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Performance Analysis of Contrast Stretching Enhancement Techniques for Medical Images

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ABSTRACT

Leukemia 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 leukemia patients. The screening result from looking at a sample of patient blood, can determine the abnormal levels of white blood cells, which may suggest leukemia for further diagnostic stage. Therefore, medical professional using medical images to diagnose leukemia. However, there are blur ness and effects of unwanted noise on blood leukemia 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 these enhancement techniques are applied on the ALL (Acute Lymphocyclic Leukemia) images and AML (Acute Myelogenous Leukemia) images. Results are observed for several images. All the proposed image enhancement techniques are carried to find out best technique for enhancing the Acute Leukemia images. PSNR value is used to measure the performance of these techniques. Based on the results, the partial contrast stretching method is considered as the best technique that helps to improve quality of the image.

Keywords: Acute Lymphocyclic Leukemia(ALL), Acute Myelogenous Leukemia(AML), bright contrast stretching, dark contrast stretching, local contrast stretching, partial contrast stretching and PSNR.

I. INTRODUCTION

Leukemia is cancer of the blood cells. It starts in the bone marrow, the soft tissue inside most bones. Bone marrow is where blood cells are made. When a body is healthy, its bone marrow consists of, white blood cells, which help your body, fight infection. Red blood cells, which carry oxygen to all parts of our body, palettes, which help blood clot. Leukemia is divided into four large groups, each of which can be Acute, which is a rapidly progessing disease that results in the accumulation of immature, useless cells in the marrow and blood. Chronic, which progresses more slowly and allows more mature, useful cells to be made. In other words, acute leukemia crowds out the good cells more quickly than chronic leukemia [5].The term myelo- genous 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 especially in the case of children. 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]. Different leukemia's have different causes such as artificial ionizing radiation, viruses-HTLV-1, benzene and some petrochemicals, alkylating chemotherapy agents used in previous cancers, hair dyes, electromagnetic energy etc.

Now days, few research groups focused on the development of computerized systems that can analyze different types of medical images and extract useful information for the medical professional [4]. When images are captured from blood slide, in some cases, the leukemia images are blurred, low contrast, affected by unwanted noises. These problems can hide and cause difficulty to interpret the important leukemia morphologies, hence increasing false diagnosis. This paper proposes, introduction to several contrast stretching enhancement techniques and applied for acute leukemia images for reducing false diagnosis.

2. CONTRAST ENHANCEMENT

Image enhancement is the process of manipulating an image so that result is suitable for specific applications. Enhancement consists 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].

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

2.1 Local 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. In this a sliding window is moved across the image and the center element is adjusted by the formula [1].

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

where
I_p (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.

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]:

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

where,
Pk: : color level of the output pixel.
qk : color level of the input pixel.
fmax: maximum color level values in the input image.
fmin : 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 [10]:

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

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 [10]. 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.

$$\frac{in(x,y)}{minTH} * NminTH \quad for\ in(x,y) > minTH \quad (4.1)$$

$$\left[\frac{NmaxTH - NminTH}{maxTH - minTH} * (in(x,y) - f_{min})\right] + NminTH$$
$$for\ minTH < in(x,y) < maxTH \quad (4.2)$$

$$\frac{in(x,y)}{maxTH} * NmaxTH \quad for\ in(x,y) > maxTH \quad (4.3)$$

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

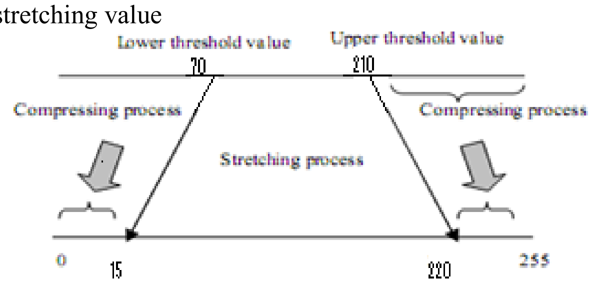

Figure 1: Partial contrast method

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 processes, the

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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.

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, [8].

$$\frac{\square\square(\square,\square)-\square\square}{255-\square\square} * \square\square\square\square\square\square \qquad \square\square\square\ \square\square(\square,\square) < \square\square \qquad (5.1)$$

$$\left(\frac{\square\square(\square,\square)-\square\square}{255-\square\square} * (255-\square\square)\right) + \square\square\square \quad \text{for } in(x,y)>TH \quad (5.2)$$

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.

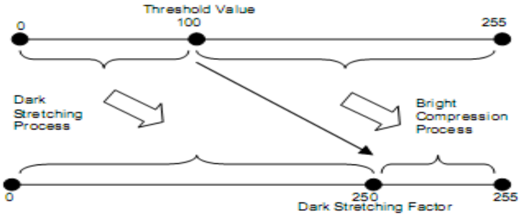

Figure 2: Dark Stretching Process.

2.4 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 [10].

$$\frac{\square\square(\square,\square)}{\square\square} * \square\square\square\square\square\square \qquad \square\square\square\ \square\square(\square,\square) < \square\square \qquad (6.1)$$

$$\left[\frac{\square\square(\square,\square)-\square\square}{255-\square\square} * (255-\square\square\square\square\square\square)\right] + \min \quad \square\square\square\ \square\square(\square,\square) > \square\square$$

(6.2)

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.

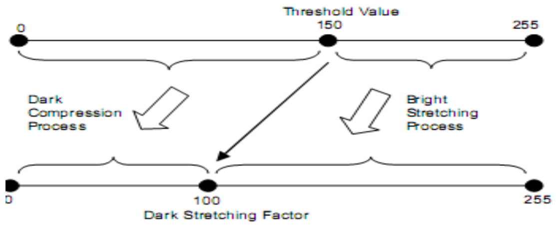

Figure 3: Bright Stretching Method.

3- METRICS FOR ENHANCED IMAGES

3-1 Peak-signal-to-noise-ratio (PSNR): PSNR is the evaluation standard of the reconstructed image quality, and is important measurement feature. PSNR is measured in decibels (dB) and is given by:

$PSNR = 10*\log 10(255^2/MSE)$

where the value 255 is maximum possible value that can be attained by the image signal.

Mean square error (MSE) is defined as [2]:

MSE=

$$\left[\frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}\left[\hat{f}(x,y)-f(x,y)\right]^2\right]^{\frac{1}{2}}$$

Where:

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M*N is the size of the original image
$\hat{f}(x, y)$: is the enhanced image
$f(x, y)$: is the original image
Higher the PSNR value is, better the reconstructed image.

3-2 Absolute mean brightness error (AMBE)

It is the difference between original and enhanced image and is given as[5]:
AMBE= |E(x) - E(y)|
Where E(x)= average intensity of input image,
E(y)=average intensity of enhanced image . Lower the value of (AMBE), lower the value of the error.

3-3. Contrast

Contrast defines the difference between lowest and highest intensity level. Higher the value of contrast means more difference between lowest and highest intensity level[5].

3-4. Visual Quality

By looking at the enhanced image, one can easily determine the difference between the input image and the enhanced image and hence, performance of the enhancement technique is evaluated.

3. 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 Sample 1,Sample 2 & Sample 3. Those images were categorized based on the human visual interpretation as shown in fig.1

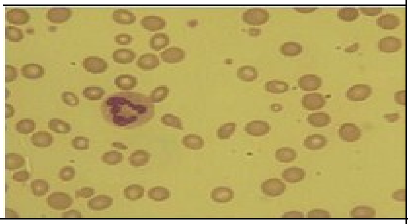
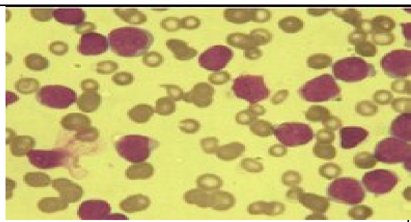
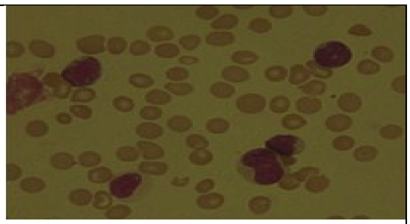
		
(a) Sample 1	(b) Sample 2	(c) Sample 3

Fig1: Original images

Table1 shows the result for 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.

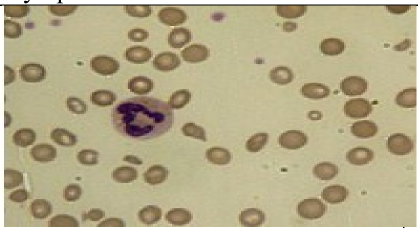
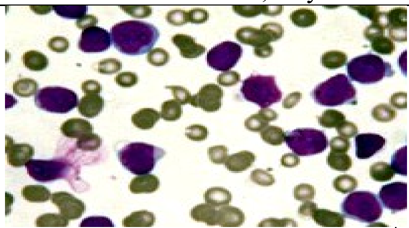
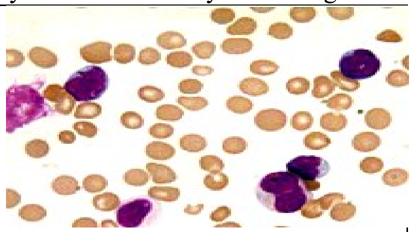
		
(a) For Sample 1	(b) For Sample 2	(c) For Sample 3

Table1: Results of local contrast stretching

Table 2 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.

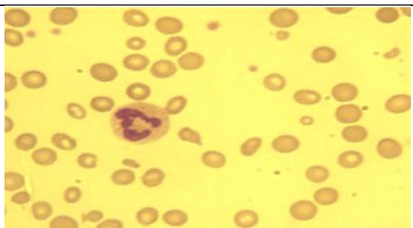
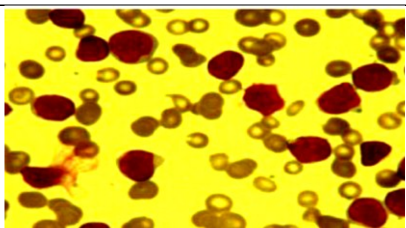
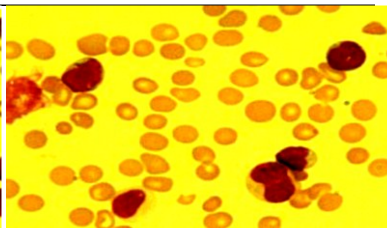
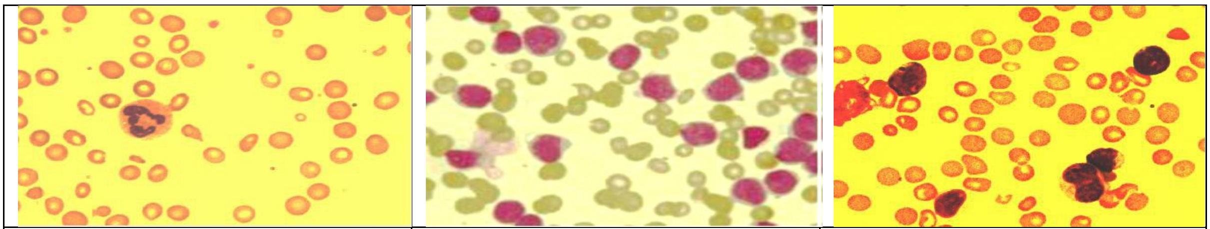
		
(a)For Sample 1	(b)For Sample 2	(c)For Sample 3

Table 2: Results of Global contrast stretching.

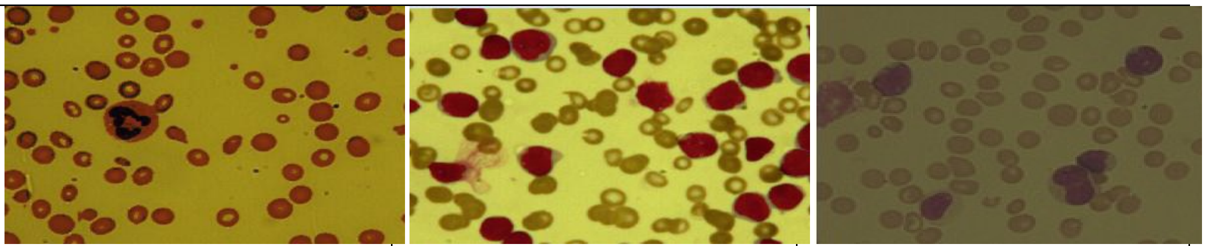
Table 3 shows the selected original leukemia images for three different types of images with the processed images after applying partial contrast method. The lower and upper threshold was chosen as 80 and 200 respectively. The desired range of the color levels for the output image is 20 to 230. These values were found to be suitable for the three different types of images. 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.



(a)For Sample 1	(b)For Sample 2	(c)For Sample 3

Table 3: Results of Partial contrast stretching

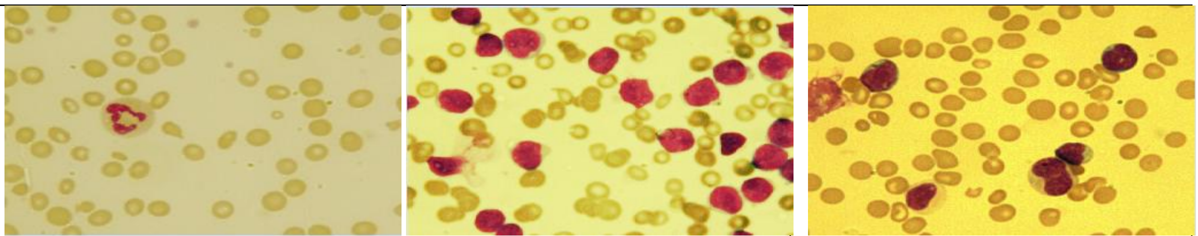
Table 4 shows results for bright stretching method that the image becomes brighter where more bright pixels are stretched towards the dark region. This way the color of the cytoplasm is enhanced. The shape of cytoplasm can be seen clearly. Besides that, the contrast was increased between the edge of 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 sample1 is 150 and the bright stretching is 100, for threshold value for sample2 is 100 and the bright stretching factors is 50. While, for threshold value for sample3 is 150 and the bright stretching factor is 200.



(a)For Sample 1	(b)For Sample 2	(c)For Sample 3

Table 4: Results of 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 sample according to the contrast and brightness level of the original leukemia images. Table 5 shows the results after dark contrast stretching. The threshold value for sample 1 is 100 and the dark stretching factor is 150, the threshold value for sample 2 is 150 and the dark stretching factors is 200. While, the threshold value for sample 3 is 100 and the bright stretching factor is 250. threshold value for sample 3 is 100 and the bright stretching factor



(a) For Sample 1	(b) For Sample 2	(c) For Sample 3

Table 5: Results of dark contrast stretching

Table 6 shows the comparison of peak signal to noise ratio of various techniques.

Method	Dark Image PSNR (dB)	Normal image PSNR (dB)	Bright image PSNR (dB)
Local Contrast	33.284	32.284	31.541
Bright Contrast	33.116	32.126	31.604
Dark Contrast	32.802	32.101	31.351
Partial Contrast	33.112	32.885	31.915

CONCLUSION

This work focus on developing image enhancement techniques designed specifically for leukemia images. All the proposed techniques are effective in enhancing the leukemia images, from those techniques the partial contrast gives the best results and hopefully could give extra information for nucleus and cytoplasm of acute leukemia image. PSNR value is more for partial contrast. Experimental results shows that the proposed techniques produce significant improvement for leukemia images that have been lead to be clearer and hopefully would use further analysis by hematologist.

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