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Comparison of Segmentation Framework on Digital Microscope Images for Acute Lymphoblastic Leukemia Diagnosis using RGB and HSV Color Spaces

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ABSTRACT

Image segmentation process is considered the most essential step in image analysis especially in the medical field. In this paper, the color segmentation for acute lymphoblastic leukemia images (ALL) is applied to segment each leukemia image into two clearly defined regions: blasts and background. The ALL segmentation process is based on two different color spaces: RGB color space and HSV color space. The comparison performance between the segmentation methods based on RGB and HSV color spaces are investigated to find the best method to segment the acute lymphoblastic leukemia images. The experimental results show that the segmentation of ALL images based on HSV color space yield better accuracy than RGB color space when compared with the manual segmentation image made by medical experts. Using HSV color space, the shape of blasts in ALL blood samples is closely preserved with segmentation accuracy over 99.00%. However, segmentation based HSV color space was chosen as it produced the highest ALL segmentation rate.

Keywords: Image Segmentation, Microscope Images, ALL, RGB, HSV.

1 Introduction

Leukemia disease is a group of cancers resulting from abnormal increase of the white blood cells that divided and grew in uncontrolled way. Thousands of people all over the world die of leukemia every year that is caused by the nature of Leukemia cells that become out of control and spread independently as well. Early diagnosis and treatment applied to the correct cells are vital.

Leukemia can be classified into two main categories: acute and chronic. Acute leukemia spreads very quickly and has to be treated immediately rather than chronic leukemia where immediate treatment is not a must. Acute leukemia can be either lymphoblastic (ALL) or myelogenous (AML), based on affected cell type. Chronic leukemia can be either lymphoblastic (CLL) or myelogenous (CML) [1]. Acute lymphoblastic leukemia (ALL) is considered to be the prime focus of this work because the survival rate here is expected to be higher when compared to AML.

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Segmentation is one of the most demanding tasks in image processing. It is used in Computer Vision to automatically divide a digital image into a number of different meaningful regions. For biomedical imaging applications, image segmentation is a founding step in image analysis as it will directly affect the post-processing. It is a crucial component in diagnosis [2] and treatment [3].

The main aim of acute leukemia blood cell segmentation is to extract component such as blast from its complicated blood cells background. There are many techniques that have been developed for image segmentation such as threshold techniques [4], clustering technique [5] and watershed clustering [6]. Due to the complex nature of blood cells and overlapping between these cells, segmenting them remains a challenging task [7]. Many algorithms for segmentation have been developed for color images that produce more information of the scene than grayscale images do [8].

For leukemia segmentation process, transformations of original RGB images to different color spaces such as (HSI, HSV, YUV, XYZ, Lab…etc.) are proposed in many works. According to [9], Lab color space is used for segmentation process. Also, algorithm Based on HSI color space is proposed in [10]. Based on HSV color space, segmentation technique [11] for ALL images is proposed. This work focuses on RGB and HSV color spaces for acute lymphoblastic leukemia segmentation.

2 Methodology

2.1 Image Dataset

Microscope Images of ALL are taken from ALL-IDB database [12]. An optical laboratory microscope together with a Canon Power Shot G5 camera was used to capture the images of the database. In addition, all images are in JPG format with 24 bit color depth, resolution 2592 × 1944. Moreover, the images are taken with different magnifications of the microscope ranging from 300 to 500. ALL-IDB2 version of the database is used as well. Figure 1 shows the sample of ALL images.

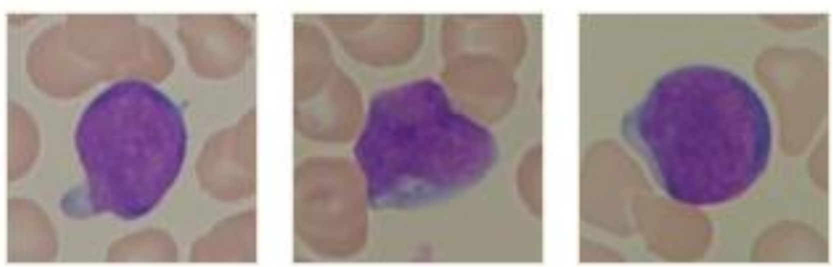

Figure 1: Sample of ALL images

2.2 Segmentation Based RGB Color Space

The main goal is to use RGB color space in segmentation of acute lymphoblastic leukemia images to extract blasts from background. There are 4 steps involved in applying image segmentation process based on RGB color space as shown in figure 2.

- Step1: Apply the contrast enhancement technique namely local contrast stretching (LCS) on the original acute lymphoblastic leukemia image.
- Step2: Select the threshold value by using histogram.

- Step3: Apply the 7×7 median filter.
- Step4: Display the resulted image in RGB color space.

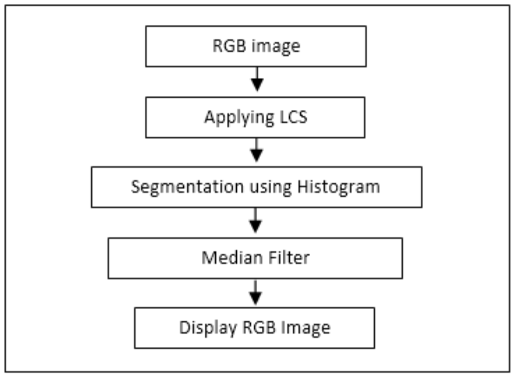

Figure 2: Block diagram of segmentation using RGB

Local contrast stretching is a preprocessing enhancement technique that is applied on an ALL image for adjusting each image element value locally for visualization improvement. LCS is performed by the convolution of the kernel across the image and adjusting the center element using the following formula:

$$Ip\,(x, y) = 255 \bullet [Io\,(x, y) - min] / (max - min) \quad (1)$$

Where:
Ip(x, y) is the color level for the output pixel(x, y) after the LCS process.
Io(x, y) is the color level input for data the pixel(x, y).
max - is the maximum value for color level in the input image.
min - is the minimum value for color level in the input image.

According to formula, (x, y) are the coordinates of the center picture element in the kernel and min and max are the minimum and maximum values of the image data in the selected kernel [13].

LCS considers each range of color channel (R, G and B) in the ALL image separately. The range of each color channel will be used for contrast stretching process to represent each range of color. This will give each color channel a set of min and max values [14].

2.3 Segmentation Based HSV Color Space

HSV color space is a nonlinear transformation of RGB color space. The representation of HSV cone is shown in figure 3.

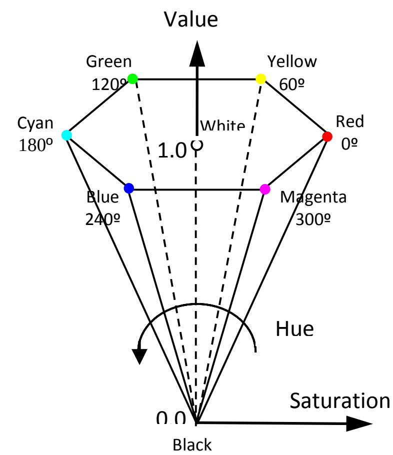

Figure 3: HSV color space

The hue (H) channel refers to the color type such as (Red, Green, Yellow…etc.). The range of hue values changes from 0º to 360º passing throw rainbow colors as shown in figure 4.

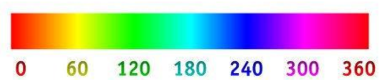

Figure 4: Hue Scale

Saturation (S) value affects the purity of the colors while Value (V) means the amount of light in the color. Both S and V range from 0 to 1. Transformation the source RGB color space to HSV color space is performed based on the following equations:

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

$$S = \begin{cases} 0 & \text{if } M = 0 \\ \frac{M-m}{M} = 1 - \frac{m}{M} \quad , & \text{otherwise} \end{cases}$$

$$V = M$$

Where:

M means the maximum values in R, G, and B elements.
m means the minimum values in R, G, and B elements.

The ultimate goal of ALL segmentation is to extract component such as blast from its complicated blood cells background by using HSV color space. There are 6 steps involved in applying image segmentation process as shown in figure 5.

Step 1: transform the source RGB color space to HSV color space.

Step 2: extract H channel from HSV color space.

Step 3: Select color range of nucleus and cytoplasm by using color histogram of H channel. Two angle values A1, A2 are obtained from color histogram for segmentation using multilevel thresholding.

Step 4: Implement the median filter N X N (N = 7) to the resulted images.

Step 5: Synthesize the HSV image.

Step 6: Convert the HSV image to RGB to display.

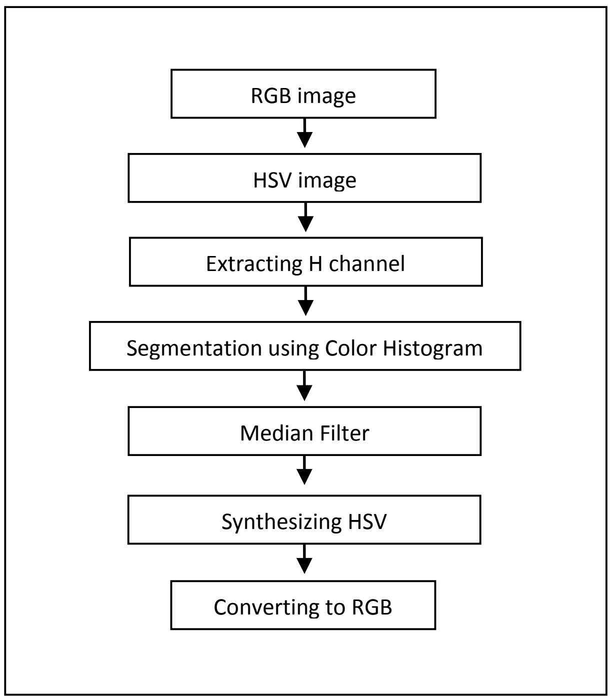

Figure 5: Block diagram of segmentation using HSV

3 Results and Discussion

In this study, image segmentation framework using RGB and HSV color spaces have been applied on two acute lymphoblastic leukemia images labeled as a and b. The quality of segmented images has been determined based on both qualitative and quantitative evaluations.

3.1 Qualitative Analysis

The original acute lymphoblastic leukemia images are shown in figure 6(a), (b). Based on these ALL images, the morphologies of blasts are hardly seen due to the low images contrast.

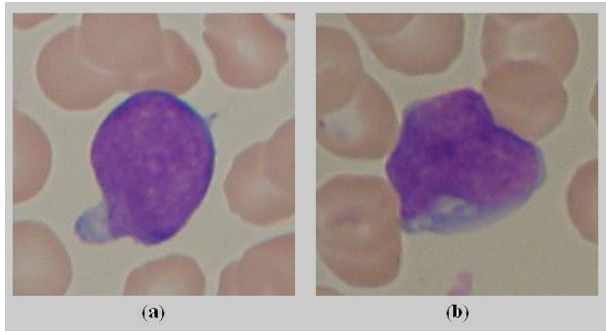

Figure 6: Original RGB images

For segmentation framework based RGB color space, the results of applying the local contrast stretching technique on (a), (b) leukemia images are shown in Figure7 (a), (b) with histogram respectively. Based on these resultant images, the contrast of blast (cytoplasm and nucleus) and background regions has been improved significantly compared to the original images. Also, the LCS histogram of two images is used to select the threshold value.

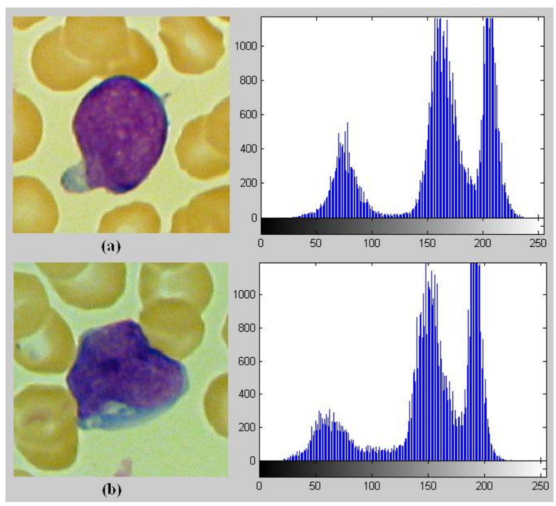

Figure 7: LCS and histogram of RGB images

The results obtained in Figure 8 shows that the elimination of all cytoplasm blast after segmentation using RGB color space. Figure 9 shows the ghost of segmented images using RGB color space that contains cytoplasm blast and background.

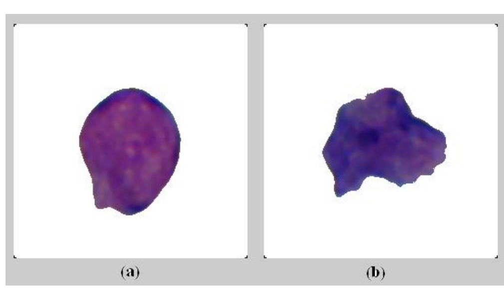

Figure 8: Segmented images using RGB

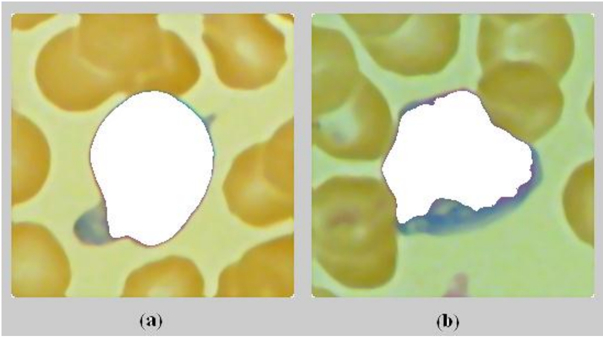

Figure 9: Ghost images for RGB segmentation

According to figure 10, the equivalent HSV images are represented. Meanwhile, Figures 11 shows the color histogram of h channel that used to obtain multilevel thresholding values.

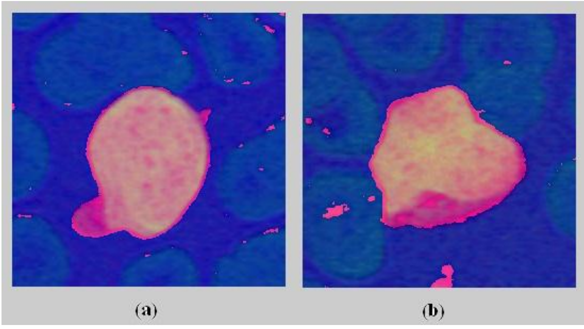

Figure 10: Equivalent HSV images

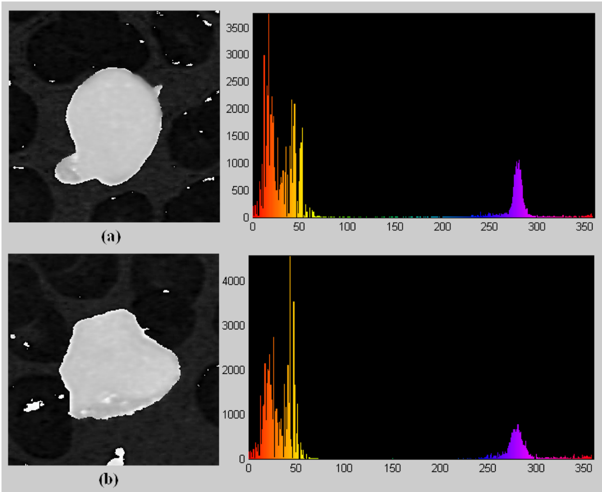

Figure 11: H channel color histogram of HSV images

Figure 12 illustrate the segmented images using an HSV color space which seems to overcome the problem of cytoplasm elimination caused by segmentation based RGB color space. The ghost of segmented images using HSV color space is shown in figure 13.

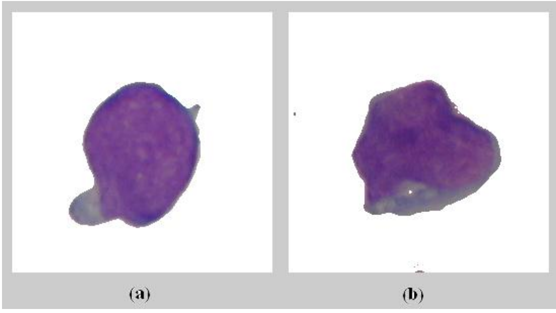

Figure 12: Segmented images using HSV

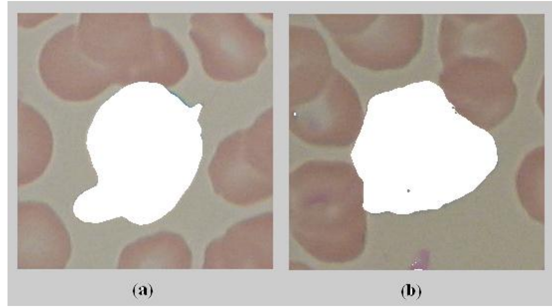

Figure 13: Ghost images for HSV segmentation

Therefore, Figure 12 (a), (b) indicates that the shape of the blasts resulted from segmentation based HSV color space yields almost similar shape to Figure 6 (a), (b) respectively whereas the shape from Figure 8 (a), (b) is quite dissimilar.

3.2 Quantitative Analysis

The quality of segmented ALL images using RGB and HSV color spaces is determined statistically based on global quantitative method. Area pixels of the resultant segmented ALL images is compared to manual segmented image made by medical experts as reference. Table 1 tabulates the segmentation performances based on RGB and HSV color spaces.

Table1: Segmentation performances of ALL images based on RGB and HSV color spaces

Image Label	Segmentation results in pixels			Performances (%)	
	Manual	RGB	HSV	RGB	HSV
(a)	52140	54459	52596	95.74	99.13
(b)	51624	55456	52034	93.09	99.21

4 Conclusion

In this work, a performance comparison between image segmentation framework by using RGB and HSV color spaces for ALL blast detection is performed. The results obtained from segmentation based on hue channel of HSV color space provide almost similar pixel values when compared to manual segmentation with average accuracy about 99.17%. While the segmentation based on RGB gives average accuracy about 94.42% which mean that it has not performed well. The results also show that the color histogram of hue channel is also useful for the selection of the multilevel thresholding values using HSV color space. In the future, the result of this work can be used as the basis for features extraction from the acute lymphoblastic leukemia blood samples.

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