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Image Enhancement Techniques Using Local, Global, Bright, Dark and Partial Contrast Stretching For Acute Leukemia Images

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Abstract— **Leukaemia is a malignant disease (cancer) that affects people in any age either they are children or adults over 50 years old. Nowadays, there are screening system guidelines for leukaemia patients. The screening result from looking at a sample of patient blood, can determine the abnormal levels of white blood cells, which may suggest leukaemia for further diagnostic stage. Therefore, medical professional using medical images to diagnose leukemia. However, there are blurness and effects of unwanted noise on blood leukaemia images that sometimes result in false diagnosis. Thus image pre-processing such as image enhancement techniques are needed to improve this situation. This study proposes several contrast enhancement techniques which are local contrast stretching, global contrast stretching, partial contrast stretching, bright and dark contrast stretching. All techniques are applied on the leukaemia images. The comparison for all the proposed image enhancement techniques was carried out to find the best technique to enhance the acute leukaemia images. The results show that the partial contrast stretching is the best technique that helps to improve the image quality.**

Index Terms ó **Image enhancement, local contrast, global contrast, partial contrast, bright contrast, dark contrast, Acute Leukemia**

I. INTRODUCTION

Leukemia is the common malignancy in childhood and is second only to accidents as the major cause of most death in childhood in the age group 1-15 years [1]. It is characterized by the uncontrolled accumulation of immature white blood cells. Leukemia is divided into four categories: myelogenous or lymphocytic, each of which can be acute or chronic. The term myelogenous or lymphocytic denotes the cell type involved. Each type of leukemia begins in a cell in the bone marrow, it becomes immature cell and functionless in the blood.

Acute leukemia comes suddenly, progressing quickly and need to be treated urgently. Acute leukemia is a disease of the leukocytes and their precursors. It is characterized by the appearance of immature, abnormal cells in the bone marrow

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and peripheral blood. The aspirated marrow is found to be infiltrated by abnormal cells [2].

There are some signs or symptoms of leukemia that are similar to other common illnesses. Initial symptoms of acute leukemia are quite common, namely weight loss and/or loss of appetite, excessive bruising or bleeding from wound [3].

Leukemiaøs patient will also feel tired, short of breathe during physical activity and pale skin. Early diagnosis of the disease is fundamental for the recovery of patient especially in the case of children [3].

To date, several research groups have focused on the development of computerized systems that can analyze different types of medical images and extract useful information for the medical professional [4]. Most of the proposed methods use images acquired during a diagnostic procedure [5]. However, in some cases, the leukemia images are blurred, low contrast, hazy and afflicted by unwanted noises. These problems can hide and cause difficulty to interpret the important leukemia morphologies, hence increasing false diagnosis.

II. METHODOLOGY

A. Image Enhancement

Image enhancement processes consist of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or machine [6]. Meanwhile, the term image enhancement is mean as the improvement of an image appearance by increasing dominance of some features or by decreasing ambiguity between different regions of the image [7].

Contrast stretching is the image enhancement technique that commonly used for medical images. To date, contrast stretching process plays an important role in enhancing the quality and contrast of medical images [8]. This study proposes 5 techniques for contrast enhancement based on local contrast, global contrast, partial contrast, bright and dark contrast.

There are 4 steps involved in applying image enhancement process.

> a) The first step is image capturing of acute leukemia blood slide under 40 x magnifications.
> b) Then, save the images under .bmp extension.

c) The third step is to select picture with 3 different types which is normal image, bright image and dark image. Three images are selected for each different type.

d) The last step is applying the 5 proposed techniques to the selected images.

B. The Proposed techniques

i- Local and Global Contrast Stretching

Local contrast stretching (LCS) is an enhancement method performed on an image for locally adjusting each picture element value to improve the visualization of structures in both darkest and lightest portions of the image at the same time. LCS is performed by sliding windows (called the KERNEL) across the image and adjusting the center element using the 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 contrast stretching 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.

From the 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 [9].

Local contrast stretching will consider each range of color palate in the image(R, G and B). The range of each color will be used for contrast stretching process to represent each range of color. This will give each color palate a set of min and max values [10].

Meanwhile, global contrast stretching will consider all color palate range at once to determine the maximum and minimum for all RGB color image. The combination of RGB color will give only one value for maximum and minimum for RGB color. This maximum and minimum value will be used for contrast stretching process [10].

ii. Partial Contrast

Partial contrast is an auto scaling method. It is a linear mapping function that is usually used to increase the contrast level and brightness level of the image. This technique will be based on the original brightness and contrast level of the images to do the adjustment.

The mapping function is as follows [11]:

$$P_k = \frac{(max - min)}{(f_{max} - f_{min})} \left(q_k - f_{min} \right) + min \quad (2)$$

where,

P_k : color level of the output pixel

q_k : color level of the input pixel

f_{max} : maximum color level values in the input image

f_{min} : minimum color level values in the input image

max & min : desired maximum and minimum color levels that determines color range of the output image, respectively

Before the mapping process start, the system will find the range of where the majority of the input pixels converge for each color space. Since the input images are the RGB model, so it is necessary to find the range for the red, blue and green intensities. After that, the average will be calculated for these upper and lower color values of the range of three color space by using the following formula [12]:

$$maxTH = (maxRed + maxBlue + maxGreen)/3$$
$$minTH = (minRed + minBlue + minGreen)/3$$

$$(3)$$

$maxRed, maxBlue$ and $maxGreen$ are the maximum color level for each red, blue and green color palettes, respectively. $minRed, minBlue$ and $minGreen$ are the minimum value for each color palette, respectively. $maxTH$ and $minTH$ are the average number of these maximum and minimum color levels for each color space. The $maxTH$ and $minTH$ will be used as the desired color ranges for all the three color palettes. The purpose of the three color palette to have the same threshold value is to avoid the color level to be placed out side of a valid color level. After that, the mapping process will start [12]. The function in *Equation 4* will be used for the pixels transformation, which is based on the concept of the linear mapping function in *Equation 2*.

$$out(x,y) = \begin{cases} \dfrac{in(x, y)}{minTH} * N\,minTH & for \quad in(x, y) > minTH \\[3mm] \left[\dfrac{(NMaxTH - NMinTH)}{maxTH - minTH} * (in(x, y) - f\,min) \right] + min & for \quad minTH < in(x, y) < maxTH \\[3mm] \dfrac{in(x, y)}{maxTH} * N\,maxTH & for \quad in(x, y) < maxTH \end{cases}$$

$$(4)$$

where,

$in(x,y)$: color level for the input pixel

$out(x,y)$: color level for the output pixel

$minTH$: lower threshold value

$maxTH$: upper threshold value

$NminTH$: new lower stretching value

$NmaxTH$: new upper stretching value

The pixel within the range of $minTH$ and $maxTH$ will be stretched to the desire range of $NmaxTH$ to $NminTH$, whereas the remaining pixels will experience compression. By this stretching and compressing proceses, the pixels of the image can be mapped to a wider range and brighter intensities; as a result the contrast and the brightness level of the raw images are increased. Figure 1 illustrates the compression and stretching processes for partial contrast method. The value of

80 and 200 were used as an example of lower and upper threshold value while 20 to 230 as the desired range of the color level for the output image. The original range of the input image will be stretched to the range from 20 to 230. The color level below 80 will be compressed to the range of 0 to 20 and the color level more than 200 will be compressed to the range of 230 to 255 [12].
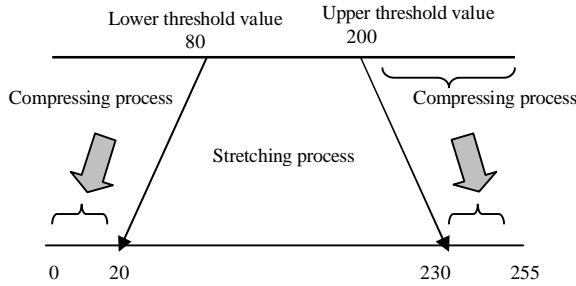

Figure 1: Partial contrast method

iii. Dark Contrast Stretching

Dark stretching is known as part of partial contrast stretching. This process is also based on equation 2 as describe in previous section which involves auto scaling method. Dark stretching is a reverse process of bright stretching process. The color level produces is based on equation 5, [8]:

$$out(x,y)=\begin{cases} \dfrac{in(x,y)-TH}{255-TH}*NewTH & for\ \ in(x,y)<TH \\ \left[\dfrac{(in(x,y)-TH)}{255-TH}*\left(255-NewTH\right)\right]+min & for\ \ in(x,y)>TH \end{cases}$$

(5)

where,

$in(x,y)$: value of pixel color level located at *(x,y)* input image
TH : threshold value.
$NewTH$: dark stretching factor

Figure 2 shows the dark stretching process with the value of 100 is used as an example of threshold value and 250 as a dark stretching factor.
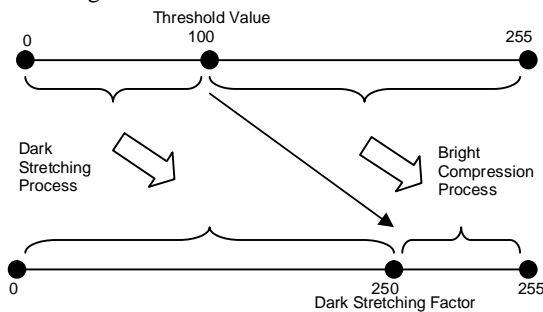

Figure 2 : Dark Stretching Process

iv. Bright Contrast Stretching

Bright stretching is a process that also used auto scaling method which is a common linear mapping function to enhance the brightness and contrast level of an image. This method is based on Equation 2 [11]. The bright stretching process is implemented based on Equation 6 [12],

$$out(x,y)=\begin{cases} \dfrac{in(x,y)}{TH}*NewTH & for\ \ in(x,y)<TH \\ \left[\dfrac{(in(x,y)-TH)}{255-TH}*(255-NewTH)\right]+min & for\ \ in(x,y)>TH \end{cases}$$

(6)

where,

TH : threshold value
$NewTH$: bright stretching factor

$NewTH$ is a new range of bright stretching pixel for the threshold value of red, green and blue. $in(x,y)$ is a value of color level at pixel *(x,y)* from the input image. **Figure 3** illustrates the compression and stretching processes for bright stretching technique.
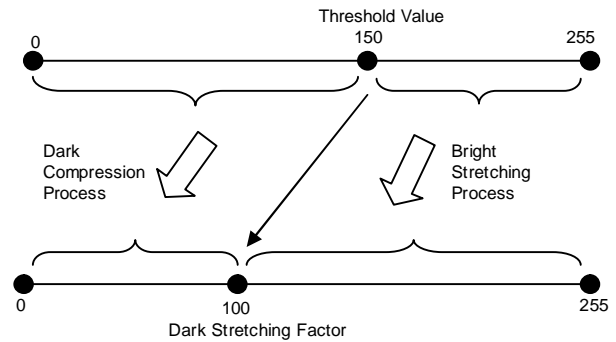

Figure 3 : Bright Stretching Method

III. RESULT AND DISCUSSION

In order to compare the image enhancement techniques, the comparison of image before and after enhancement is needed. The proposed contrast enhancement techniques were applied to three leukemia images labeled as normal, dark and bright images. Those images were categorized based on the human visual interpretation. Figure 4 shows original the three images. Meanwhile, the results for each normal, dark and bright image for each technique are shown in Figure 5, Figure 6, Figure 7, Figure 8 and Figure 9.

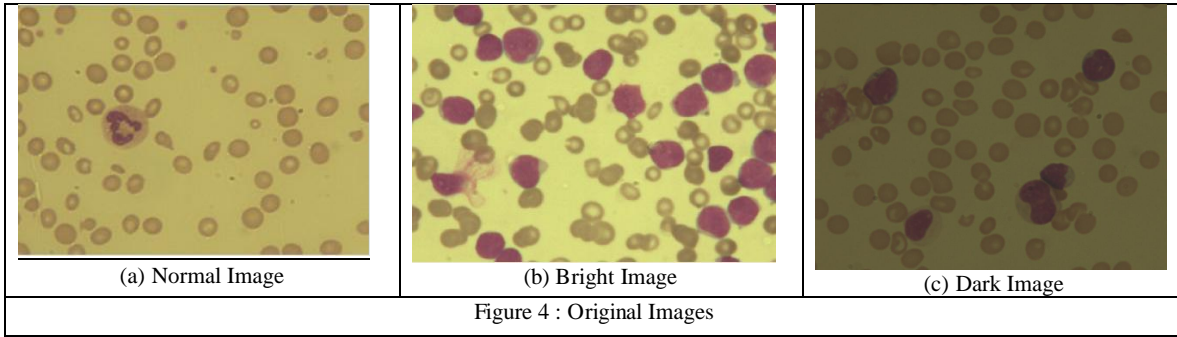|		
(a) Normal Image	(b) Bright Image	(c) Dark Image
Figure 4 : Original Images		

Figure 5 shows the result from the local contrast stretching technique. The resultant, images become clearer and the features of leukemia cells can easily been seen and improved from the original for each category. Nucleus and cytoplasm of immature white blood cells become clearer. Hence, they can easily been discussed by hematologists.

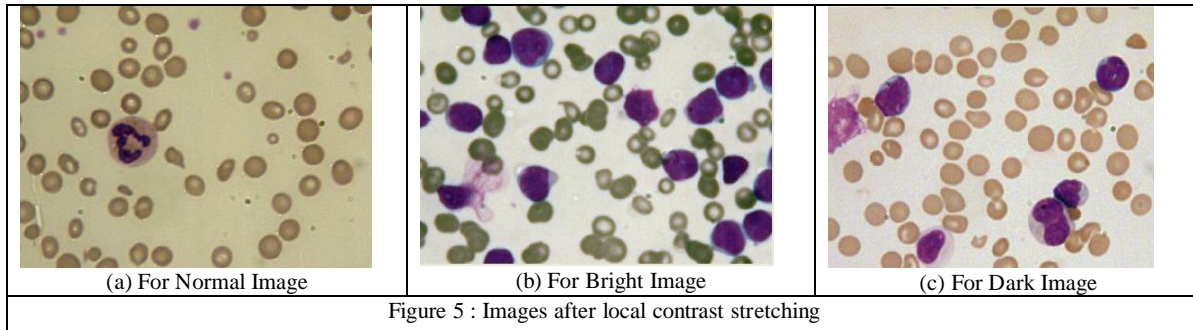|		
(a) For Normal Image	(b) For Bright Image	(c) For Dark Image
Figure 5 : Images after local contrast stretching		

Figure 6 shows the result after global contrast stretching techniques. Generally, global contrast stretching produced the resultant images that were not much different from the original images. Globally, for all type of images it only become brighter than the original images. Characteristic of nucleus and cytoplasm of the immature white blood cells after global stretching was not as good as the ones produced by local contrast stretching.

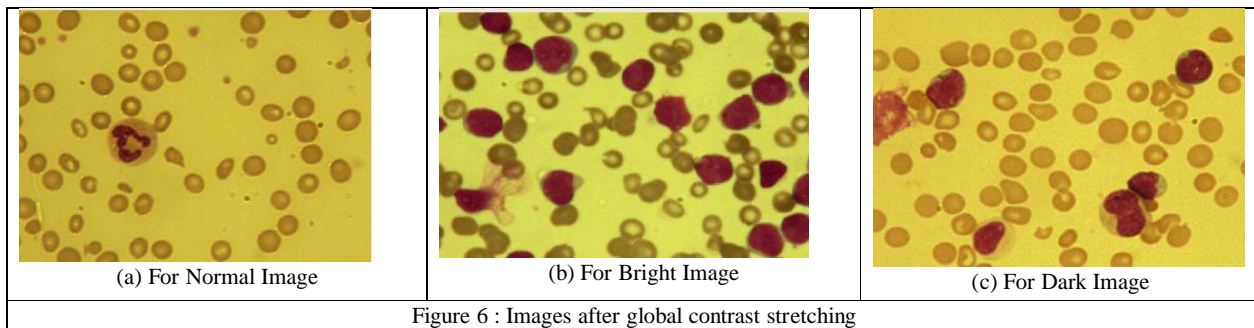|		
(a) For Normal Image	(b) For Bright Image	(c) For Dark Image
Figure 6 : Images after global contrast stretching		

Figure 7 shows the selected original leukemia images for three different types of images with the processed images after applying partial contrast method. The lower and upper threshold were chosen as 80 and 200 respectively. The desired range of the color levels for the output image is 20 to 230. These values were found to be suitable for the three different types of images (*normal, bright and dark*). Nucleus, cytoplasm and background regions can be seen clearly. The results show the leukemia images after applying the partial contrast process have better contrast than the original images. These choices of parameters can improve the quality of the original images.

(a) For Normal Image	(b) For Bright Image	(c) For Dark Image

Figure 7 : Images after partial contrast stretching
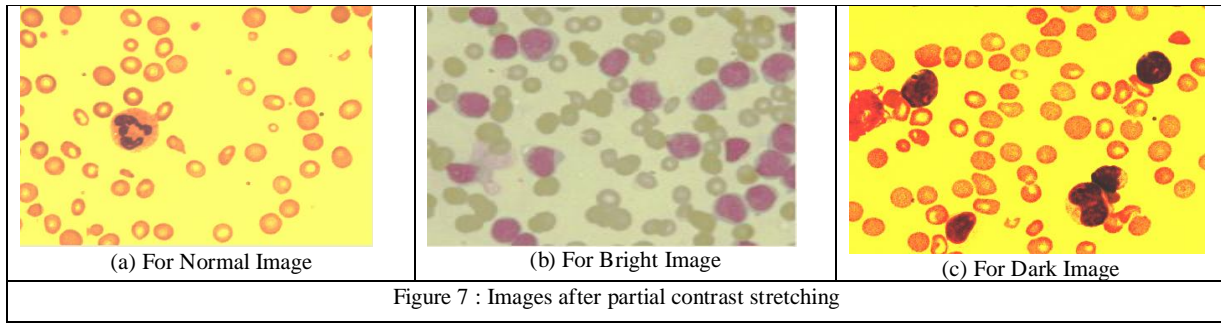
Results for bright stretching method are shown in Figure 8. Figure 8 shows that the image become brighter where more bright pixels are stretched towards the dark region. This way the color of the cytoplasm is enhanced. The shape of cytoplasm can be seen clearly. Beside that, the contrast was increased between the edge of cytoplasm and the background. Different controlled parameters called thresholds and bright stretching factors have been used for the three different types of images.

Figure 8 shows the results after bright contrast stretching. The threshold value for normal image (Figure8(a)) is 150 and the bright stretching is 100, for threshold value for bright image (Figure 8(b)) is 100 and the bright stretching factors is 50. While, for threshold value for dark image (Figure8(c)) is 150 and the bright stretching factor is 200.

(a) For Normal Image	(b) For Bright Image	(c) For Dark Image
Threshold value=150	Threshold value=100	Threshold value=150
Bright stretching factor=100	Bright stretching factor=50	Bright stretching factor=200

Figure 8 : Images after bright contrast stretching
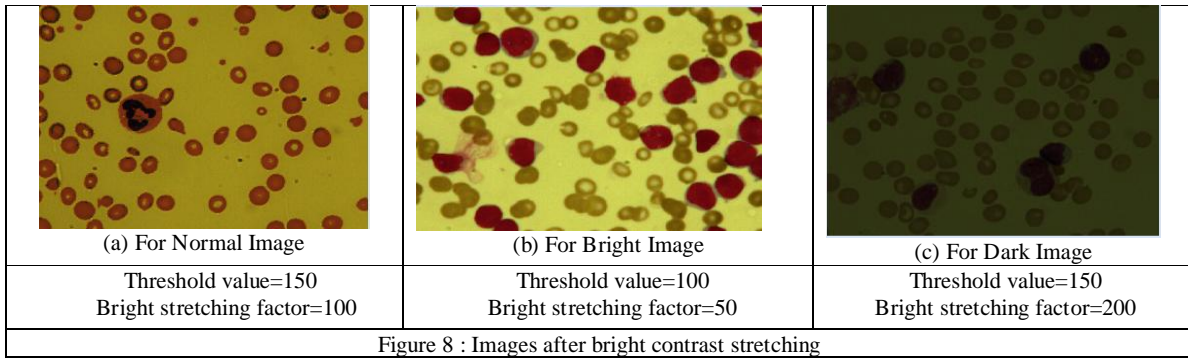
In contrast to bright stretching process, dark stretching results as shown below where dark areas of the image are stretched and the bright areas are compressed. In the leukemia images dark area is refer to nucleus, therefore the nucleus is clearer because of the stretching step in dark stretching method. The results for dark stretching method are similar to partial contrast method in term of contrast and brightness. The controlled parameters called threshold value and dark stretching factor have being used. The parameters are different for each figure according to the

contrast and brightness level of the original leukemia images.

Figure 9 shows the results after dark contrast stretching. The threshold value for normal image (Figure9(a)) is 100 and the dark stretching factor is 150, the threshold value for bright image (Figure 9(b)) is 150 and the dark stretching factors is 200. While, the threshold value for dark image (Figure9(c)) is 100 and the bright stretching factor is 250

(a) For Normal Image	(b) For Bright Image	(c) For Dark Image
Threshold value=100	Threshold value=150	Threshold value=100
Dark stretching factor=150	Dark stretching factor=200	Dark stretching factor=250

Figure 9 : Images after dark contrast stretching
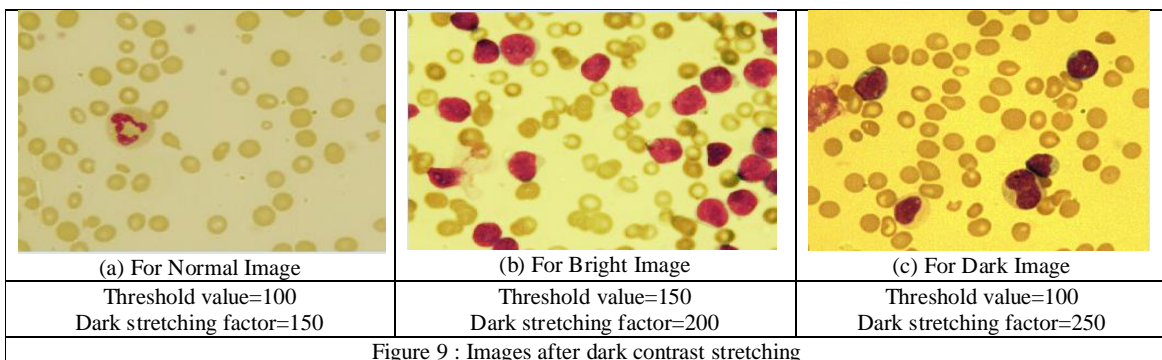
IV. Conclusion

The presented contrast enhancement techniques are effective in enhancing the contrast of leukemia images. From those 5 techniques, partial contrast gives the best result and hopefully could give extra information for nucleus and cytoplasm of acute leukemia images. As a result, acute leukemia blood images that have been applied with this technique appears to be clearer and hopefully would ease further analysis by hematologist.

Acknowledgment

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