IOP Conference Series: Materials Science and Engineering

PAPER • **OPEN ACCESS**

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To cite this article: Aeri Rachmad *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **546** 052061

Image Enhancement Sputum Containing Mycobacterium Tuberculosis Using A Spatial Domain Filter

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Abstract. Image enhancement sputum is needed to identify bacteria mycobacterium tuberculosis (TB). The number of TB bacteria in sputum images determines the severity of tuberculosis sufferers. In this paper, we study image enhancement sputum techniques by using spatial domain filter-based methods such as median filtering, Gaussian filtering, adaptive noise-removal filtering and bilateral filtering. These filtering techniques are used to overcome the problems when taking sputum images such as adjusting the focus of the lens, lighting and dirt that stick to the lens and on the slide glass. The obtained results for 100 data sputum images from this study are average means square error (MSE) of median filtering, Gaussian filtering, adaptive noise-removal filtering and bilateral filtering, i.e., 30.68, 17.10, 18.92 and 26.28, respectively. Also, average peak signal-to-noise ratio (PSNR) of them are 33.70 dB, 35.91 dB, 35.59 dB and 34.01 dB, respectively. The avarage computational time are 0.09 sec, 0.18 sec, 0.38 sec and 134 sec respectively.

Keywords: image enhancement, sputum, mycobacterium tuberculosis, spatial domain filter.

1. Introduction

The technological development of digital image processing today is very fast. In the world of processing health as in microscopic bacteria, a method is needed to clarify or detect the desired object or target [1]. To see bacteria, an enlargement device is needed such as a microscope. Taking microscopic images must be done carefully, so that the object taken is clearly visible. the lack of clarity of an object can cause problems that can affect the outcome of the decision and will affect the analysis. Then a variety of image processing techniques are needed to obtain the ideal image [2].

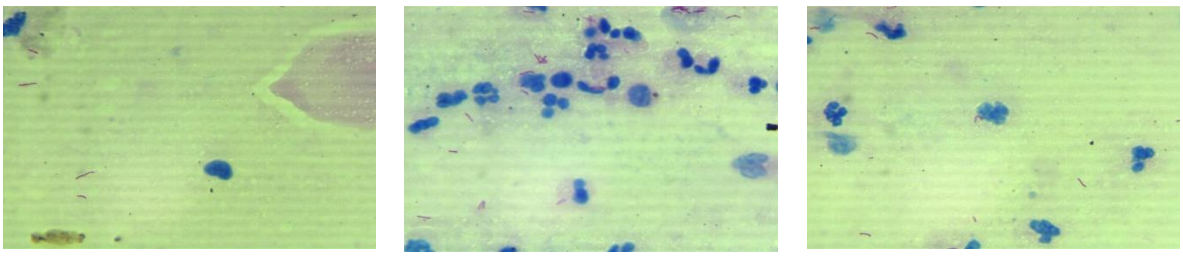
TB is one of the main causes of death in developing countries [3]. India is the country with the most population contracting tuberculosis by 23%, followed by China and Indonesia at 10% of all sufferers in the world [4]. TB is caused by TB germs that can be transmitted directly. TB bacteria mostly attack the lungs, but these germs can also infect other organs such as the brain, kidneys, bones and skin [2]. Germ TB is a type of germ (bacillus) stem with a length ranging from 1 - 4 mm with a thickness of 0, 3 - 0, 6 mm [5]. The shape and size of the TB germs are not uniform, have different lengths and thicknesses [6]. With today's technological advances, phlegm image images containing TB germs can be known automatically using computers that use digital image processing. This is very helpful in the medical world in calculating the number of TB germs in one field of view. On sputum sample slides can have more than 100 fields of view [7]. The level of TB patients can be seen from the number of germs in several fields of view. So that the doctor can provide the right treatment recommendations according to the dose.

Images of germs obtained need to be improved on the image to get maximum results. This is caused by lighting, lens cleanliness, thickness of the smear on the preparation or slide or the distance of the lens to the object which is less focused. Image improvement is based on the level of focus of the image using the Gaussian derivative, variance of the log-histogram, and energy of the image Laplacian [6]. Several image repair methods have been done such as Foreroa's Adaptive Color Threresholding method in 2004, gray thresholding by Raof in 2008.

In this study, researchers will use image repair techniques using the spatial doman filtering such as Gaussian fiter, Median filter, Adaptive Noise Removal Filer and bilateral filter in TB cases. This filter is used in sputum images containing TB bacteria. This is done so that the TB bacteria will be clearly visible. on the image repair process. This level of clarity will help doctors in their observation.

2. Methodology

An enhancement technique is a heuristic way to change an image so that the farm is better when viewed by the human eye. This enhancement technique can be exemplified as changing brightness (brightening stretching), eliminating image blurring (inverse process). This image enhancement technique is carried out because of noise or noise. Noise on phlegm imagery can occur due to several factors such as lighting, the resolution of the camera, and the lens or slides that are dirty due to dust as shown in Figure1 taken from http://14.139.240.55/znsm.



(a) (b) (c)

Figure 1. Images of sputum that have been given Ziehl Nielsen coloring with a size of 800x600 pixels (a) Noise due to lighting (b) Noise due to camera Resolution (c) Noise due to dust.

Noise can interfere with the segmentation process so that it affects the results of identification and classification. Based on that condition, we need a method to reduce noise in sputum images containing TB bacteria. This noise reduction is the most important thing before proceeding to the next process. There are several ways to reduce noise by using spatial domain filtering such as Median Filtering, Gaussian Filtering, Adaptive Noise Filtering and Bilateral Filtering. The following is a system design to improve sputum image seen in Figure 2.

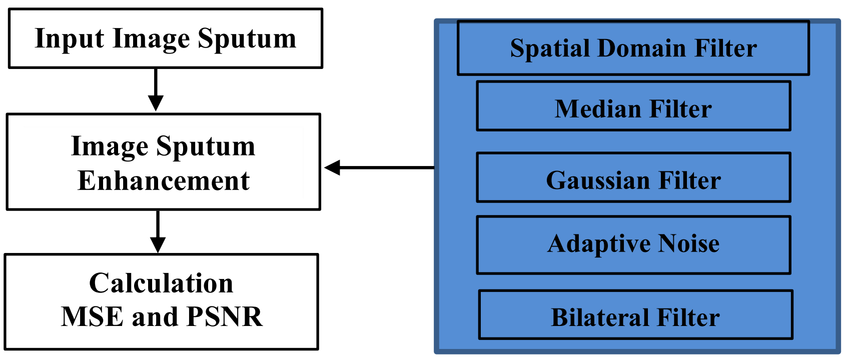


Figure 2. System Design.

2.1. Median Filtering
The median filter method is a non-linear filter that has been developed by Tukey. This method aims to reduce noise and smooth the image [8]. Median is the middle value of an odd number of data sets [9]. The median filter process is carried out by ascending the intensity of a group of pixels. After the calculated median value is calculated, this value will replace the value in the center of the windows field or filter. Below is the example of a median filter with a 3x3 dimension matrix containing the main pixels and pixels surrounding it as seen Figure 3 [10] [11]:

100	75	90
85	120	50
88	95	65

Figure 3. Matrix for median filtering.

The above matrix values will be sorted first in the form of a one-dimensional matrix or 1x9 as shown in Figure 4.

50	65	75	85	88	90	95	100	120

Figure 4. Matrix for median filtering after being sorted.

From the 1x9 matrix above, the pixel value is sorted ascending to produce the following values: 50, 65, 75, 85, 88, 90, 95, 100, 120. The median value lies in the position of the 5th matrix with the value 88. This median value will replace the center value of the 3x3 matrix, so the value of 120 will be replaced by 88.

2.2. Gaussian Filtering
Gaussian filtering is the result of convolution operations, where the weighting value for each member is chosen based on the form of the Gaussian Function. Multiplication operation in Gaussian filtering is multiplication between kernel matrix and original image matrix [12]. The following is the gaussian filter formula:

$$\mathrm{G(i, j)} = c.e^{-\frac{(i-u)^2-(j-v)^2}{2\sigma^2}} \tag{1}$$

Where :

c = constants; with c = $\frac{1}{2\pi\sigma^2}$

G (i,j) = kernel matrix gauss element in position (i,j)

(u,v) = middle index of the gauss kernel matrix

σ = the standard deviation at the center of pixels (x,y) with the largest weight 1

2.3. Adaptive Noise Removal Filtering
Wiener2 is a 2D noise removal provider that applies wiener filters to adaptive images that adjust local image variants. Adaptive filter is more selective than comparable linear filters that is keeping edges and freaking high on an image [13]. This method is most suitable for removing Gaussian noise [14]. This filter will make an image that at first there are dots of noise to be reduced and the image will appear more clearly. The image according to Niblack (1986) is described as processing images by a computer, the back also added that the results of processing this image are also an image. [15]. In the Wiener orthogonality principle, the filters in the Fourier domain can be stated as follows [16]:

$$W(f_1,f_2) = \frac{H*(f_1,f_2)S_{xx}(f_1,f_2)}{|H(f_1,f_2)|^2+S_{nn},(f_1,f_2)'} \tag{2}$$

Where $S_{xx}(f_1, f_2)$) is the original image power spectrum
$S_{nn}(f_1, f_2)$) is a noise additive
$H(f_1, f_2)|^2$ is a blurring filter

2.4. Bilateral Filtering

In 1998 Tomasi and Manduchi proposed the bilateral filter method as a non-iterative method for edge-preserving smoothing filters, smoothing and noise reduction [17]. The method works to replace the intensity value of each pixel in an image with the average pixel intensity value of the nearest pixel. In this method, weight does not depend on Euclidian distance but n color intensity [18].

$$BF[I]_p = \frac{1}{W_p} \sum_{q \in s} G_{\sigma_s}(||p-q||) G_{\sigma_r}(|I_p - I_q|) I_q \quad (3)$$

$$W_p = \sum_{q \in s} G_{\sigma_s}(||p-q||) G_{\sigma_r}(|I_p - I_q|) \quad (4)$$

Where :
σs and σr = Parameters that determine the amount of filtering for image I
$G_{\sigma s}$ = Spatial
$G_{\sigma r}$ = Gaussian range which reduces the effect of pixels q when the intensity value is different from Ip.
(q∈s) = The total number of pixels of the image indexed by q.
|| p - q || = Euclidean distance between pixel locations p and q.

2.5. Mean Squre Error

MSE (Mean Square Error) is an error value of the average square between the original image results and processed images [11]. Obtaining the MSE value is done by comparing the resulting image value to the pixel position which is the same as the difference in the pixel of the original image [8].

$$MSE = \frac{1}{mn} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} (I(i,j) - K(i,j))^2 \quad (5)$$

Where :
I = original image
K = the image after the filter process
m = number of lines in the original image
n = number of columns in original image

2.6. Peak Signal-to-noise Ratio

PSNR (Peak Signal to Noise Ratio) is a value that is used to determine the quality of the reconstruction of an image. PSNR is expressed in units of decibels (dB) in the form of logarithms [8] [19]. The image quality will be assessed from the size of the PSNR value, the smaller the PSNR value, the worse the image produced [12] [20].

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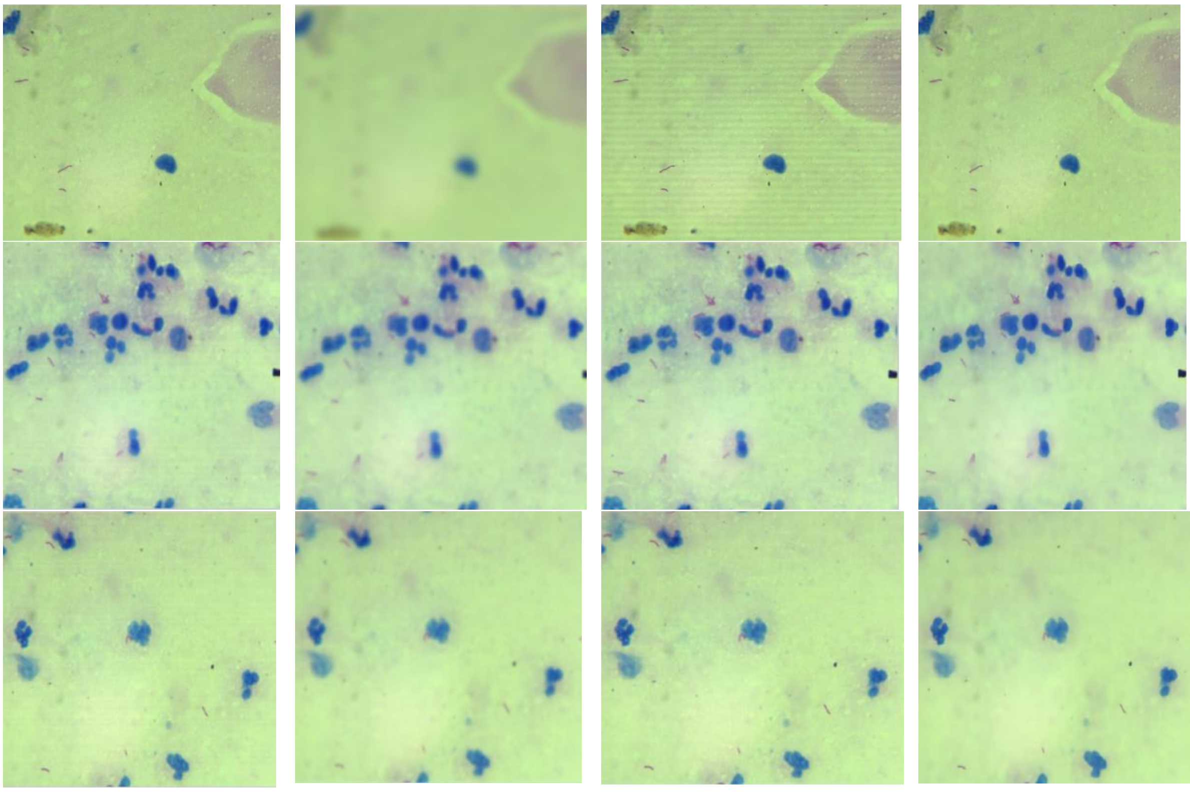
$$PSNR = 10 log_{10} \left(\frac{MAX_i^2}{MSE}\right) \quad (6)$$

MAX_i is The maximum pixel value in the Original image

3. Result and Analysis

The trials in this study used 100 data examples of sputum images that had been given Ziehl Neilsen coloring. The color image data has a size of 800 x 600 pixels. Image improvement method used in this study uses spatial domain filters that have noise reducing properties such as Median filters, Gaussian filters, Adaptive Noise Removal filters and Bilateral filters.

IOP Conf. Series: Materials Science and Engineering **546** (2019) 052061 doi:10.1088/1757-899X/546/5/052061



Median Filter | Gaussian Fiter | Adaptive Noise Removal Filter | Bilateral Filter

Figure 5. The result of image repair experiments with spatial domain filter.

Based on Figure 5, at a glance, the filtering results of the median filter method, the Gaussian filter, the adaptive noise removal filter and the bilateral filter look the same, but when they are viewed carefully the MSE results in table 3 show different results. If the maximum filter window is added to the PSNR result, the higher it means the bilateral method's filtering results are better than the median filter method, the Gaussian filter and adaptive noise removal filter. The results can be seen in Table 3, bilateral filter results, images of 100 data sputum with MSE results averaged = 26.28, median filter results with MSE average = 30.68, Gaussian filter results with average MSE = 17.10 and results adaptive noise removal filter with an average MSE = 18.92.

Table 1. The Comparison of Average MSE and PSNR value in the sputm images

Average	Median Filter (dB)	Gaussian Filter (dB)	Adaptive Noise Removal Filter (dB)	Bilateral Filter (dB)
MSE	30.68	17.10	18.92	26.28
PSNR	33.51	35.91	35.59	34.01

In the Table 3 show that the highest PSNR value is the best value, because the value of PSNR is obtained from the value of filtered image quality compared to the value of the quality of the original image that is noisy. So, the lower the signal to noise ratio, the greater the PSNR value. Based on Table 3 above, the Gaussian filter has the highest average value of 35.91 dB of all the other three filtering methods. Those three filtering methods are 35.59 dB bilateral filter, 34.01 dB bilateral filter, and 33.51 dB Median filter. High PSNR value not certainly produces the best image in visual vision. In Figure 6 shows the median filter method has a fast computation time of 0.09 seconds followed by a 0.18 second Gaussian filter, Adaptive Noise Removal filter of 0.38 seconds and Bilateral filter of 134 seconds.

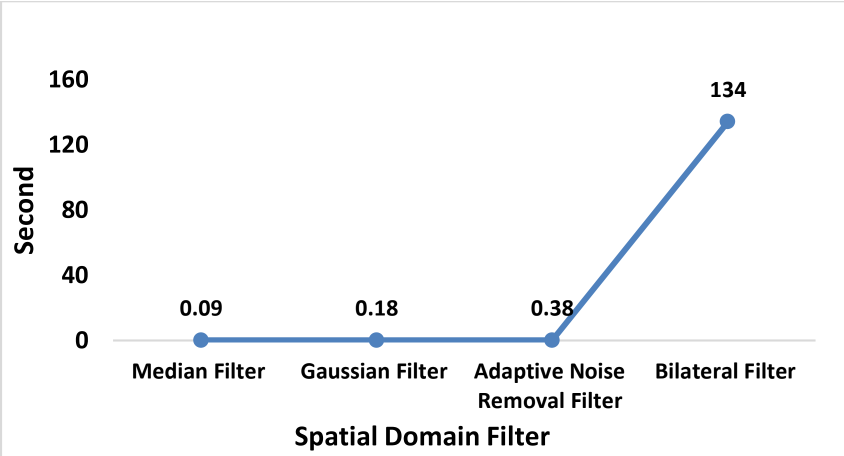


Figure 6. Average time needed in filtering techniques.

4. Conclusion

From the conducted experiments, based on the values of MSE and PSNR, we conclude that Gaussian filtering is the best technique in spatial domain filter-based of image enhancement sputum. But visually the median filter method shows results that are more tangible and clearly visible. In addition, the median filter method has the fastest computation than other filter methods.

Of the 100 data sputum images, the value of MSE and PSNR was used to measure the level of quality of reconstruction from the image of TB sputum. The higher the MSE value, the better for image quality is. While the greater the PSNR value, the better the image.

5. Acknowledgment

We would like to thank the Faculty of Sciences and Technology for funding the international BASIC seminar in 2019 at Malang Brawijaya University.

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