Colour Image Enhancement using Bright and Dark Stretching Techniques for Tissue based Tuberculosis Bacilli Detection

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***Abstract*- Tuberculosis is a serious disease caused by infection with the germ *Mycobacterium tuberculosis.* Sputum sample analysis is a common method for TB bacilli detection. In some cases, tissue from the suspected system is also obtained using bronchoscope or fine needle aspiration for diagnosis. The Ziehl-Neelsen stain or acid-fast stain is a special stain used to identify the TB bacilli. The preparation of Ziehl-Neelsen slides require several procedures and the slide should be analysed under microscope. There are some factors that may degrade the image quality such as exposure and staining problems. Therefore, image enhancements are necessary to produce fine images in term of contrast and intensity. This paper proposes two methods for colour image enhancement; bright stretching and dark stretching algorithms. Both methods are well known to produce good image enhancement for gray scale images. However, the current study has adapted these methods to be used for colour images. Although the adapted image processing technique is quite simple, the results indicate that these methods may have some potential to be used for improving the quality of Ziehl-Neelsen slide images. The results show that both techniques were successfully improved the image contrast and enhance the image quality.**

***Keywords* - Colour image enhancement, TB bacilli detection, tissue section, bright stretching, dark stretching.**

I. INTRODUCTION

Tuberculosis, commonly known as TB is a serious disease caused by infection of microbacteria called *Mycobacterium tuberculosis.* Even though TB can be successfully treated with specific antibiotics taken for certain duration, it continues to kill people every day. It has become one of the most frequent causes of mortality by communicable disease around the world after HIV/AIDS. According to the World Health Organization (WHO) report in 2007 [1] an estimate of two billion people or one-third of world's population is infected with the bacteria that causes TB, 9 million cases per year and 1.7 million deaths from the disease. Currently in Malaysia, an average of 16 000 new TB cases is reported yearly with notification rate of 62-63/100,000 population and mortality of 5.4/100,000 population [2]. An overview of annual national TB incidence also indicates that there has been no drastic reduction in the notification rates over the last 20 years [3].

With the large number of cases diagnosed over the year, one of the key to control the disease is through early detection and accurate diagnostic techniques. Currently, the identification of tuberculosis is performed manually by microbiologist or pathologist through visual identification of TB bacilli in sputum or tissue section. However, there are some problem associated with the manual screening process for TB slides, such as time consuming and labor-intensive [4]. It has been estimated that for the experienced technologists, it takes about 15 to 20 minutes to read and confirm one negative slide.

In a day, an optimum of about 25 slides can be read by a technologist. Mass screening for the foreign worker and increase in the incidence of TB cases recently makes the need for the faster and accurate automated screening system.

Recent developments in computer hardware, software and algorithms have led to the investigation of new approaches to the TB diagnostic problem. Several studies have also been done to detect TB disease from sputum samples.

Veropoulos et al. [4] proposed a neural network method to classify the sputum samples. Shape descriptions based on Fourier coefficients were calculated in feature extraction. MLP network trained by backproporgation algorithm was used to train 1000 samples in recognition stage. Overall performance indicates that the system has achieved recognition rate of up to 97.9% for 147 test samples. Similar studies on computer assisted TB bacteria detection based on sputum can be found in [5]. However, all these works used grey level image processing techniques to extract the TB bacteria features. In the actual screening process by microbiologists, the screening process is performed on stained slide based on Ziehl-Neelsen method where the TB bacteria

are detected based on colour and shape. However, the use of grey level image causes the features that are based on colour will be lost.

To overcome the problem, identification of TB bacilli based on shape and colour were proposed in [6-8]. However, the availability of the colour image processing algorithms is quite limited. Therefore, the current study aims to improve colour image enhancement. Those algorithms will be specially formulated and optimized to be used in TB bacteria automated diagnostic system.

The current literature also found that very little research has been carried out to analyse the TB bacilli in tissue section [9, 10]. Identification of TB bacilli in tissue section is more challenging since the presence of TB bacilli in sputum is more obvious with less complex background compared to TB bacilli in tissue. In order to address the issues discussed above, the current study focuses on TB diagnostic system based on tissue samples.

II. METHODOLOGY

The research methodology involves the following key tasks:

A. Image Acquisition

The Ziehl-Neelsen slide images for tissue section were analysed using Leica microscope at 40x magnification. Then, Infinity 2 camera was used to capture images and saved into bitmap (*.bmp) format with the resolution of 800x600.

B. Image Enhancement Using Contrast Stretching

Some major difficulties faced in image processing are contrast and brightness problems [10]. To overcome these, image enhancement is employed to increase the contrast of an image. In general, an image can be enhanced by spreading the range of colour values to make use of all possible values. This method is called contrast stretching. It changes the distribution and range of the digital numbers assigned to each pixel in an image. This is normally done to accent image details that may be difficult for the human viewer to observe. Two types of contrast stretching method, bright and dark stretching have been utilised for colour image enhancement.

1. Bright Stretching

In general, bright stretching method is based on linear mapping function used to enhance the brightness and contrast level of the images. Consider the mapping function as given in [11]:

$$P_{new} = \frac{(P_{in}-min)}{(max-min)}(f_{max} - f_{min}) + f_{min} \qquad [1]$$

where
P_{new} : new pixel color level
P_{in} : input pixel color level
min : lowest pixel value in the image
max : highest pixel value in the image
f_{min} : minimum value of desired range
f_{max} : maximum value of desired range

For bright stretching method, Equation 1 can be futher interprated as follows:

$$P_{new} = \begin{cases} \frac{P_{in}-min}{TH-min} \times SF_b & if\ P_{in} < TH \\ \frac{(P_{in}-TH)}{(max-TH)}(255 - SF_b) + SF_b & if\ P_{in} \geq TH \end{cases} \qquad [2]$$

where TH and SF_b are the threshold value and the bright stretching factor respectively. Referring to Equation 2, the process tends to compress the range of image value which is less than the threshold value. On the other side, it expands the range of image values which are greater than the threshold value. Figure 1 illustrates the bright stretching process.

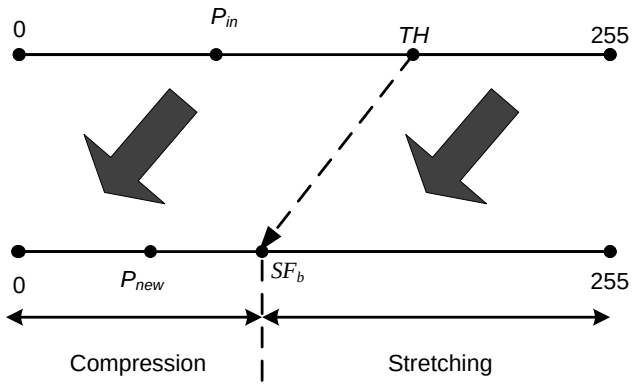


Fig. 1. Bright stretching process

2. Dark Stretching

Dark stretching is a reverse process of bright stretching process. The equation for dark stretching is defined by:

$$P_{new} = \begin{cases} \frac{P_{in}-min}{TH-min} \times SF_d & if\ P_{in} < TH \\ \frac{(P_{in}-TH)}{(max-TH)}(255 - SF_d) + SF_d & if\ P_{in} \geq TH \end{cases} \qquad [3]$$

where TH and SF_d are the threshold value and the dark stretching factor respectively. Referring to Equation 3, the process tends to stretch the range of image value which is less than the threshold value. On the other side, it compresses the range of image values which are greater than the threshold value. Figure 2 illustrates the dark stretching process.

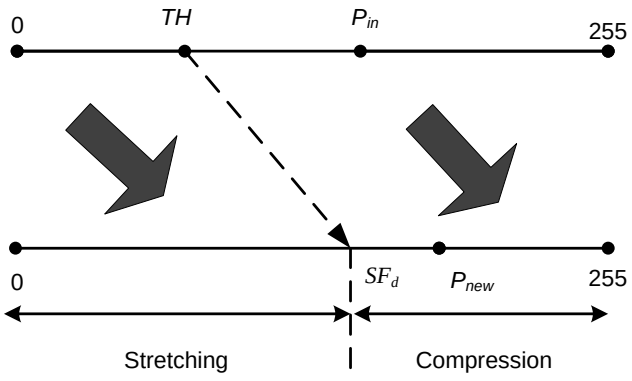


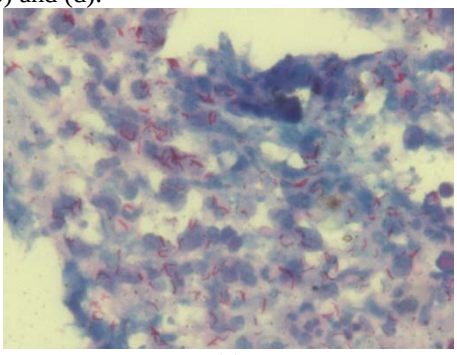
Fig. 2. Dark stretching process

III. RESULTS AND DISCUSSION

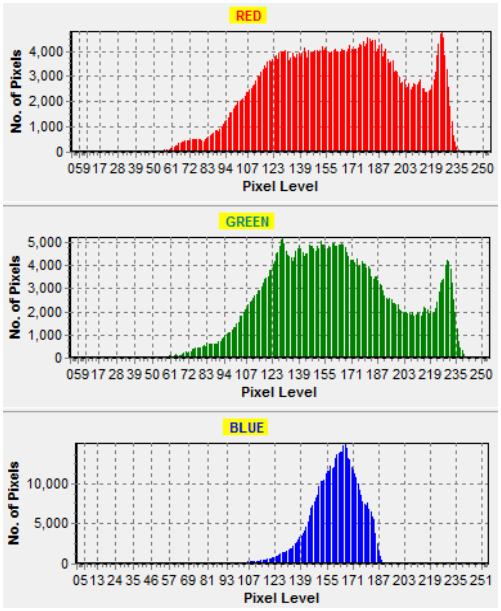
Exposure of a microscope and staining are some factors that influence the image quality. Understaining of slides and overexposure setting will lead to produce bright images. On the other hands, overstaining of slide and underexposure setting will produce a dark image.

Histograms can be used to identify the bright and dark images. In general, an image with its histogram clustered at the high end corresponds to bright image, while an image with its histogram clustered at the low end corresponds to dark image [12]. Figure 3 shows an example of bright images and its corresponding histograms, while Figure 4 shows the dark images and its histogram.

Figure 4 shows bright images and resultant images after applying bright stretching. Both *TH* and SF_b values are chosen manually according to the brightness level of original image. Since the dominant spectral for TB bacilli is red, the *TH* value was selected based on the minimum intensity of red colour in the pixel consist of TB bacilli. The SF_b value should be smaller than *TH*. On average, 20-40 intensity difference from *TH* value is adequate to improve the image contrast. Bright stretching stretched the higher range of intensity and compressed the lower range of intensity. As a result, the presences of TB bacilli became more obvious as shown in Figure 4 (b) and (d).

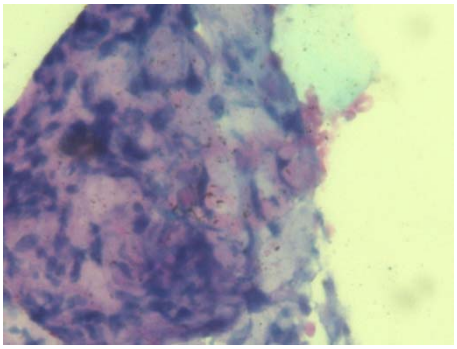


(a)

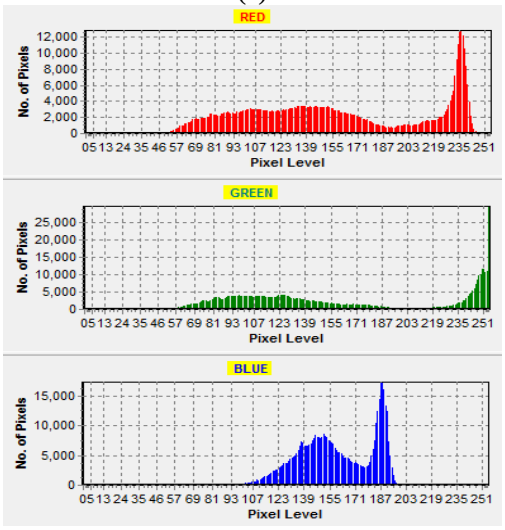


(b)

Fig. 3. (a) Bright image and (b) its histogram



(a)



(b)

Fig. 4. (a) Dark image and (b) its histogram

Figure 5 shows example of dark images and the results after applying dark stretching. Similar to bright stretching method, both *TH* and SF_d values are chosen manually according to the brightness level of original image. The *TH* value was chosen based on the highest intensity of red colour in the pixel consist of TB bacilli. The SF_d value should be greater than *TH*, with 20-40 intensity difference from *TH* value is adequate to improve the image contrast. Dark stretching stretched the lower range of intensity while compressed the higher range of intensity. As a result, the presences of TB bacilli became more obvious as shown in Figure 5(b) and (d).

IV. CONCLUSION

A method for image enhancement of colour images by using bright and dark stretching techniques have been presented. Bright stretching method was used to enhance bright image while dark stretching for dark image. The results yielded by the proposed techniques are acceptable in term of visual quality.

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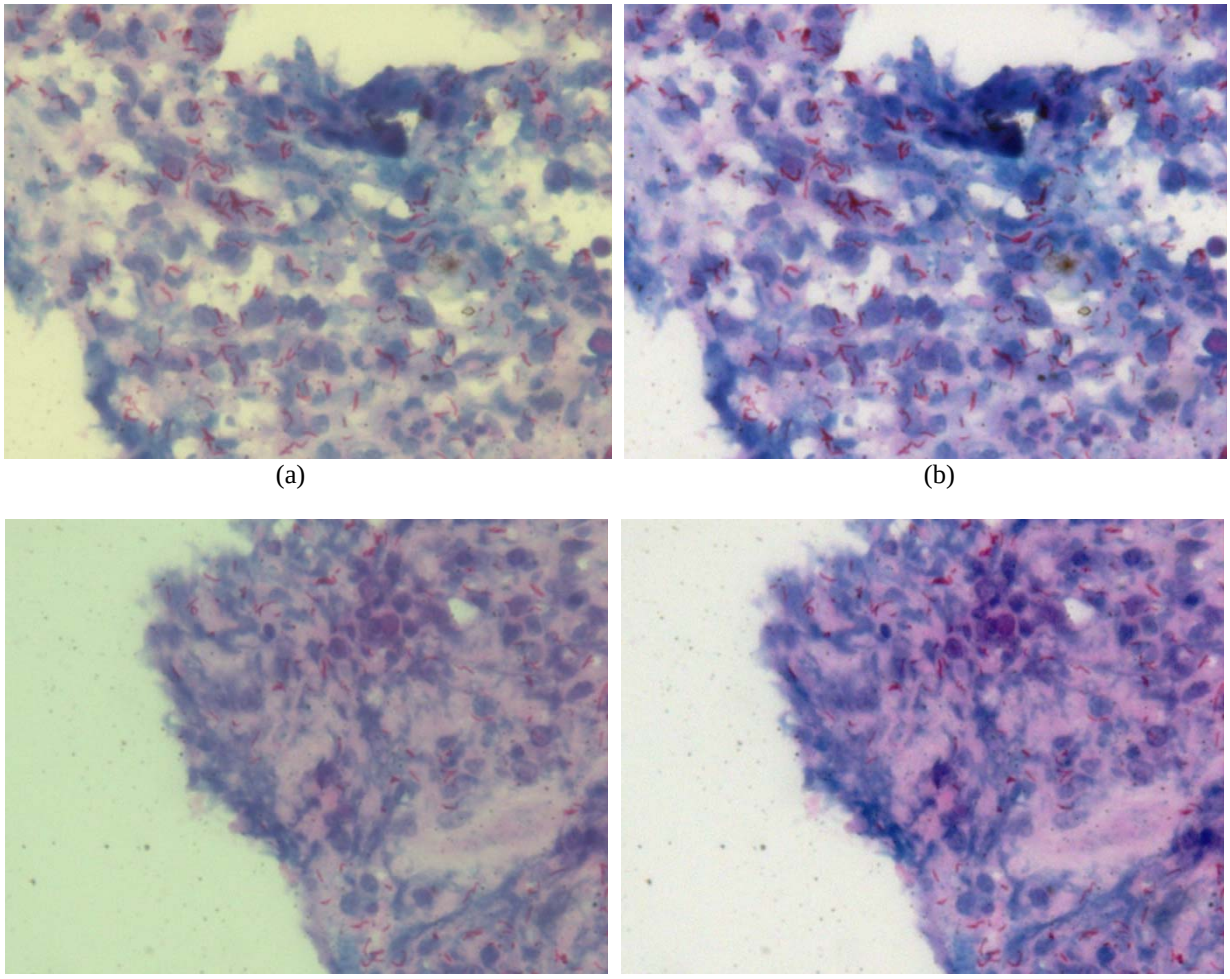
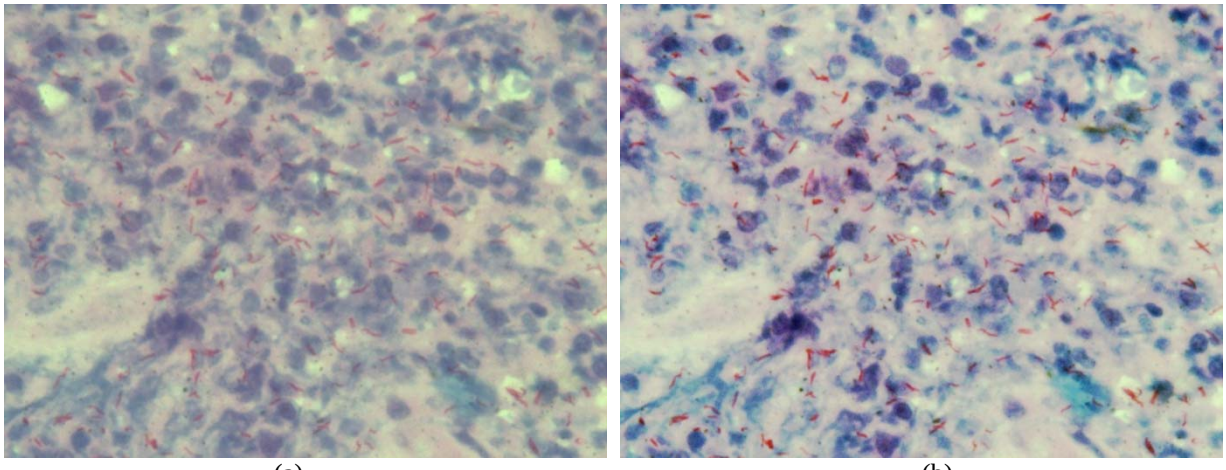


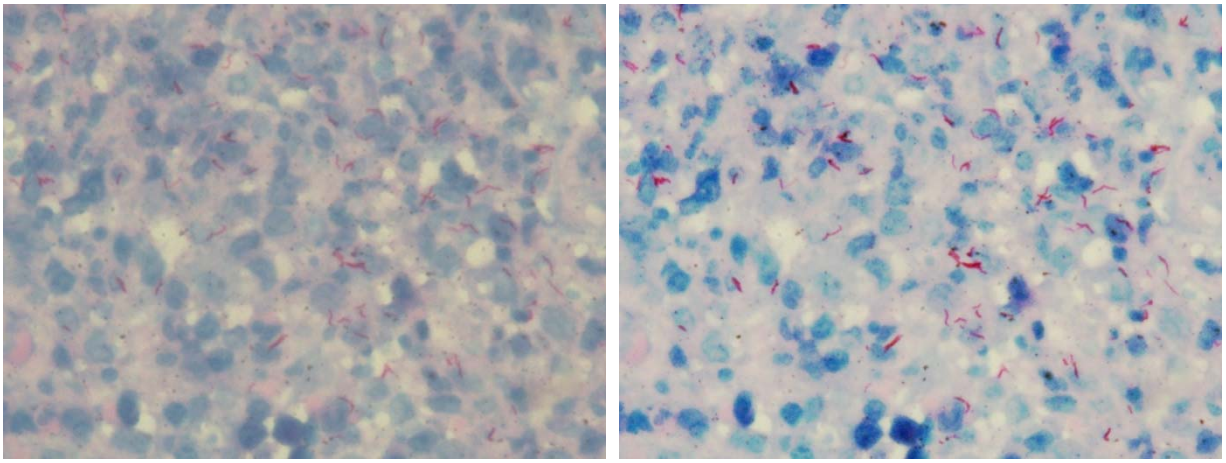
(a) (b)

(c) (d)

Fig. 4. Enhancement results of TB tissue slide images (a) Original bright image (b) Result after applying bright stretching (TH = 100, SF_b = 70) (c) Original bright image and (d) Result after applying bright stretching (TH = 100, SF_b = 80)



(a) (b)



(c) (d)

Fig. 5. Enhancement results of TB tissue slide images (a) Original dark image (b) Result after applying dark stretching (*TH* = 150, SF_d = 170) (c) Original dark image and (d) Result after applying dark stretching (*TH* = 150, SF_d = 175).