\}$);

S – Image area D.

However, the procedure of bloodstaining may be poor, which may leads to spurious points; therefore, our task will be to improve the efficiency of image segmentation procedures by using the contrast modification procedure of the input image[16].

CONTRAST MODIFICATION AS a TOOL TO IMPROVE THE IMAGE QUALITY

Contrast is one of main characteristics of image because it is directly related to the brightness of pixels that are the sources of information about the objects in the image. Modifying the contrast of the image makes some of its details more distinct, which is allow improving both image perception accuracy, as well as the efficiency of its further processing[13-17].

The following methods can be used to change the contrast of the image[16-18].

- Histogram equalization of brightness values (luminance) (A),
- Non-linear stretching of dynamic range of brightness values (B),
- Masks filtering (C),
- Fuzzy masking (D),

We will review and examine the effectiveness of all of the above methods with the aim of color segmentation for effective and accurate study of blood components.

DATA FOR ANALYSIS

For the analysis, we will use one of publicly available images on the web (**Fig. 1**).

In **Fig. 1** we can see red blood cells (red and pink color), white blood cells (cells with dark blue nuclei) (using 10X objective lens, image size 300x254 pixels).

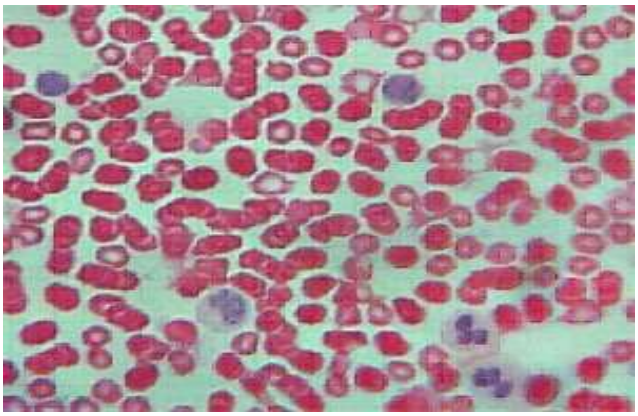

Fig. 1: Cells of human blood (using the 10X objective lens).

RESULTS AND DISCUSSION

To achieve the goals of our study, we begin by modifying the image contrast (**Fig. 1**) by applying the above listed methods A, B, C, and D. After that, we have to define markers to distinguish individual objects in the image based on color segmentation as shown in **Fig. 2**, where markers of first, second and third rows are to identify red cells, white cells and plasma respectively.

Fig. 2: Markers for individual objects of **Fig. 1.**

The result of detection of objects of **Fig. 1** is shown in **Fig. 3**, where the colors: blue, yellow and red, respectively represent red cells (occupy 54.4%), plasma (occupy 35.7%) and white cells (occupy 8.9%).

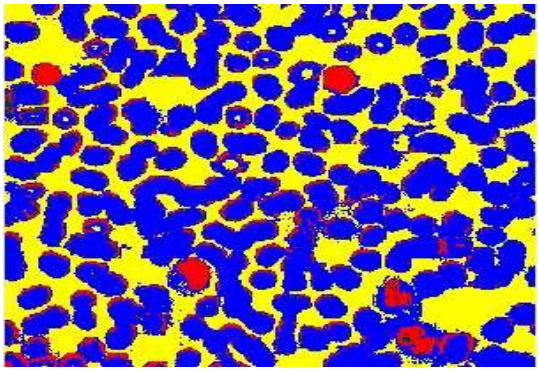

Fig. 3: Result of detection of objects in **Fig. 1**.

Fig. 4a, **Fig. 4b**, **Fig. 4c**, and **Fig. 4d** respectively show the results of modifying the contrast by applying the methods A, B, C and D on the original image (**Fig.1**).

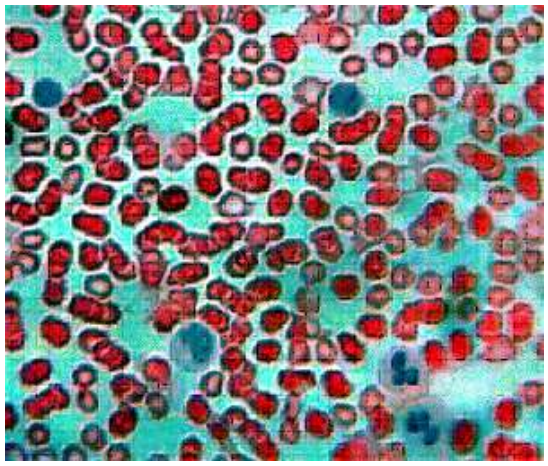

Fig. 4a: Changing the contrast using method A.

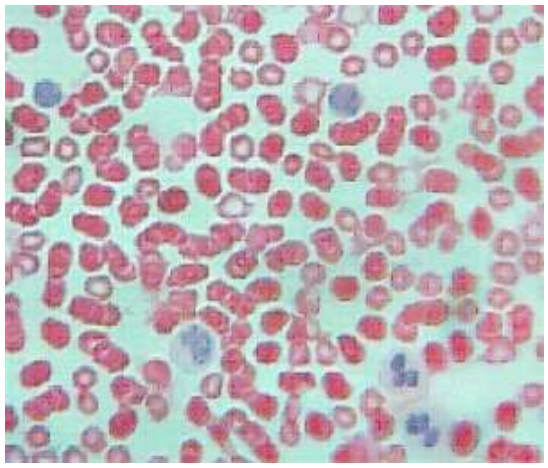

Fig. 4b: Changing the contrast using method B.

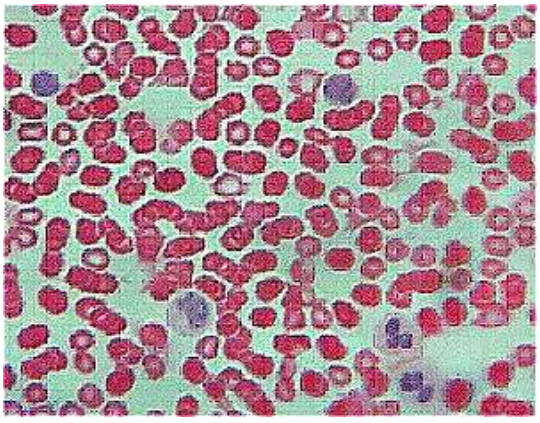

Fig. 4c: Changing the contrast using method C.

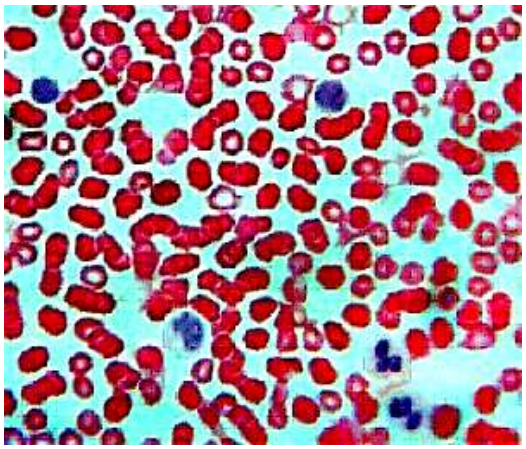

Fig. 4d: changing the contrast using method D.

The rate of change of contrast for the images presented in **Fig. 4a**, **Fig. 4b**, **Fig. 4c**, **and Fig. 4d**, characterized by the relevant image histogram (see. **Fig. 5**).

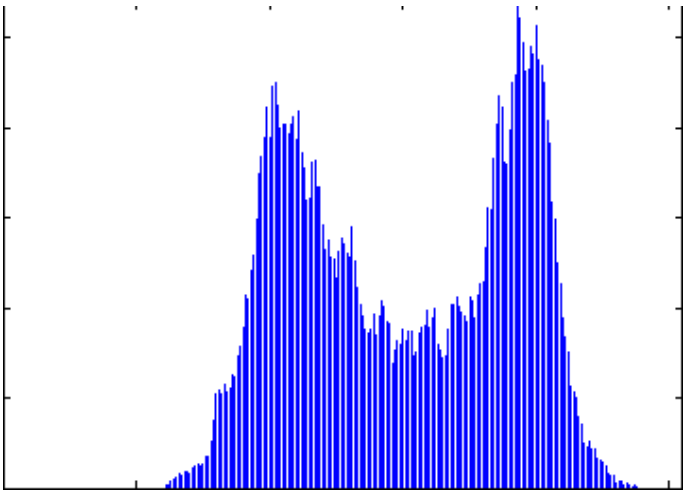

Fig. 5a: Histogram of **Fig. 1**.

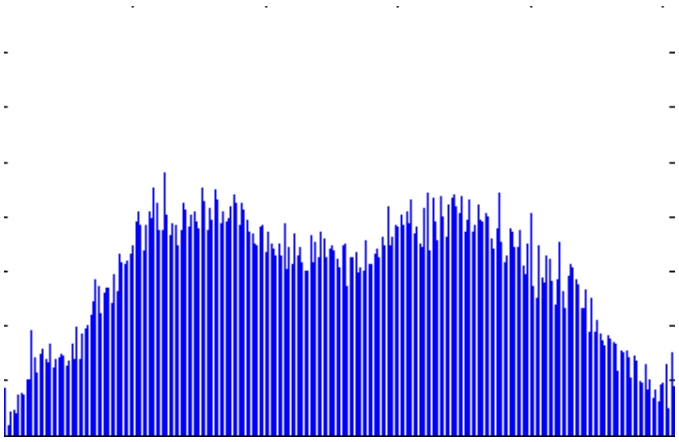

Fig. 5b: Histogram of **Fig. 4a**.

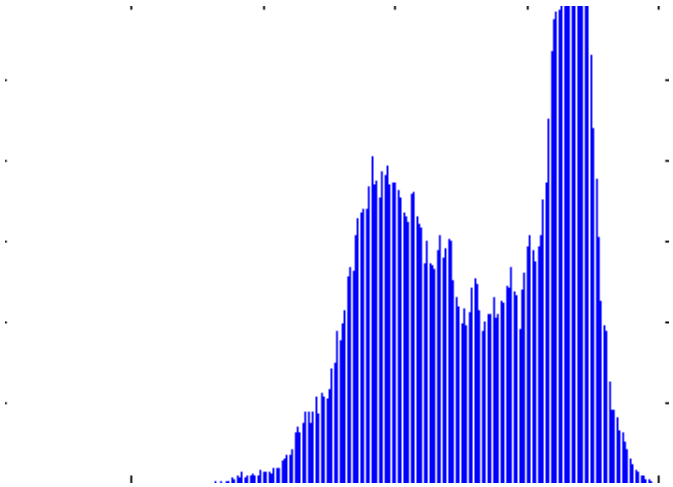

Fig. 5c: Histogram of **Fig. 4b**.

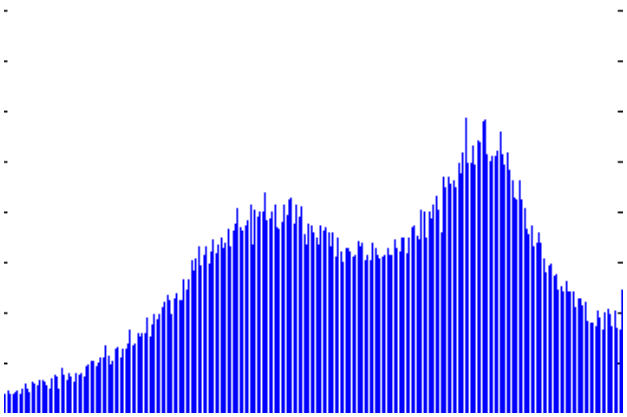

Fig. 5d: Histogram of **Fig. 4c**.

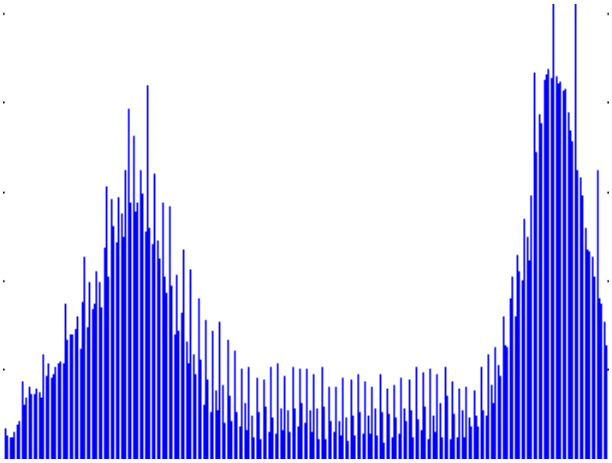

Fig. 5e: Histogram of **Fig. 4d**.

For each modified image (**Fig. 4a**, **Fig. 4b**, **Fig. 4c** and **Fig. 4d**) we choose a set of markers to detect the structure of the image, taking into consideration that the choice of markers is mostly approximate (as it was possible). **Fig. 6** shows the results of automatic detection of image objects (red cells = blue color, plasma = yellow color and white cells = red color) respectively.

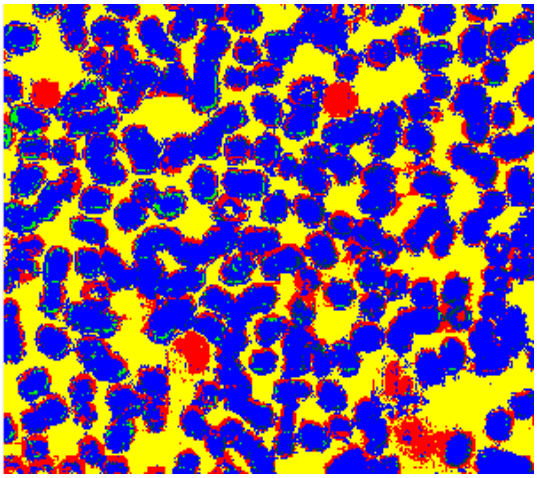

Fig. 6a: Result of detection for **Fig. 4a**.

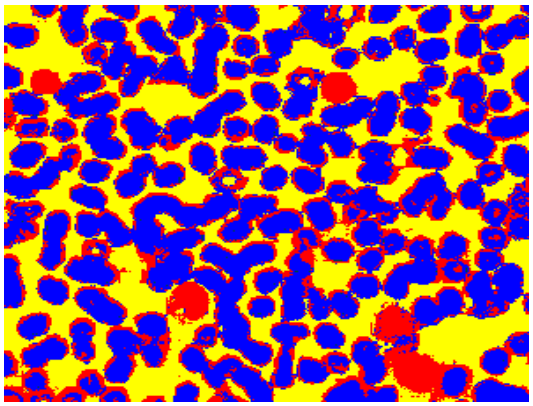

Fig. 6b: Result of detection for **Fig. 4b**.

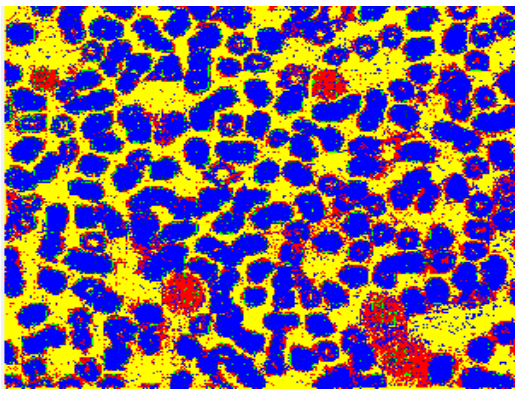

Fig. 6c: Result of detection for **Fig. 4c**.

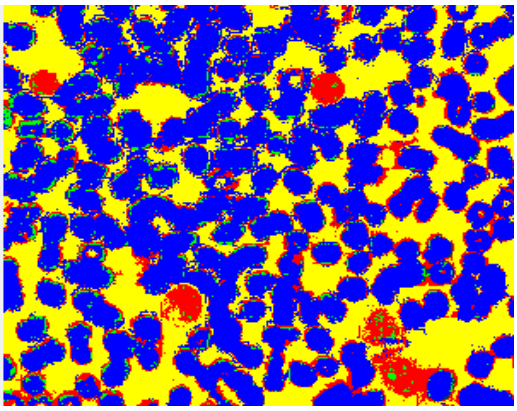

Fig. 6d: Result of detection for **Fig. 4d**.

From **Fig. 6a** through **Fig. 6d**, it seems that the above listed contrasting methods (A, B, C and D) are differently and distinctly make a great effect on objects detection Visually, in terms of structure of individual objects of blood elements, **Fig. 6c** presents the best result in spite of so many false points that are identified as elements of white blood cells.

Table 1 shows the results of blood structure determination based on the findings of experts, while **Table 2** shows the results of blood structure based on automatic color segmentation and it shows the great convergence between expert's results and the results of **Fig. 4d** ,which has been modified using fuzzy masking method (D). It should be noted that the fuzzy masking method has effectively reinforced the image borders and enhanced its details, consequently, we recommend changing the contrast of images using fuzzy masking method to increase the accuracy of the results dramatically and significantly. At the same time, because of lack in contrasting procedure, which may lead to many false point it is advisable to combine both image contrasting procedure with filtering procedures, to prevent such case.

Table 1: results of blood components analysis based on the findings of experts.

Blood elements	Average	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5
Red blood cells, %	53.66	53.8	54.0	54.1	53.4	53.0
Blood plasma, %	36.52	36.6	36.0	35.7	36.8	37.5
White blood cells, %	9.82	9.6	10.0	10.2	9.8	9.5

Table 2: results of blood components analysis based on automatic color segmentation.

Blood elements	Fig. 1	Fig. 4a	Fig. 4b	Fig. 4c	Fig. 4d
Erythrocytes, %	54.4	47.8	46.2	45.1	53.4
Blood plasma, %	35.7	35.9	34.1	39.1	36.1
White blood cells, %	8.9	16.3	19.7	15.8	10.5

CONCLUSIONS

In this paper, we proposed a method for studying the structure of blood components to provide an automated procedure as a support to medical activity. The proposed method mainly based on segmentation of blood components by color using colored markers to distinguish each components in a different color. To improve the accuracy of segmentation, we have used contrast modification methods. Results of each method have been compared with each other and with results of experts and have determined that the fuzzy masking is the best one to analyze the blood components.

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