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AN IMPROVED ACUTE LYMPHOBLASTIC LEUKEMIA IMAGE SEGMENTATION SCHEME BASED ON HSV COLOR SPACE

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Abstract. *In this paper, an improved HSV color space based Acute Lymphoblastic Leukemia (ALL) image segmentation scheme is proposed to improve accuracy of segmentation on digital microscope color images, especially for those taken in non-uniform background illumination conditions and by a microscope with different magnifications. The proposed method has several steps including contrast stretching, color space transformation, threshold segmentation, morphological operations and median filtering. Adopting two thresholds is the innovation of this work. For performance evaluation, 260 ALL blood cell images from ALL_IDB2-a public and free available blood sample dataset are used. The experimental results show the proposed method gets a higher accuracy in segmenting both high- and low- contrast blood cell images than the original HSV color space based single threshold method, showing a better prospect in subsequent automatic acute lymphoblastic leukemia feature extraction and classification.*
Keywords: White blood cell segmentation, Acute Lymphoblastic Leukemia, HSV color space, Image processing

1. **Introduction.** The microscope inspection of blood slides by counting different classes of white blood cells (WBCs) is one of the most frequently performed blood tests by hematologists. It can provide important qualitative and quantitative information concerning the existence or not of serious hematic related pathologies such as leukemia, anemia and HIV [1], hence playing an important role in the diagnosis of these diseases. For decades, the operation is performed by experienced operators. However, it is easily affected by doctors themselves and some other external factors. So, the corresponding feedback results always tend to be subjective, imprecise and also are difficult to be reproduced afterwards.

As a substitute, automatic identification of white blood cells in microscopic blood cell images has become an important topic in the domain of cancer diagnosis [2]. Generally, this kind of system consists of four parts: segmentation, feature extraction, classification and counting. In this paper, our proposal mainly focuses on the first step-white blood cell segmentation-differentiating the leukocytes from their complicated background. As the first step of the typical automatic WBC differential counting system, segmentation will directly influence the accuracy of the final classification and counting results [3]. However, it is a difficult and challenging task due to the complex nature of the cells and the uncertainty of the microscopic images. Cells often overlap each other and have variations of different sizes and shapes. What is worse, the contrast between the cell boundary and the background also varies with illumination inconsistencies [4,5].

Though, there is a lot of segmentation work done in recent years [1-15]. Among various segmentation schemes, most common methods are thresholding [6], fuzzy C means [8], scale-space filtering and watershed [9] or feature space clustering [3]. In [10], it presents a robust method for WBC identification by suitably combining a segmentation based on Lab color space with a gray level threshold. Morphological operators are used in [7,12]. A color and shape based algorithm within which it mainly refers to the overlapped cell segmentation problem which is also the focus of [15] is presented in [14]. When analyzing those existing segmentation approaches, it can be easily found most of them separate the segmentation process into two parts. Nucleus and cytoplasm are extracted respectively using different methods [16-19] which is bound to increase the complexity of the problem.

To make full use of the color perception characteristics of human eyes for images, some previous works have made an attempt to do the segmentation in a transformed color space such as HSV [9,20,21], HSI [22-25] and Lab [26,27] instead of RGB and have gained a good result. HSV color space based segmentation method proposed by [20] is used in this study. The method is based on nonlinear transformation of microscope color images from RGB to HSV color space and in the latter, H (hue) channel is used for segmentation of WBCs from image background. It shows an inspiring result for some cell images. However, when tested with some other images from the same dataset only taken with different microscope magnifications, the results are not so satisfactory. In order to extend the perfect segmentation results of [20] to more situations, we propose an improved WBC segmentation scheme based on HSV color space and make a comparison between our proposed method and the method presented in [20].

The remainder of this paper is organized as follows. In Section 2, a short introduction of HSV color space and our proposed segmentation scheme are given. Experimental results are shown in Section 3. Finally, Section 4 gives a concluding remark.

2. Our Proposed Method.

2.1. HSV color space. Due to the inherent interdependence between luminance and chrominance in the RGB color space, an HSV color space is used in this paper to segment white blood cells since it can provide useful chromatic information of the image and is more familiar to human eye perception characteristics which all make it more suitable for image processing. Every color of HSV color space is represented by three components: hue (H), saturation (S) and value (V). The hue of a color referring to which pure color it resembles is described by a number that specifies the position of the corresponding pure color on the color wheel, as a fraction between 0 and 1. The saturation of a color signals how much the color is polluted with white color. It ranges from 0 to 1. The value of a color, also called lightness, describes how dark the color is. A commonly used single-hexcone model of HSV color space is shown in Figure 1.

Transformation from RGB color space to the HSV can be achieved on the following equations:

$$H = \begin{cases} 0 & \text{if } (M = m) \\ \left(60^\circ \times \frac{G-B}{M-m}\right) \bmod 360^\circ & \text{if } (M = r) \\ 60^\circ \times \frac{B-R}{M-m} + 120^\circ & \text{if } (M = g) \\ 60^\circ \times \frac{R-G}{M-m} + 240^\circ & \text{if } (M = b) \end{cases}$$

$$S = \begin{cases} 0 & \text{if } (M = 0) \\ \frac{M-m}{M} & \text{otherwise} \end{cases}$$

$$V = M$$

where M and m respectively represent the maximum and minimum values of all R, G and B elements.

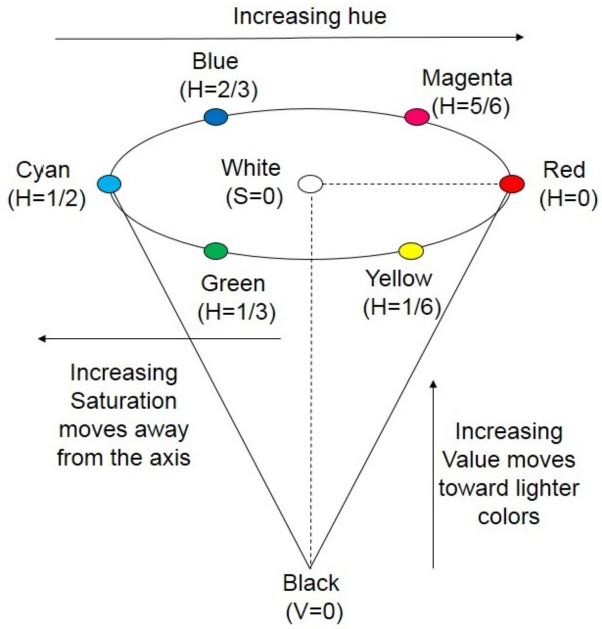


FIGURE 1. HSV color space model

2.2. **Our proposed method.** The goal of this study is to extract the lymphoblasts from image background as accurately as possible. The scheme proposed here for this purpose is sketch in Figure 2. It consists of three parts: pre-processing, thresholding segmentation and post-processing. RGB and HSV color space jointed here for WBC segmentation is the novelty of this method. The whole algorithm can be concluded in five steps. The details of these steps are given in the following subsections.

Step 1: Preprocess the original color image with gray scaling, and contrast stretching to robustly extract the image background through an Otsu threshold method;

Step 2: Transform the input image from RGB color space to the HSV one and extract its H component;

Step 3: Remove red blood cells from the H channel gray image through another suitable threshold;

Step 4: Synthesize the results of Steps 1 and 2. Then morphological dilation and median filtering operations are applied to refine the above result. At last, a maximum connected region extraction algorithm is adopted to remove the incomplete leukocytes in the image.

1) Image Background Extraction:

In this step, we convert the input image into a gray one at first (Figure 3(a)). Then apply global contrast stretching algorithm to enhance the contrast between the foreground and background pixels of the gray image. From Figure 3(b), we can see that after contrast enhancement, image background now has a great contrast with other elements in the image, so it is easy to extract it from the image through an Otsu method. Figure 3(c) gives the image background extraction result (the black region).

2) Red Blood Cells Removal:

From H component image (Figure 4(a)), we can see that red blood cells have a certain contrast with the WBC and image background. As a result, they can be easily removed from the image by choosing a suitable threshold (Figure 4(b)). Then, since background has been extracted in the last step, WBC can be obtained by intersecting the resultant image there with the image obtained in this step.

3) Refinement of the Segmentation Result:

After Step 2, a roughly segmented WBC image can be obtained (Figure 5(b)). We can see that there exist some false contours and boundaries in the image. To further refine

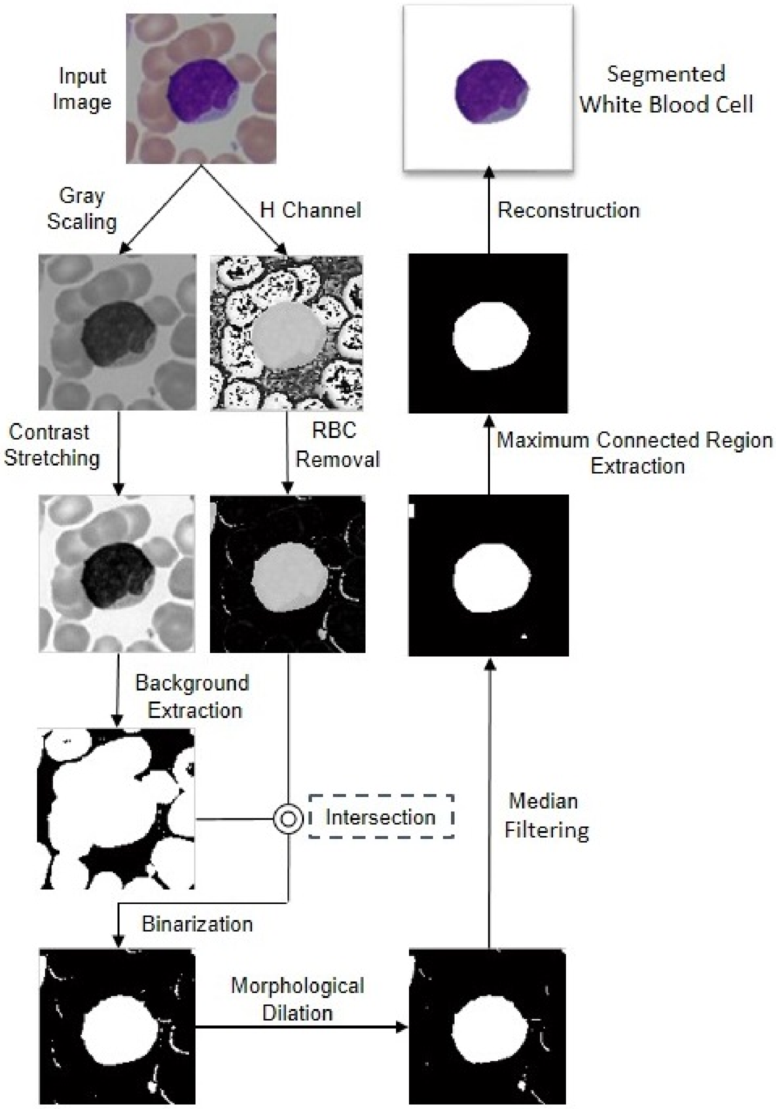


FIGURE 2. Scheme of the proposed method

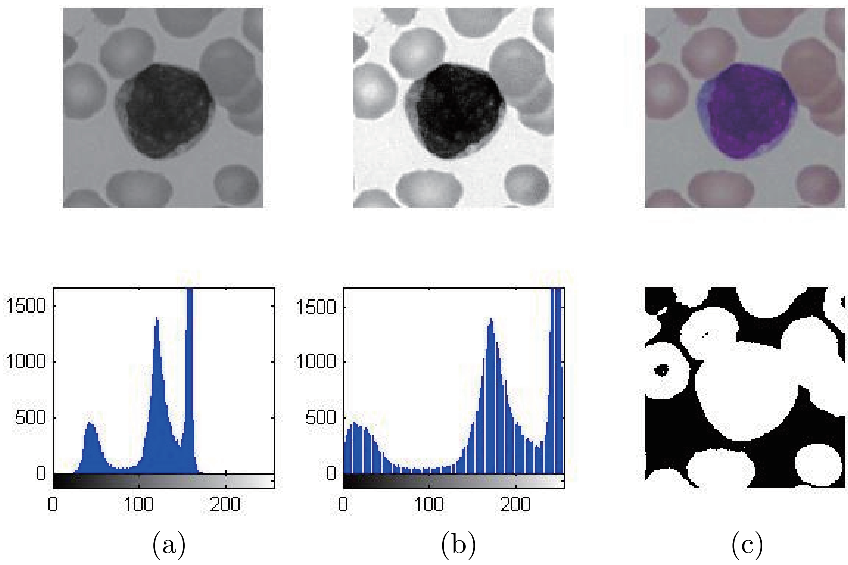
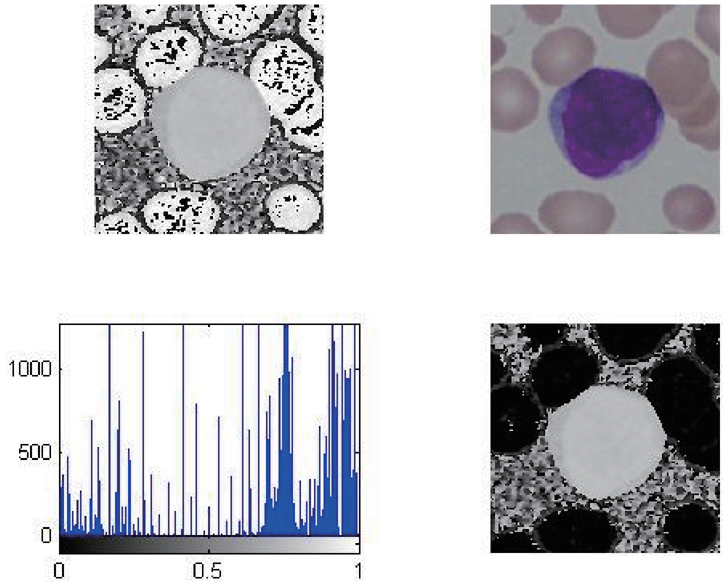


FIGURE 3. Image background extraction: (a) gray image; (b) image after contrast stretching; (c) extracted image background (shown in black)



(a) (b)

Figure 4. Red blood cell removal

(a) (b) (c)

Figure 5. Segmentation result

the segmentation result, median filtering, morphological dilation and maximum connected region extraction are used. Figure 5(c) shows the final binary segmentation result.

3. **Experimental Results.** The test blood cell images used here for segmentation performance evaluation are taken from ALL_IDB2, a public ALL image database of 260 classified cell images [29]. The first half of the dataset are ALL cell images while the other half are normal lymphocytes. They are taken under microscopy magnifications ranging from 300 to 500, thus showing several color characteristics. Segmentation algorithm of literature [20] is used here as a reference. A comparison of the two methods is given in Figure 6. It can be easily found segmentation results obtain a good improvement on basis of [20].

4. **Conclusions.** In this paper, an improved HSV color space based segmentation scheme has been investigated to overcome one white blood cell segmentation problem which exists in literature caused by illumination variations. By removing the red blood cells of the image through HSV color space based single threshold method taking full advantage of its good WBC cytoplasm outline retention capability and extracting the pure image background in contrast-stretched gray-scaling image via Otsu threshold method, the segmentation accuracy as opposed to the original method proposed in literature is effectively

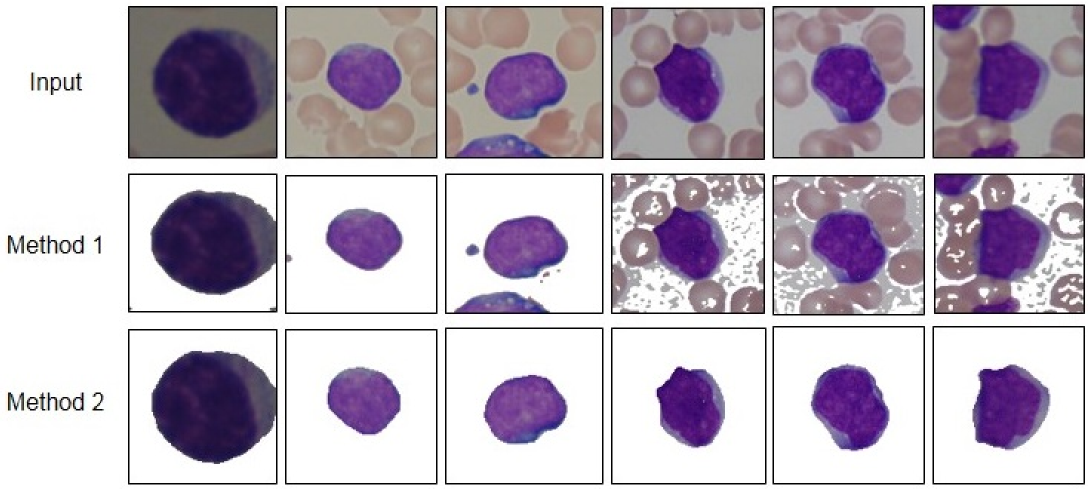


FIGURE 6. Segmentation result comparison: Method 1: Method proposed by [20]; Method 2: Our proposed method

increased. As the first step of automatic WBC differential counting system, the proposed method shows a good prospect in further WBC feature extraction, classification and counting.

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