

Demarcation of Blast from Acute Leukemia Images Using Different Color Format

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Abstract

Image processing plays an important role in computer vision and medical diagnosis. One of the main tasks for detecting leukemia is analyzing of white blood cells (WBC) where the WBC composition reveals important diagnostic information of a patient. Leukemia is a malignant disease (cancer) seen in people of any age groups either in children or adults aged over 50 years. The recognition of acute leukemia blood cell based on color image is one of the most challenging tasks in image processing. Also, the conventional method of manual counting using a microscope is a time consuming, produces errors and put an intolerable amount of stress to technicians. As a solution to this problem, this paper presents different color spaces to obtain a fully segmented abnormal white blood cell (blast) in an acute leukemia images, Different color spaces used are CMY, YIQ, YUV and Kekre's LUV color space. Out of all color space Kekre's LUV color space gets better result. These methods are applied on 115 microscopic images and succeed with specificity of 97% and sensitivity of 75% to detect abnormal white blood cells (blast).

Keywords: Leukemia, Segmentation, CMY, YIQ, YUV, Kekre's LUV color space.

1. INTRODUCTION

Leukemia is a cancer of the bone marrow and blood. It is caused by an excessive production of immature white blood cells (blast) that replace the normal blood cells in the body. The two main types of acute leukemia are Acute Lymphoblastic Leukemia (ALL) and Acute Myelogenous Leukemia (AML) [1-4]. Leukemia can be cured if it is detected and treated at the early stage. Generally in leukemia screening process, hematologists will first perform the complete blood count process [5].

If there are abnormalities in this count, a study of morphological bone marrow smear is done to confirm the present of leukemia cells. By observing morphological features of acute leukemia, a hematologist will classify the samples as either ALL or AML [6, 7]. Currently, the microscopic investigation to identify the types and maturity of blood cells is performed manually by hematologists through visual identification under the light microscope.

However, the manual recognition method has an error rate between 30% and 40% depending on the hematologists experience and difficulties to distinguish the types of leukemia [8]. In conventional leukemia screening process, Hematologists will look for the large number of abnormal white blood cells on stained slide. The appearance of white blood cells and red blood cells can be distinguished based on colour where WBC tends to appear in blue or purple [9]. Then, specific morphological features will be observed in order to classify the leukemia as either ALL or AML. The characteristic of these features include:

- a) The size and shape of white blood cells nucleus.
- b) The presence of Auer rode and multiple nucleoli inside the nucleus are prominent in AML.

The work we have done is to propose a segmentation process which segments abnormal white blood cells (blast), present in the acute leukemia image using different color spaces. Segmentation of an image refers to the separation of regions with similar characteristics. There are several segmentation techniques such as Thresholding, edge detection, pixel clustering and region growing that have been combined in order to segment region of interest in medical images.

In this paper, the proposed methodology will focus on different color space for obtaining the fully segmented abnormal white blood cells from Leukemia images.

2. COLOR SPACES FOR SEGMENTATION

It is been seen that the color of abnormal white blood cell is blue or purple so we have tried to use different color space to get appropriate results with better efficiency.

2.1 RGB Color Space

The RGB color format is based on the three color components red (R), green (G) and blue (B). The RGB color model describes a color space with additive color composition as it is used in CRT or LCD monitors. Thus, the RGB color format is very popular in computer graphics and image processing. Within computer graphics or image processing

applications, each color component is typically represented by 8 bits. Thus, a color value needs 24 bits to define a single color out of 16 million possible colors. For higher color accuracy 10 bits (or even 12 bits) are used for each color component [9, 10].

2.2 CMY Color Space

The CMYK color model (process color, four color) is a subtractive color model, used in color printing, and is also used to describe the printing process itself. CMYK refers to the four inks used in some color printing: cyan, magenta, yellow, and key (black). Though it varies by print house, press operator, press manufacturer, and press run, ink is typically applied in the order of the abbreviation.

$$\text{computedC} = 1 - (r/255); \quad (1)$$

$$\text{computedM} = 1 - (g/255); \quad (2)$$

$$\text{computedY} = 1 - (b/255); \quad (3)$$

When CMY color format is applied on Acute Myelogenous Leukemia (AML) images nucleus can be seen clearly and when applied on acute lymphoblastic leukemia (ALL) images, area of blast can be detected [11].

2.3 YIQ Color Space

In the YIQ color space, Y component represent the intensity, I and Q component represents the color information. By separating the intensity from the color information makes the YIQ color space very attractive to TV broadcasting, because it helps to maintain compatibility with monochrome TV standards. The YIQ model also takes advantage of the fact that the human eye is more sensitive to changes in luminance than changes to hue or saturation. The Y, I, Q components are assumed to be in the [0, 1] or [0, 255] range.

The RGB to YIQ conversion is defined as:

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.275 & -0.321 \\ 0.212 & -0.523 & 0.311 \end{bmatrix} \times \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (4)$$

When YIQ color format is applied on Acute Myelogenous Leukemia (AML) images nucleus is segmented and when applied on Acute Lymphoblastic leukemia (ALL) images, area of complete blast can be seen with lack of cytoplasm region [12].

2.4 YUV Color Space

The YUV color format is used only for analog PAL or analog NTSC video - not for any digital video format. The following equation describes the conversion of an RGB color into the YUV color format.

$$\begin{bmatrix} Y \\ U \\ V \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ -0.147 & -0.289 & 0.436 \\ 0.615 & -0.515 & -0.100 \end{bmatrix} \times \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (5)$$

When YUV color format is applied on Acute Myelogenous Leukemia (AML) images nucleus region is segmented and when applied on acute lymphoblastic leukemia (ALL) images abnormal white blood cell (blast) is seen clearly.

2.5 Kekre's LUV Color Space

Here we have used Kekre's LUV color Space. Where L gives luminance and U and V gives chromaticity values of color image [10]. Negative value of U indicates prominence of red component in color image and negative value of V indicates prominence of green component over blue. To get Kekre's LUV components we need the conversion of RGB to LUV components. The RGB to LUV conversion matrix given in equation 6 gives the L, U, V components of color image for respective R, G, and B components [13].

$$\begin{bmatrix} L \\ U \\ V \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ -2 & 1 & 1 \\ 0 & -1 & 1 \end{bmatrix} \times \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad (6)$$

The LUV to RGB conversion matrix given in equation 7 gives the R, G, B components of color image for respective L, U and V components.

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 & -2 & 0 \\ 1 & 1 & -1 \\ 1 & 1 & 1 \end{bmatrix} \times \begin{bmatrix} L/3 \\ U/6 \\ V/2 \end{bmatrix} \quad (7)$$

2.5.1 Binary Image

Binary images are images containing only two colours, black (0) and white (1 or 255). Binary images are formed by Thresholding a grayscale or color image to segment region of interest of an object from unwanted areas. In this study, the Thresholding technique was implemented on the grayscale image to obtain binary image of WBC (WBC will be white in colour while RBC and background areas will be black) and RBC (RBC will be white in colour while WBC and background areas will be black).

2.5.2 Morphological Operations

Morphological operations are a set of image processing operations that analyzes the shapes within the image. It applies a structuring element to the image and output the image of the same size. The output value of each pixel is determined by the neighbouring pixels with its corresponding pixel of input image. The size and shape of the structuring element affects the number of pixels being added or removed from the object in the image. The most basic morphological operations used are dilation and erosion. Erosion removes pixels on the object boundaries in the image by changing it to the background pixel. This shrinks the object and breaks up a single object. Dilation, on the other hand, adds pixels to the object boundaries by changing the background pixel surrounding it. This enlarges the object and multiple objects could merge together as one. Opening or closing is a single function with the combination of dilation and erosion. In opening, the image would undergo erosion followed by dilation. This removes the small object pixels before enlarging the remaining while in closing, the image would undergo dilation followed by erosion. This removes the small background pixels before enlarging the remaining. In this way, the contours of the object smoothen and small object gaps fused. These functions help to handle noise in the image or adjust it to “enclose” a certain desired object [14].

3. RESULTS

In this study, different color spaces have been applied on acute leukemia images. In order to compare different color spaces on morphological features of blood cells, the comparison of image before and after applying color space is needed. The different color spaces were applied to leukemia images. The qualities of images were determined based on human visual interpretation.

In this section, the final results of blast detection are presented. This algorithm was tested on 115 microscopic images of size 256x256 captured with a simple light microscope with three ocular lenses and an analog video CCD which is coupled to a

Pinnacle to digitize the captured images.

In this study, we successfully designed a system that can segment the blast (abnormal white blood cell) and evaluated the accuracy of the proposed methods. The specificity and sensitivity of this method is calculated using the following formula: [14, 15].

$$\text{Sensitivity} = \frac{TP}{TP+FN} \quad (9)$$

$$\text{Specificity} = \frac{TN}{TN+FP} \quad (10)$$

Where TP, FP, FN, and TN stand for true positive results, false positive results, false negative results, and true negative results. True Positives (TP) is the number of images correctly classified as positive by the test; True Negatives (TN) is the number of images correctly classified as negative by the test; False Positive (FP) is the number of images classified as positive by the test, but they are not; False Negative (FN) is the number of images classified as negative by the test, but they are not .

Table 1.1 Segmentation performance of color space for AMLtype

Algorithm	Sensitivity	Specificity
CMY	68%	90%
YIQ	60%	92%
YUV	65%	92%
KEKRE'S LUV	70%	96%

Table 1.2 Segmentation performance of color space for ALL type

Algorithm	Sensitivity	Specificity
CMY	70%	90%
YIQ	65%	92%
YUV	68%	92%
KEKRE'S LUV	75%	97%

Table 1.3 Different color spaces applied on AML images

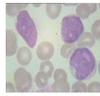
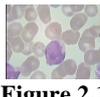
Original AML Image	Image after applying CMY	Image after applying YIQ	Image after applying YUV	Image after applying KEKRE'S COLOR SPACE
 Figure 1.1	 Figure 1.2	 Figure 1.3	 Figure 1.4	 Figure 1.5
 Figure 2.1	 Figure 2.2	 Figure 2.3	 Figure 2.4	 Figure 2.5

Table 1.4 Different color spaces applied on ALL images

Original ALL Image	Image After Applying CMY	Image After Applying YIQ	Image After Applying YUV	Image after applying KEKRE'S COLOR SPACE
 Figure 3.1	 Figure 3.2	 Figure 3.3	 Figure 3.4	 Figure 3.5
 Figure 4.1	 Figure 4.2	 Figure 4.3	 Figure 4.4	 Figure 4.5

4. CONCLUSION

With the increasing number of leukemia cases in Malaysia and worldwide, there is a need for fast and cost-effective production of blood cell count reports. This paper proposed various color spaces which includes an effective and efficient method in recognizing and counting blood cells as a practical alternative to the manual blood cell counting. As seen kekre's LUV color space gives better result compared to other color spaces.

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