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Spatial domain image enhancement techniques for acute myeloid leukemia (M1,M4,M5,M7)

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Article Info	ABSTRACT
	In this paper, several techniques of image enhancement spatial domain is elucidated and analyzed for the purpose of enhancing Acute Myeloid Leukemia (AML) subtype of M1, M4, M5 and M7. The techniques involved contrast stretching of greyscale images, image subtraction and image sharpening. The three methods compared with one another to achieve the highest PSNR value for the suitability technique of AML subtypes (M1, M4, M5 and M7). Firstly, subtypes images converted into grayscale. Then, each four images tested with contrast stretching techniques followed by image subtraction and image sharpening. The performances were evaluated based on Mean Square Error (MSE) and Peak Signal to Noise Ratio (PSNR). Due to its higher value obtained, image sharpening is a good enhancement techniques for Acute Myeloid Leukemia with 68.2083 dB and the lowest MSE achieved of 0.0103.

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1. INTRODUCTION

In medicinal field, medical imaging is one of the controlling apparatus for having an insight on the pathological procedures. Images that includes computer tomography (CT), magnetic resonance imaging (MRI), ultrasound and X-ray are one of the focal bases for diacrisis of diseases. The main purposes of medical image processing is to diagnose medical images more efficiently and accurately. Typically, these images are affected by noise, blurriness and other bad qualities that interrupts the quality of the image.[1][2] Thus, image enhancement techniques can improve the visual appearance of medical images especially in detecting Leukemic cell.

1.1. Leukemia

Leukemia are bone marrow cancerous cell, which involves proliferation of white blood cells that disables its main function to fight bacteria more efficiently. The blast cell are grouped by affected blood cell type called lymphocytes and myelocytes.[3] The disease also categorized by its speed of illnesses. Acute means the cells spreads fast while chronic takes time growing but do worsens over the year. Thus, Leukemia are grouped by four main types which are acute lymphocytic leukemia (*ALL*), chronic lymphocytic leukemia (*CLL*), acute myelocytic leukemia (*AML*) and chronic myelocytic leukemia (*CML*). AML type leukemia usually detected until it has spread into other organs. The cells classified by a system known as French-American British (FAB), which categorized into eight subtypes as shown in Table 1.

Table 1. French-American-British Classification [4]

FAB Subtypes	Name
M0	Undifferentiated acute myeloblastic leukemia
M1	Acute myeloblastic leukemia with minimal maturation
M2	Acute myeloblastic leukemia with maturation
M3	Acute promyelocytic leukemia (APL)
M4	Acute myelomonocytic leukemia
M4 eos	Acute myelomonocytic leukemia with eosinophilia
M5	Acute monocytic leukemia
M6	Acute erythroid leukemia
M7	Acute megakaryoblastic leukemia

In Malaysia, Myeloid type states the highest amount for both male and female as depicted in Figure 1 and Figure 2.
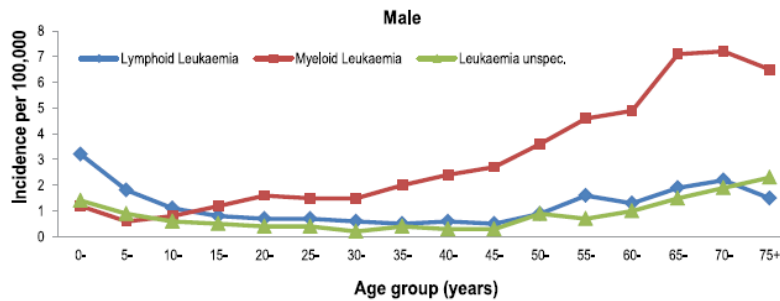

Figure 1. Leukemia types age-specific incidence rate, males, Malaysia, 2007-2011 [5]
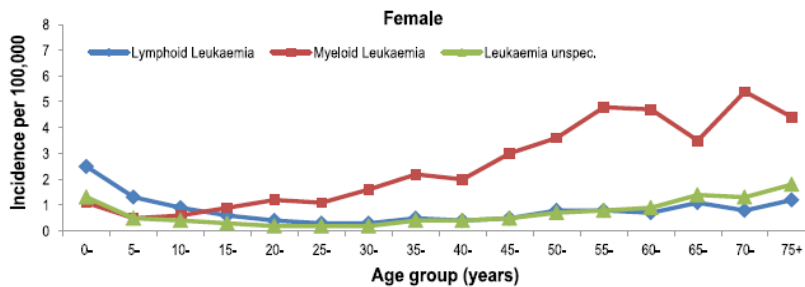

Figure 2. Leukemia types age-specific incidence rate, females, Malaysia, 2007-2011

Based on the graph, it shows that Myeloid in Malaysia is severe. Hence, alternative early diagnostic to enhance current hospitality are much needed. This is where medical image processing becomes useful for diagnosing early detection of AML subtypes.

1.2. Image Enhancement
In image processing, image enhancement is capable of improving the image's contrast for making various features to be easily recognized.[6].The role is vital in enhancing quality of medical images such as AML because the image's quality depends on the exposure of the microscope and staining process[7]. Enhancement techniques are divided into two broad categories:
a)   Spatial domain methods
b)   Frequency domain methods
Spatial domain operates on the pixel whilst frequency domain are computed in Fourier transform in order to modify the frequency content of the image so that edges and other subtle information can be enhanced [8], [9]. This paper solely focuses on spatial domain methods. The term itself works in the given space (the image). This means that the procedure works directly on pixels as shown on Figure 3.
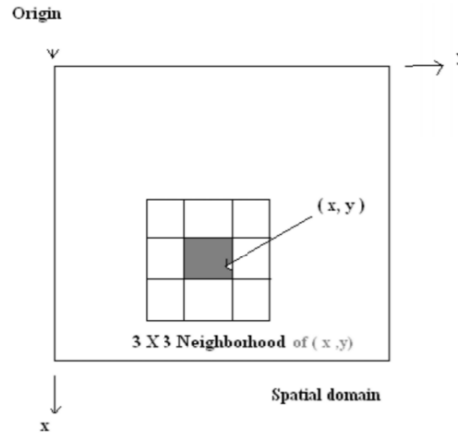
Figure 3. Spatial domain of an image [9]

Spatial domain expression are denoted by the expression,

$$g(x,y) = T[f(x,y)] \tag{1}$$

Where g(x,y) = processed image
f(x,y) = input image
    T = operator on f defined over some neighborhood of (x,y) if using (x,y)

There are many techniques that can be involved in spatial domain enhancement such as contrast stretching, image subtraction, sharpening, histogram equalization, log transformations etc… Author [8] conducted a survey on spatial domain techniques which involved point processing, Histogram stretching, Histogram equalization, sharpening filtering and many more. Based on the review, the effectiveness of each techniques becomes more effective when combined more than one method. Whilst [9] works on comparing spatial and frequency enhancement and obtained result shows that spatial domain are apt for small kernel since Fourier transform takes time. On the other hand, [10] implemented image sharpening and smoothing by filters on the particular image. The input image sharpened by using weighted kernel of different values and gives sharper image with the boundary edge information. The analyzed results performed by MSE and PSNR. Research by[6] surveys variety of contrast enhancement techniques like Histogram equalization (HE), Contrast limited Adaptive Histogram Equalization (CLAHE), Morphological enhancement on a single scale and Multiscale Morphological enhancement. Compared result of these techniques onto a synthetic image of kidney and brain shows that the Multiscale morphological approach obtained respectable results as to the results achieved with other ultramodern techniques. Moreover, [11] improves image quality by analyses contrast enhancement, sharpening and noise reduction of the dataset BSDS300 Berkely. Quantitative performance involves MSE, PSNR and SSIM, which proves that image sharpening provides decent results due to no change of information or pixel as it is close to the information of the original image.

2.   RESEARCH METHOD

This section explains the methodology of this paper. Firstly, apply input image of M1 then, the RGB image converted into greyscale. Next, implement contrast stretching on the given image. To find the performance, calculate MSE onto M1 followed by PSNR. These steps are continuous until all input images tested with contrast stretching techniques. After that, implement Image subtraction techniques onto the four images followed by Image sharpening. Finally, for each techniques, calculate the mean value of the four images as so to find which of the three enhancement techniques are apt for enhancing M1, M4, M5 and M7. Flow chart on Figure 4 depicts clearly on the explained methods.
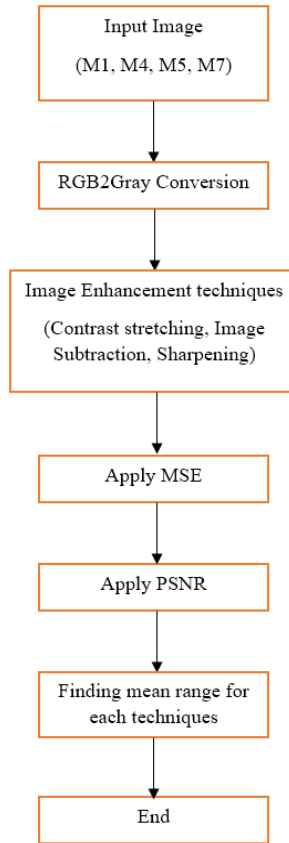
Figure 4. Overall Flowchart of the methods

Input images of M1, M4, M5 and M7 inserted according to Figure 5.
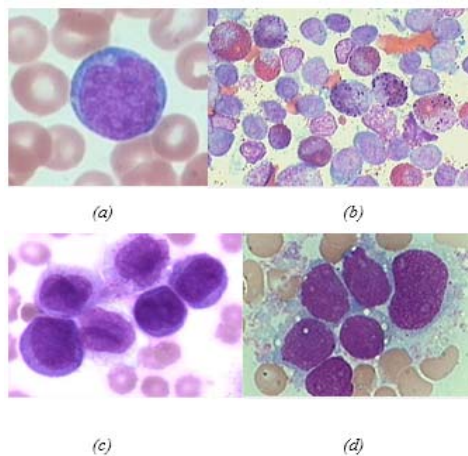

Figure 5. (a) RGB M1 (b) RGB M4 (c) RGB M5 (d) RGB M7

The RGB images convert into greyscale(Figure 6) to reduce dimension of image[12]. Also, processing becomes flexible when a single intensity value of each pixel is specified [13].
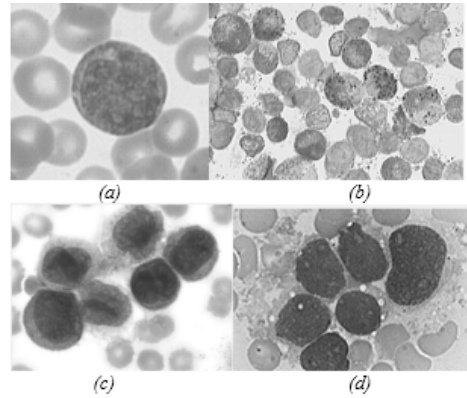
Figure 6. (a) Greyscale M1 (b) Greyscale M4 (c) Greyscale M5 (d) Greyscale M7

Contrast stretching attempts to improve the contrast of the image by stretching range of the intensity values. It changes the distribution and range of digital numbers assigned to each pixel in an image. In medical imaging, contrast stretching plays an important role for quality enhancement[14]. Figure 7 illustrates the results from stretching.
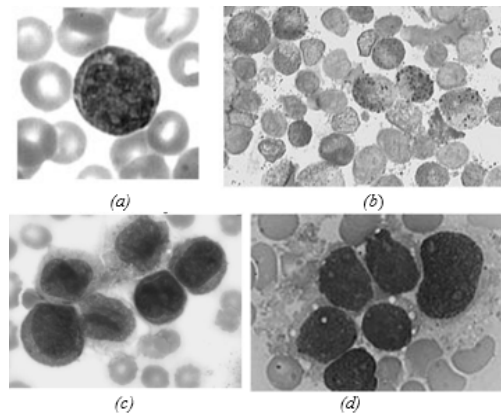

Figure 7. (a) Contrast M1 (b) Contrast M4 (c) Contrast M5 (d) Contrast M7

Image subtraction is one of the popular machine vision technique for extracting foreground objects in an image[15].It is obtained by computing the difference between all pairs of corresponding pixels from f and h

$$G(x, y) = f(x, y) - h(x, y)$$

(2)

Where   G(x,y)= Image Subtraction
                f(x,y)= Image background
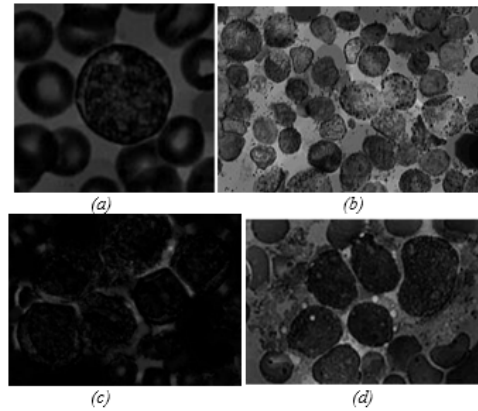   h(x,y)=Image foreground

Figure 8. (a) Subtraction M1 (b) Subtraction M4 (c) Subtraction M5 (d) Subtraction M7

The aim of sharpening in image processing is to enhance the details of an image or even line structures. The techniques designed to increase the high frequency aspects of the image. In details, sharpening contains of adding signal that is proportional to a high-pass filtered version of the original image.[11].
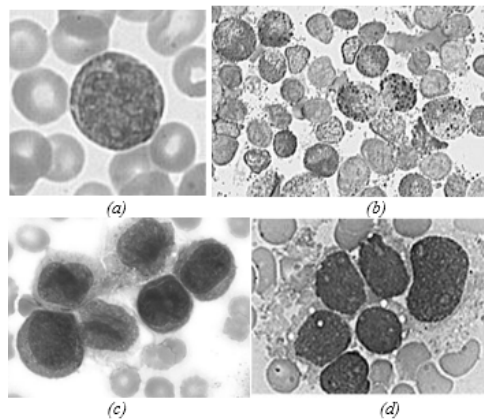

Figure 8. (a) Sharpening M1 (b) Sharpening M4 (c) Sharpening M5 (d) Sharpening M7

The images were analysed by using the Mean Squared Error(Mse) and Peeak Signal to Noise Ratio(PSNR). MSE represents the cumulative squared error between compressed image and original image [2]. The lower the MSE value, the lower the error rate.

$$MSE = \frac{\sum_{M,N} [I_1(m,n) - I_2(m,n)]^2}{M \times N}$$

(3)

Where $I_2(m, n)$= original image
 $I_1(m, n)$= output image
 M, N is the size of image

PSNR measures the peak error. It computes the peak signal-to-noise ratio in decibels between two images. The higher the PSNR value, the better the quality of the image.

$$PSNR = 10 \log_{10} \left(\frac{R^2}{MSE} \right)$$

(4)

Where $R^2 = 2n^{\eta}-1$ and n represents number of bits. In representing the pixel of the image.

3. RESULTS AND ANALYSIS

After the MSE and PSNR have calculated, the results are tabulated as shown on Table 2, Table 3 and Table 4.

Table 2. Results on Contrast Stretching

Subtypes	MSE	PSNR dB
M1	0.0240	64.3290
M4	0.0006,	70.1579
M5	0.0256	64.0474
M7	0.0240	64.3246

Table 3. Results on Image Subtraction

Subtypes	MSE	PSNR dB
M1	0.3831	52.2981
M4	0.1879	55.3914
M5	0.5163	51.0017
M7	0.1894	55.3580

Table 4. Results on Image Sharpening

Subtypes	MSE	PSNR dB
M1	0.0060	70.3261
M4	0.0133	66.9005
M5	0.0096	68.2993
M7	0.0121	67.3073

Since the aim of this paper is to analyze and select which techniques is apt in enhancing AML subtype, a mean value of each techniques are calculated. To find the mean, total value of MSE and PSNR are divided over the number of subtypes. As shown on equation 4.

$$mean = \frac{M1 \oplus M4 \oplus M5 \oplus M7}{4}$$

(5)

Table 5. Mean values for Image Enhancement Techniques

Enhancement Techniques	MSE	PSNR dB
Contrast Enhancement	0.0186	65.7147
Image Subtraction	0.3192	53.5123
Image Sharpening	0.0103	68.2083

As shown on Table 5, the results of mean values have tabulated. According to the result, Image sharpening achieved the highest PSNR of 68.2083 dB. Hence, it shows good quality for enhancing AML subtypes M1, M4, M5, and M7. The technique agreed with [11] as the author also achieved image sharpening as a good result compared to other techniques.

4. CONCLUSION

Concisely, this paper is about experimenting on various image enhancement techniques such as contrast stretching, image subtraction and image sharpening. These techniques tested on AML subtype M1, M4, M5 and M7. Enhancing medical images is essential as it helps to improve the quality of the image. Performance analysis such as MSE and PSNR helps to analyze the tested techniques. Since a high PSNR value means a better quality of the particular image, Image sharpening shows good quality out of the other two techniques with a value of 68.2083 dB. Future work is to test the performance of these images with other image quality measurement such as SSIM, F1 score or even profiling time performance.

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