Comparison of Contrast Stretching methods of Image Enhancement Techniques 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 project 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.

Keywords-image enhancement,local contrast,global contrast,partialcontrast,dark contrast,Acute Leukaemia

1. Introduction

The word **Leukemia** comes from the Greek *leukos* which means "white" and *aima* which means "blood". It is cancer of the blood or bone marrow (which produces blood cells). A person who has leukemia suffers from an abnormal production of blood cells, generally leukocytes (white blood cells).The DNA of immature blood cells, mainly white cells, becomes damaged in some way. This abnormality causes the blood cells to grow and divide chaotically. Normal blood cells die after a while and are replaced by new cells which are produced in the bone marrow. The abnormal blood cells do not die so easily, and accumulate, occupying more and more space. As more and more space is occupied by these faulty blood cells there is less and less space for the normal cells - and the sufferer becomes ill. Quite simply, the bad cells crowd out the good cells in the blood. 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 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].

Leukemia's 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.

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.

2. Methodology

2.1. Image enhancement

Image enhancement techniques are the algorithms which improve the quality of images by removing blurring and noise, increasing contrast and sharpness of digital images. There are many image enhancement approaches (theories) like Contrast stretching, Range compression, Histogram equalization and noise smoothing. A certain amount of trial and error usually is required before a particular image enhancement approach is selected. There is no general theory of image enhancement. When an image is processed for visual interpretation, the viewer is the ultimate judge of how well a particular method works. Visual evaluation of image quality is a highly subjective process [6]. Image enhancement plays an important role in computer vision and image processing. Image enhancement was used to eliminate the background noise and improve the image quality for the purpose of determining the focal areas such as nucleus and nucleoli in acute leukaemia images [7]. There are many image enhancement approaches (theories) like Contrast stretching, Range compression, Histogram equalization and noise smoothing.

Contrast stretching is the image enhancement technique that commonly used for medical images [8]. Improvement in quality of medical images can be achieved by using Contrast stretching.

There are four steps involved in applying image enhancement process.

1)Image capturing of acute leukemia blood slide under 40 x magnifications.

2)Then, save the images under .bmp extension.

3)Select picture with 3 different types which is normal image, bright image and dark image. Three images are selected for each different type.

4)Apply the 5 proposed techniques to the selected images.

2.2. The proposed techniques

2.2.1. 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

$$I_p(x,y) = 255 * \frac{[I_0(x,y) - min]}{(max - min)} \quad (1)$$

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].

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.

2.2.2. Partial contrast stretching 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]

$$p_k = \left((max - min)/(f_{max} - f_{min})\right) * (q_k - f_{min}) + min \quad (2)$$

where,

Pk: : color level of the output pixel

qk : 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]

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$$maxTH = \frac{(maxRed + maxGreen + maxBlue)}{3}$$

$$minTH = \frac{(minRed + minGreen + minBlue)}{3} \qquad (3)$$

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 outside of a valid color level. After that, the mapping process will start. The function will be used for the pixels transformation, which is based on the concept of the linear mapping function.

$$out(x,y) = \left(\frac{in(x,y)}{minTH}\right) * nminTH \qquad forin(x,y) > minTH$$

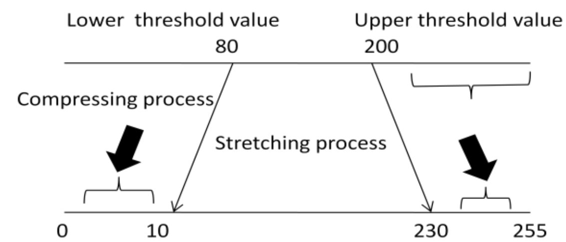
$$= \left(\left(NmaxTH - \frac{NminTH}{maxTH} - minTH\right) * (in(x,y) - f_{min})\right) + min \qquad for\ minTH < in(x,y) < maxTH$$

$$= (in(x,y)/maxTH) * NmaxTH \quad forin(x,y) < maxTH \qquad (4)$$

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.



"Figure 1. Partial stretching process"

2.2.3. 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.

$$out(x,y) = \left(\frac{(in(x,y) - TH)}{(255 - TH)}\right) * NewTH \qquad for\ in(x,y) < TH$$

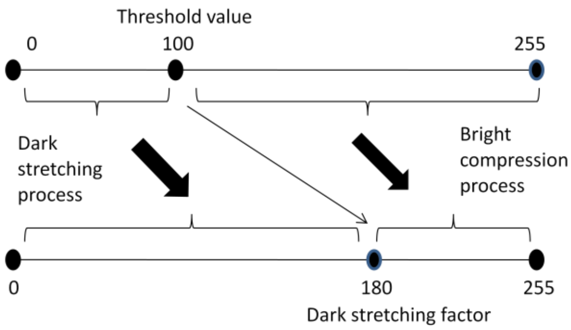
$$\left(\left[\left(\frac{(in(x,y) - TH)}{255 - TH}\right) * (255 - NewTH)\right] + min\right) \qquad for\ in(x,y) > TH$$

(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"

2.2.3. 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 mapping equation .The bright stretching process is implemented based on Equation 6[12],

$$out(x,y) = (in(x,y)/TH) * NewTH \quad for\ in(x,y) < TH$$

$$= \left(\left(\frac{(in(x,y) - TH)}{255 - TH} * (255 - NewTH) + min\right)\right) \quad for\ \ in(x,y) > TH \tag{6}$$

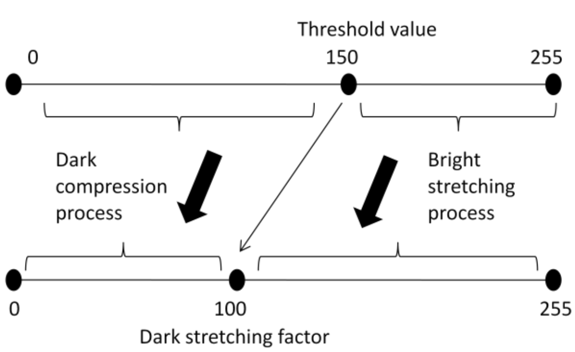
where,

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 process.



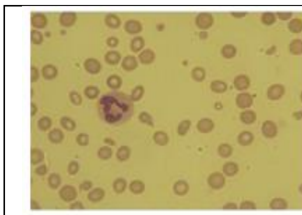
"Figure 3. Bright stretching process"

3. Results and discussion

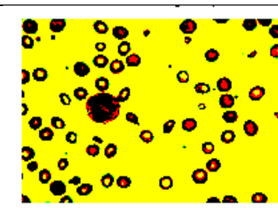
In order to compare the image enhancement techniques, the comparison of image before and after enhancement is needed. The proposed contrast enhancement techniques were applied to three leukemia images labeled as normal, dark and bright images. Those images were categorized based on the human visual interpretation.

3.1. Results for local contrast stretching

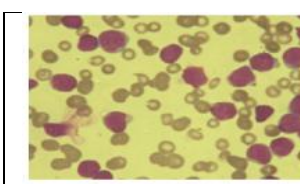
Figure 4, Figure 5, Figure 6 shows original the three images. Meanwhile, the results for each normal, bright and dark image for Local Contrast Stretching technique are shown in, Figure 7, Figure 8 and Figure 9.



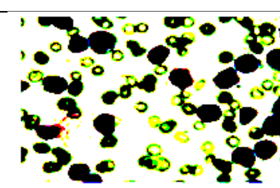
"Figure 4. Original normal image"



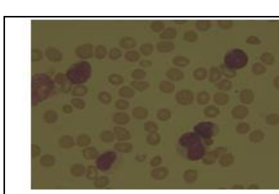
"Figure 7. Normal image after local contrast stretching"



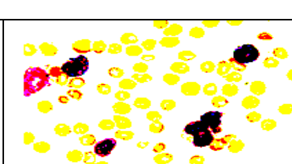
"Figure 5. Original bright image"



"Figure 8. Bright image after local contrast stretching"



"Figure 6. Original dark image"

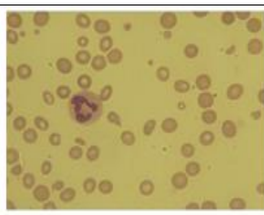


"Figure 9. Dark image after local contrast stretching"

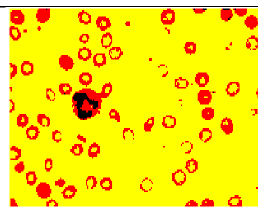
The resultant, images become clearer and the features of leukemia cells can easily been seen and improved from the original for each category. Nucleus and cytoplasm of immature white blood cells become clearer. Hence, they can easily been discussed by hematologists.

3.2. Results for global contrast stretching

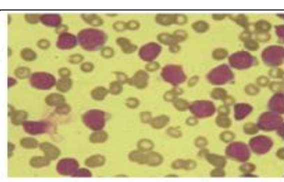
Figure 10, Figure 11, Figure 12 shows original the three images. Meanwhile, the results for each normal, bright and dark image for global Contrast Stretching technique are shown in, Figure 13, Figure 14 and Figure 15.



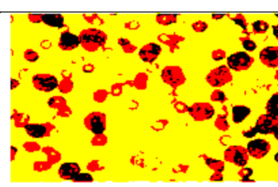
"Figure 10. Original normal image"



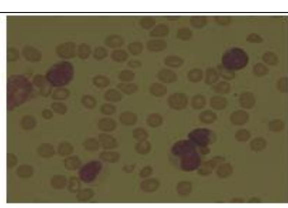
"Figure 13. Normal image after global contrast stretching"



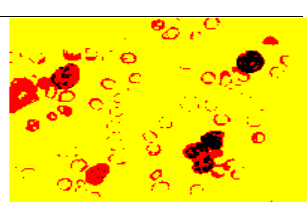
"Figure 11. Original bright image"



"Figure 14. Bright image after global contrast stretching"



"Figure 12. Original dark image"

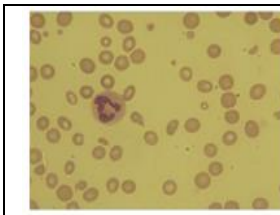


"Figure 15. Dark image after global contrast stretching"

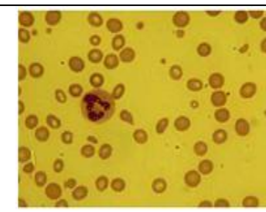
Generally, global contrast stretching produced the resultant images that were not much different from the original images. Globally, for all type of images it only become brighter than the original images. Characteristic of nucleus and cytoplasm of the immature white blood cells after global stretching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

3.3. Results for partial contrast stretching

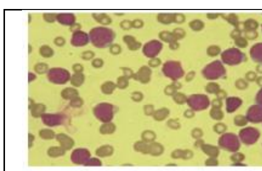
Figure 16, Figure 171, Figure 18 shows original the three images. Meanwhile, the results for each normal, bright and dark image for partial Contrast Stretching technique are shown in, Figure 19, Figure 20 and Figure 21.



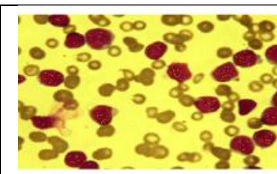
"Figure 16. Original normal image"



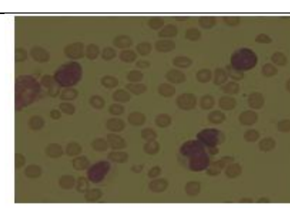
"Figure 19. Normal image after partial contrast stretching"



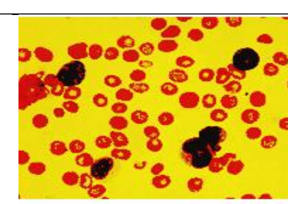
"Figure 17. Original bright image"



"Figure 20. Bright image after partial contrast stretching"



"Figure18. Original dark image"



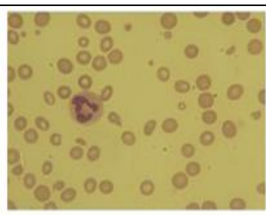
"Figure 21. Dark image after partial contrast stretching"

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.

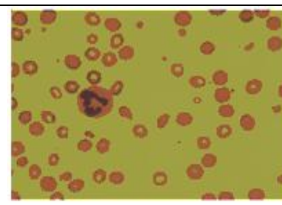
The lower and upper thresholds were chosen as 80 and 200 respectively. The desired range of the color levels for the output image is 10 to 230. These values were found to be suitable for the three different types of images

3.4. Results for bright contrast stretching

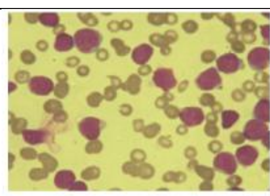
Figure 22, Figure 23, Figure 24 shows original the three images. Meanwhile, the results for each normal, bright and dark image for Bright Contrast Stretching technique are shown in, Figure 25, Figure 26 and Figure 27.



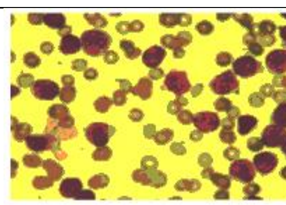
"Figure 22. Original normal image"



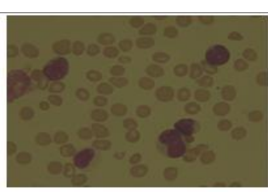
"Figure 25. Normal image after bright contrast stretching"



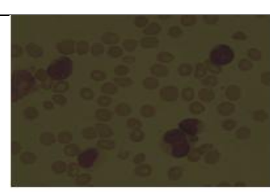
"Figure 23. Original bright image"



"Figure 26. Bright image after bright contrast stretching"



"Figure 24. Original dark image"



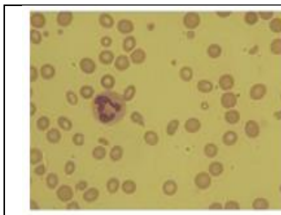
"Figure 27. Dark image after bright contrast stretching"

Results for bright stretching method shows that the images 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. Besides 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.

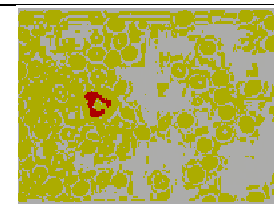
The threshold value for normal image is 150 and the bright stretching is 100, for threshold value for bright image is 100 and the bright stretching factors is 50. While, for threshold value for dark image is 150 and the bright stretching factor is 200.

3.5. Results for dark contrast stretching

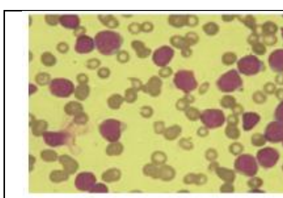
Figure 28, Figure 29, Figure 30 shows original the three images. Meanwhile, the results for each normal, bright and dark image for Dark Contrast Stretching technique are shown in, Figure 31, Figure 32 and Figure 33.



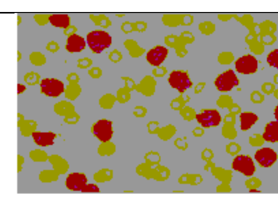
"Figure28. Original Normal image"



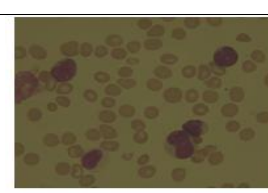
"Figure31. Normal image after dark contrast stretching"



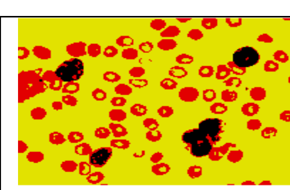
"Figure 29. Original bright image"



"Figure 32. Bright image after dark contrast stretching"



"Figure 30. Original dark image"



"Figure 33. Dark image after dark 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.
The threshold value for normal image is 100 and the dark stretching factor is 150, the threshold value for bright image is 150 and the dark stretching factors is 200. While, the threshold value for dark image is 100 and the bright stretching factor are 250.

4. 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.

5. Acknowledgment

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