



DETECTION OF SPUTUM SMEAR CELL BASED ON IMAGE PROCESSING ANALYSIS

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ABSTRACT

Sputum is a liquid substance or mucus produced in the lungs and in the airways leading to the lungs. Sputum can be categorized in a type of bloody that often found in tuberculosis (hemoptysis), rusty colored where it can be found in pneumonia, purulent, foamy white and frothy pink. A patient suspected having respiratory infection could be examined by sputum diagnosis. Pulmonary infection is the most cases for the respiratory infection and it can cause of morbidity and mortality. Sputum sample that contain of pus cells, squamous cells, gram-positive and gram-negative organisms are usually examines by microbiology technologist using visualize inspection through microscope image. It is less practical to examine the huge sample of sputum by manually visualizing image under the microscope. Hence, it is crucial to introduce an automatic system using image processing technique where it can overcome the inefficient practice of examine the sputum sample. In this paper we proposed an image processing technique to detect the types of cells in sputum smear. The image processing methods used to analyze the cells are color, morphology, image arithmetic operation, K-Mean clustering and thresholding technique. The sputum image has been tested for the cell detection where we obtained more than 95% detection of squamous cell.

Keywords: sputum, color, morphology, K-Mean clustering.

INTRODUCTION

Sputum is usually used for microbiological examinations of respiratory infections. One of the respiratory infections is pulmonary infection and it becomes the most common causes of morbidity and mortality. It is important to have a good quality of sputum so that the diseases such as *Moraxella catarrhalis*, *Mycobacterium tuberculosis*, *Streptococcus pneumoniae* and *Haemophilus influenzae* can be detected. Good quality sputum is obtained when it is cough up from the lower respiratory tract (LRT) (Miriam *et al.* 1998). In sputum sample, it contains pus cells (neutrophils), squamous epithelial cells (SEC), gram-positive and gram-negative organisms. Technologist in microbiology lab will examine the characteristics of cell based on color, shape, edge and size. Figure-1 shown the sputum samples that consists of PUS Cell, SEC, gram-positive and gram negative under the 10x magnification of microscope. Meanwhile in Figure-2 and 3 shown the individual cell of SEC and Pus Cell, gram positive and gram negative. All types of sputum have its own criteria such as color, shape, size as well as edge.

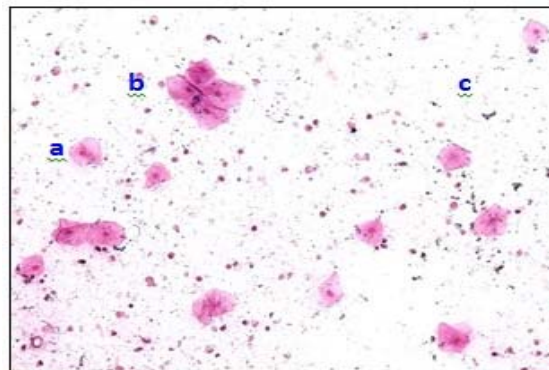


Figure-1. Sputum image under 10x magnification power
a) Squamous epithelial cells b) Pus cells c) Bacteria (gram-positive and gram-negative organisms).

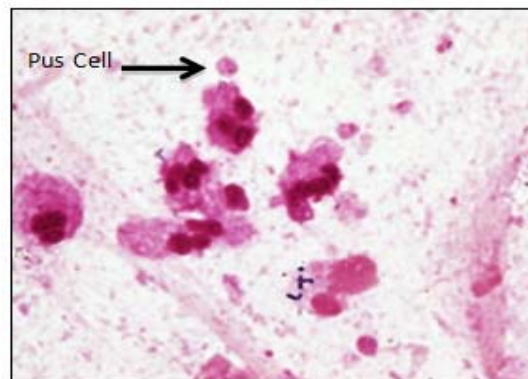


Figure-2. Pus cell image under 100x magnification power.

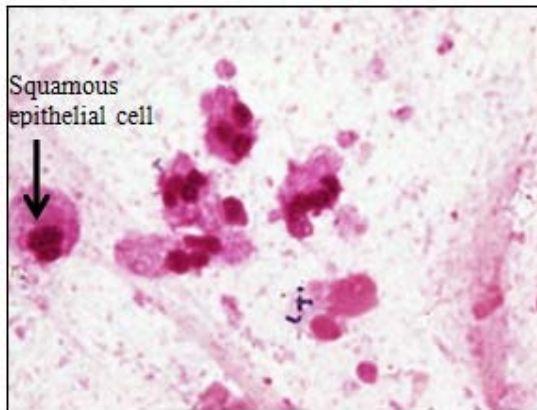


Figure-3. Squamous epithelial cell image under 100x magnification power.

Manually examine the sputum cell by using microscope image is known to be very tedious. The lab technologist need to observe and finding the SEC and Pus Cell carefully and do the counting of the cell. This procedure is not practical whenever huge data need to be examined by lab technologist. Since human might have eye drowsiness and fatigue while doing the examination, it appears as disadvantages in terms of time consuming and human being factors. Thus, a detection and summation system based on image processing needs to be developed to improve efficiency of detection. So, it can speed up and smooth the process of cell examination. In this paper, we focus our study to analyze sputum cell type SEC and Pus Cell. Meanwhile, the gram-positive and gram-negative have been studied by Rosyati *et al.* (Rosyati Hamid, 2013).

RECENT WORKS

Examination of sputum culture is a routine procedure for evaluating patients with acute pneumonia. Aim of the sputum culture is to detect diseases relates to the lung. Culturing process requires high cost and takes time to be performed. Morris *et al.* have calculated the cost and time saving by analysing seven tests and procedure that when eliminated or controlled will results in reductions in reagent cost and time consuming. In his study (Arthur J. Morris, 1996), over one year period, 5181 test and 5218 broth cultures could have been eliminated as it will saving almost \$28,000 and time saving exceeded 1000 hours. Rejection criteria which have been made to the seven tests prevented approximately \$200,000 in patient charges. Therefore it is important to apply a rejection criteria or quality testing before undergo culturing process. In previous studies, there are six different criteria for judging the acceptability of sputum specimens. Bartlett refuse to culture the sputum sample if the specimen showing evidence of excessive oropharyngeal contamination. He proposed a grading scheme for quality of sputum based on the relative number of squamous epithelial cells, inflammatory cells, and mucus seen in gram-stained smears (Bartlett, 1974).

Murray and Washington rejected all specimens with more than 10 squamous epithelial cells (SEC) per average low-power field (LPF) and Geckler *et al.* rejected specimens with more than 25 SEC which are simpler scheme compared to Bartlett's (Geckler, 1977, Murray, 1975). However Van Scoy re-examined their data and concluded that specimen with more than 25 white blood cells (WBC) per LPF should be accepted (Van Scoy, 1977). Based on Barry, his scheme is quite similar with Bartlett's which evaluates the ratio as for Barry it evaluates the ratio between white blood cells and squamous epithelial cells and minimizes the effect of variations (Barry, 1978). Heinemen and Radano rejected specimens with more than 1 epithelial cell for every 10 white blood cells in the average LPF which described a similar scheme for screening sputum specimens (Heinemen, 1977).

Christian Donner *et al.* investigated how the choice of color space affect the sputum cell segmentation. Aim of the segmentation is to determine whether or not a pixel in the sputum image belongs to the sputum cell using the pixel color information. The staining of Papanicolaou will results a dark blue nucleus and clear blue of cytoplasm for debris cells. As for sputum cell, the nucleus will be dark red and clear red for cytoplasm. Therefore, it is possible to segment the sputum cell from background using color attributes. In their study, the histograms were computed for different color spaces such as RGB, YCbCr, HSV and L^*a^*b . They conducted a set of experiments to analyse the effect of color representation. By using Rule-based algorithm, HSV shows the best performance followed by RGB while the performance of YCbCr and L^*a^*b degrades as the resolution drops (Christian Donner, 2012). Fatma, Naoufel and Hussain, they focused on extraction and detection of sputum cells based on thresholding classifier. They used a database of 100 sputum color images to test the thresholding classifier by comparing with ground truth data. In order to test their experiment, they computed a histogram for different color space such as RGB, YCbCr, HSV, L^*a^*b and XYZ in order to find the best color space with low false detection rate. In their result after undergo histogram normalization, sputum pixels have much larger variance in the RGB space than the non-sputum pixels (Fatma Taher, 2012b).

In other related studies, Makkapati has proposed a method of detecting a malaria parasite in stained blood smears which is critical for treatment of the diseases using image processing. A scheme based on HSV color space that segments red blood cells and parasites by detecting dominant hue range and by calculating optimal saturation thresholds was presented in his work (Vishnu V. Makkapati 2009).

In recent studies, we can concluded that the detection of sputum smear by image processing analysis mainly focus on the color of the cell. All color spaces have been used in the cell detection such as RGB, L^*a^*b , YcbCr and XYZ. Based on the recent works, we proposed a new approach where we integrate the color based of analysis with pre processing, segmentation, classification



and detection. This approach will be improved the technique that being used by previous studies.

IMAGE PROCESSING TECHNIQUE

General approach of the image sputum cell analysis is shown in Figure-4. The sputum data has been acquired in collaboration of Hospital Universiti Sains Malaysia KubangKerian (HUSM). The analyses of images have gone through the pre-processing, segmentation and finally the detection of cell.

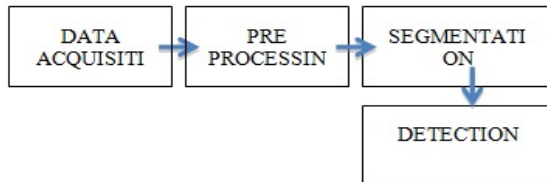


Figure-4. General steps of sputum cell image analysis.

Data acquisition

The data collection has been performed in the Microbiology Lab, HUSM KubangKerian assisted by HUSM's lab technologist. The sputum cell data have been collected using digital microscope that is attached to a digital camera, connected to a PC and runs with dedicated software for image collection. The specification of data collection apparatus is as follow:

Camera: Olympus XC50, U-CMAD3, Japan

Microscope: Model-BX41TF_CCD, Olympus, and serial number: BG22578

Software: AnalySISdocu, copyright 1986-2007, Olympus Soft Imaging Solutions GmbH.

Pre-processing

In the pre-processing stage, we introduced several methods in order to prepare a good image for the segmentation stage. Four experimental methods have been proposed to find the most suitable technique for noise removal. The following four different methods have been tested to analyze sputum image for the cell detection.

- i. Preprocessing Method 1: Apply RGB color space followed by contrast enhancement
- ii. Preprocessing Method 2: Analyze H channel of HSV and continue with contrast enhancement
- iii. Preprocessing Method 3: Analyze with S channel of HSV and continue with contrast enhancement
- iv. Preprocessing Method 4: Analyze with V of HSV color space and continue with contrast enhancement

Segmentation

As we choose the best pre processing technique of sputum cell, our work then continue by applying segmentation technique to find the suitable region of interest. In this stage, segmentation process is emphasis on getting region of interest of SEC by removing background and noises. Segmentation of SEC is important to ensure there is only SEC left in the image and no noise that

disturbing the interest cell. All the unwanted objects need to be removed so that the image contains only appropriate information of SEC pixel values. Figure-5 shows the block diagram of image segmentation process. Output from pre processing stage has been performed noise elimination followed by bores removal. Finally we applied object multiplication to get the segmented object of SEC. The same step applied to the Puss Cell.

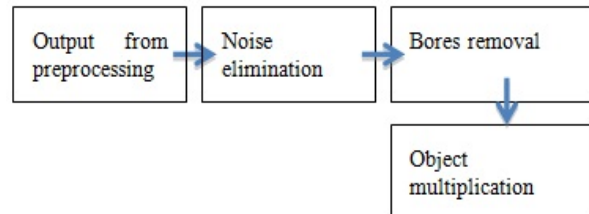


Figure-5. Block diagram of segmentation stage.

Detection

Detection process is shown in Figure-6. In the detection stage, K-means clustering and color thresholding have been used to identify SEC Cell. The result from segmentation process has been continued by applying K-mean clustering then followed by color thresholding. We set a range of thresholding values and finally the numbers of sputum cell were detected. Figure-7 is one of the examples of SEC after performing K-mean and color thresholding steps.

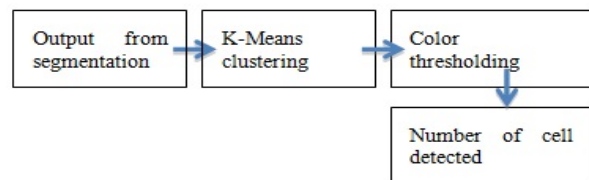


Figure-6. Detection stage.

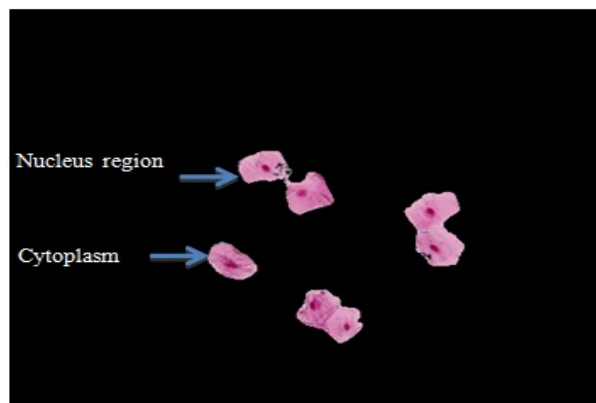


Figure-7. Nucleus and cytoplasm region of SEC.

RESULT AND DISCUSSION

To evaluate the performance of cell detection, we conducted a set of experiments and testing with more than



200 sputum images. The performance was evaluated based on detection and counting accuracy. Input data of 200 images were clustered to 10 groups, where each group contains 20 images. For example, in the group Cell 3, each image contains of three SEC cell. This clustered group is important to test the accuracy of the detection technique. Figure 8 shows samples of data in each cell groups.

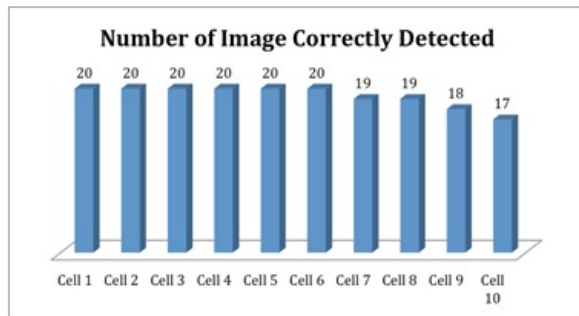


Figure-8. Group of cell for evaluating detection performance.

Table-1 shows the sample of result for each group of cell. In each group of cell, the detection will increase according to the cell group. In example, the detection in cell group 4, it is supposed 4 cells will be detected. The detection of cells will increase as the number of cell group increase. Table-1 shows the example of result for overall group of cell.

Table-1. Result of SEC cell detection and summation.

Group Cell	Image	Number of SEC in the Image	Number of SEC detected
Group Cell 1	1	1	1
	2	1	1
	.	1	1
	.	1	1
	20	1	1
Group Cell 2	1	2	2
	2	2	2
	.	2	2
	.	2	2
	20	2	2
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
.	.	.	.
Group Cell 9	1	9	9
	2	9	9
	.	.	.
	20	9	9
Group Cell 10	1	10	9
	2	10	10
	.	.	.
	20	10	10

The experiment result is shown in Figure-9. The number of images correctly detected represents images that detect the number of SEC correctly in each image.

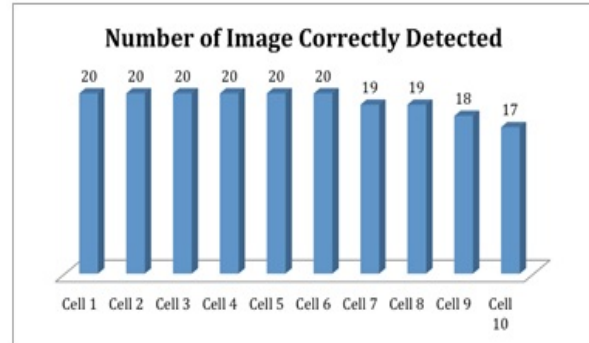


Figure-9. Number of image SEC cell correctly detected.

Figure-9 summarizes the number of image successfully detected. The graph shows that the images in-group Cell 1 to Cell 6 has been correctly detected the 20 cell images. However with the increasing number of cell in the images, the detection and counting result become less accurate. It was shown in cell group 7 to 10. The detection performance is measured by percentage of number of images successfully detected. From the results we can see that the system reliability and accuracy is 96.5%. Table-2 shows summary of the detection and summation performance.

Table-2. Summary of detection and summation performance.

No. of Images	200
No. of Images with successful detect	193
No. of Images with unsuccessful detect	7
% Ratio of error	3.5%
% Ratio of successful	96.5%

CONCLUSIONS

In this paper, detection and counting system of Squamous Epithelial Cells (SEC) in sputum slide images using image-processing analysis was presented. The algorithm proposed in this paper is focus on detecting and counting the number of SEC in sputum images. Different pre processing approaches have been used to find the best noise removal method. Our proposed technique for segmentation as well as detection has shown a promising output. We tested the detection algorithm with 200 images and 193 images was successfully detect the SEC cell while 7 images was given error detection. Based on overall percentage of detection 96.5% we can conclude that the proposed method for SEC detection was succeeded.



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