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TBC bacteria detection in microscopic image with watershed contour method

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ABSTRACT

Tuberculosis (TB) is an infectious disease that can be detected using a sputum sample. TB cases in Indonesia have spread throughout the region; the highest cases are in West Java. This problem makes the government do some handling and prevention of TB disease. The Bandung City Health Office (DKKB) conducted a cross-test to diagnose TB using a sputum sample. So in this study, a TB bacteria detection system, namely Mycobacterium Tuberculosis (MTB), will be made in sputum samples and their number to diagnose TB. Detection and calculation of the number of MTB are done by processing the image on the sputum sample using the watershed contour detection method. In this study, sputum sample data were obtained from DKKB. The acquisition of microscopic images at each point of the field of view is carried out using an SLR camera connected directly to the microscope to replace the function of the ocular lens. In this study, the microscopic sputum sample images were classified into positive and negative using the watershed and colorspace methods and were tested on a total of 90 microscopic images. From the system testing results, the system accuracy level is 100%, and the system precision is 100% for the detection of TB diagnosis. The system processing time averaged 5.811 seconds for 90 images used.

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1. INTRODUCTION

Tuberculosis (TB) is an infectious disease that has become worldwide. This disease is contagious and caused by the bacterium Mycobacterium tuberculosis. The world health agency defines countries with High Burden Countries (HBC) for TB based on three indicators, namely TB (Human Immunodeficiency Virus), TB/HIV, and Multi-Drug Resistant Tuberculosis (MDR-TBC). Indonesia and 13 other countries are included in the HBC list for the three indicators. Therefore, Indonesia has the biggest problem in dealing with TB. The number of TB cases in Indonesia was 420.994 in 2017, and the data is as of May 17, 2018) [1]. West Java is the province that has the highest number of TB cases in Indonesia; data as of January 31, 2017, found 23,774 new TB cases (Source: Directorate General of P2P, Ministry of Health RI, 2017). The city of Bandung is the most significant contributor to TB cases in West Java, with 9,147 new TB cases in 2017 [2].

TB can be detected by examining the patient's sputum. External Quality Assurance (PME) in the form of a cross-test every three months is carried out to maintain the quality of TB microscopic laboratory examinations. Dinas Kesehatan Kota Bandung (DKKB) oversees 55 health facilities to conduct cross-tests every three months. From the 55 health facilities, DKKB received an average of 1200 preparations for cross-testing. There are two levels of examination division at DKKB. If a pathologist at level 1 doubts diagnosing

TB bacteria in practice, it will be re-examined by a pathologist at level 2. An average of 30 courses must be examined by one pathologist so that there are approximately 1800 preparations that can be checked in 1 period [3]. So in this study, a system will be proposed to detect the presence of TB bacteria. Several studies related to detecting the presence of TB bacteria based on image processing are described in Table 1.

Table 1. Matriculation of previous research results

No	Year	Author	Method	A	B
1	2010	Khutlang et.al	*Color Space*	V	X
2	2015	Cicero et.al	*Color Space*	V	X
3	2016	Shah et.al	*Create* ZNSMiDB, *Watershed*	V	X
4	2017	Dirvi et.al	*Watershed*	V	X
5	2019	Rahadian et.al	*Watershed, Fuzzy C-Means*	V	X

A: Detection of TB bacteria
B: Counting TB bacteria

Based on the table above, the success of the colour space method in detecting TB bacteria was able to identify two groups of High-Density Background and Low-Density Background images. While the watershed method can segment bacteria even though their positions are randomly distributed, this method has a sensitivity of 90.3% and a precision of 70% [4][5][6][7][8].So the watershed method will be tested with the colour space method in preprocessing and the watershed method in bacterial segmentation because the watershed method can be detection random object and identification object.

2. METHOD

The system design is made using microscopic images and processed using the watershed method for segmenting TB bacteria.

2.1. Tuberculosis

Tuberculosis is an infectious disease that attacks the lungs. The bacterium Mycobacterium tuberculosis causes TB disease. The main symptom of patients with TB is coughing up sputum for two weeks or more. The cough may be followed by additional symptoms such as sputum mixed with blood, shortness of breath, weakness, decreased appetite, and malaise [1]. Classification of TB diagnosis can be done microscopically by scanning TB bacteria. By WHO standards, scanning for TB bacteria must be carried out in 100 Fields of View (FOV) or see microscopic images of sputum samples from 100 different field points of view. The number of TB bacteria at each end of the field of view was accumulated and mapped according to the International Union Against Tuberculosis and Lung Disease (IUATLD) [3].

2.2. Color Space

Color Space is a method that can be used to assist in grouping colours. The representation used to store paints and define color channel properties is called colour space [9]. RGB is the most commonly used color space for digital image representation because it corresponds to three mixed primary colors. The segmentation method with HSV color detection is done by selecting a pixel sample for the colour reference of the desired segment shape. In this process, the previously RGB image is converted to HSV. In forming segments that match the desired color, the tolerance value for each HSV colour dimension is determined. Binary image is a digital image with two possible values for each pixel. The object pixel is assigned a value of 1, while the background pixel is assigned a value of 0. A binary image is formed by coloring each pixel white and black depending on the pixel label [10].

2.3. Watershed

This method assumes an image in the form of 3 dimensions, namely the x and y positions with each color level they have. The base plane and pixel color levels are positioned x and y where the gray image is the height by assuming that the value closer to white has a higher elevation. At a certain regional minimum, a set of points that meet condition two is called a catchment basin, while a group of issues that meet requirement three is called a watershed line [11]. Watershed can use for segmentation object.

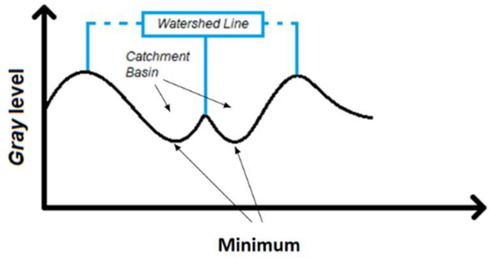


Figure 1. topographic representation watershed

Figure 1 a topographic representation of the grayscale level image using the watershed method where there is a watershed line.

2.4. System Model

The system was created to detect TB bacteria and determine the number of TB bacteria at each point of the field of view. This system uses sputum samples from tuberculosis patients given Ziehl Neelsen fluid in each preparation to determine acid-fast bacteria. Microscopic images of TB sputum are taken with a microscope connected to a camera. The color space method is used for the preprocessing stage, and the watershed method is used to segment TB bacteria..

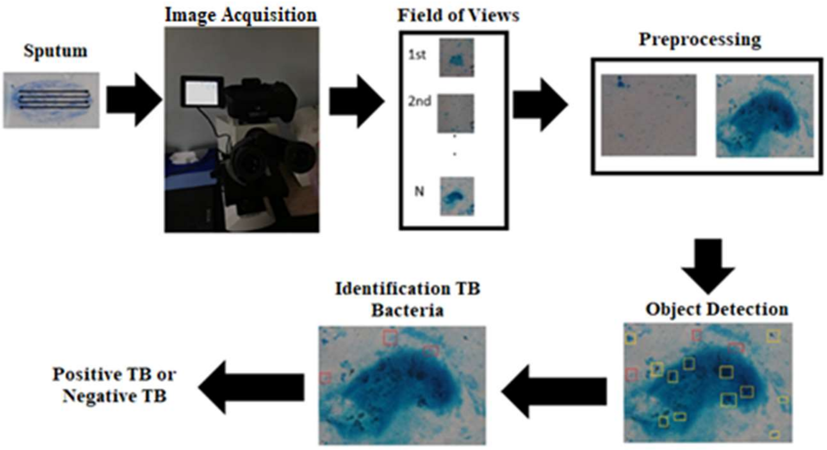


Figure 2. System Model

2.4.1. Sputum Sample

In this study, the created system started by taking sputum samples from the Bandung City Health Office. Each preparation was given an oil immersion solution before being placed in the microscope to focus on TB bacteria. The practices used were positive and negative TB preparations.

2.4.2. Image Acquisition

The sputum sample is scanned using a microscope connected to a camera instead of an eyepiece. Microscopic images were taken from as many as 90 points of the field of view from the upper right corner to the lower left end**.**

2.4.3. Preprocessing

The next stage is preprocessing. Preprocessing is a step taken to improve the quality of the microscopic images that have been taken. This process can assist in detecting objects so that they can identify between bacterial objects and artifacts scattered in the microscopic image. The preprocessing stage carried out is RGB to HSV. At this stage, it is carried out to provide color value limits for objects of artifacts and TB bacteria, and hue masked to closing to clarify things that have been selected from the RGB to HSV stage, then the closing to binary process to give black color on the detected object and the background becomes white. Binary image changes occur because the watershed method requires a distance transformation from the binary image. Furthermore, the binary image is converted to thresholding to clarify the object and converted into a grayscale image again to show the depth of the grayscale color before the watershed method is carried out.

2.4.4. Object Detection

After performing the preprocessing stage, the watershed method is used. Watershed is a method that can segment TB bacteria from images that have been preprocessed. At this stage, objects from microscopic images can be detected by looking at the watershed's bounding box results. The detected objects, artifacts, and TB bacteria will be labeled at this stage.

2.4.5. Identification TB Bacteria

The label results from the watershed method are then calculated with the contour area of the object with the contour area. The contour of the site is carried out to determine the size of the object of TB bacteria and artifacts so that a separation can be made between the thing of the artifact and the TB bacteria. The system can be detected positive TB and negative TB.

2.5. Processing Detail Image

Details of image processing in this study to detect TB bacteria are shown in the image below.

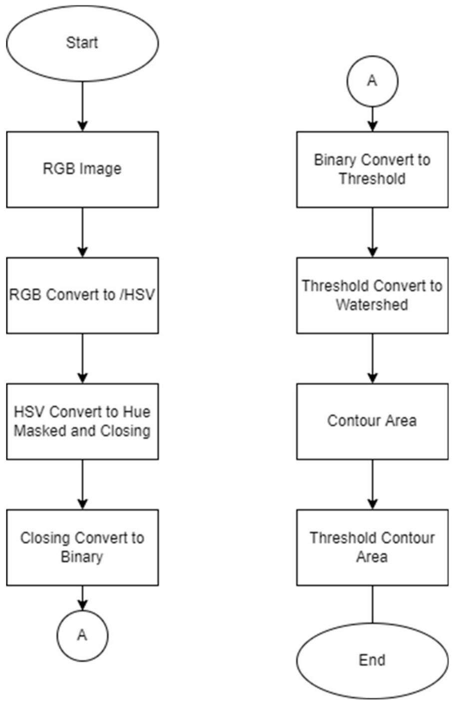


Figure 3. Processing Detail Image

Figure 3 shows the flow of image processing on the system created. First, the RGB image will be converted using a hue channel or HSV for color segmentation on microscopic image objects. At this stage, the threshold value of the hue channel segmentation will be determined. Next will be hue masked and closing to clarify the image. After that, the image will be converted into a binary image because the watershed method works with distance transformations that require a binary image. So before the watershed method is carried out, binary and threshold image conversions are carried out to clarify the object again by producing a grayscale image. After the watershed method can detect the contours of things such as TB bacteria and artifacts, a contour area detection will be carried out to determine the extent of the TB bacteria objects and artifacts detected. Furthermore, the system added a contour area threshold method to select the area of TB bacteria objects and saw artifacts to display only TB bacteria.

2.6. System Performance Testing

System performance testing is done to determine how far the system's performance has been made. The tests carried out in this study were testing system accuracy, system precision, and calculating the average system processing time. The following is an explanation of the equations used.

1. TP (True Positive): the number of positive data with correct classification by the system.
2. TN (True Negative): the number of negative data with correct classification by the system.
3. FP (False Positive): the number of positive data with incorrect classification by the system.
4. FN (False Negative): the number of negative data with incorrect classification by the system.

2.6.1. System Accuracy

The accuracy of the detection results is used to see the percentage value of the accuracy. In this study, the following equation will be used.

$$Accuracy = \frac{TP+TN}{TP+TN+FP+F} \quad (1)$$

2.6.2. System Precision

In this study, the precision calculation of the system will also be carried out with the following equation.

$$Precision = \frac{TP}{TP+} \quad (2)$$

2.6.3. System Processing Time

In addition to the value of accuracy and precision in this study, the average system processing time will also be calculated. There are three system processes used. Namely, the first 90 images are processed directly, the second 40 positive images, and 50 negative images. Calculation of the average system performance can be calculated using the following equation.

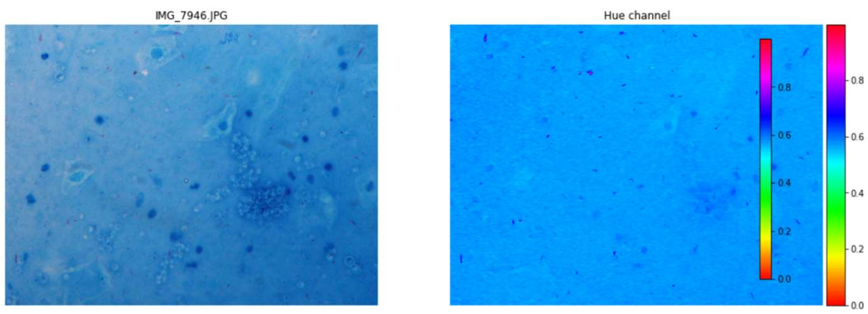
$$System\ Processing\ Time\ Average = \frac{total\ processing\ time}{number\ of\ system\ process\ scenarios} \times 100 \quad (3)$$

3. RESULTS AND DISCUSSION

In this section, we will discuss the results of the TB bacteria detection system. The research carried out includes the level of accuracy, precision, and time of the processing system.

3.1. Result

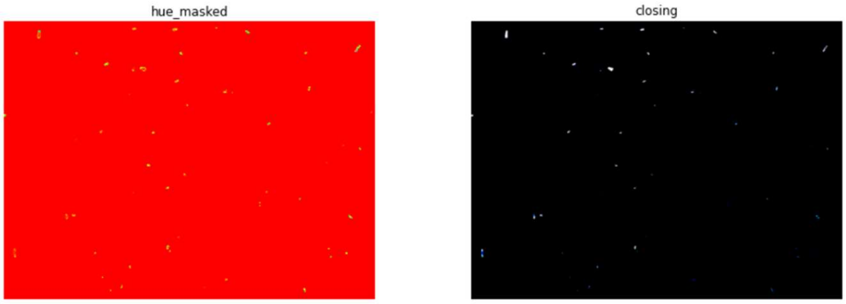
The system will be preprocessed using Hue Saturation Value (HSV) color image segmentation and the watershed method. In this test, the dataset/image will be filtered first with a Hue Channel to determine the color threshold that indicates TB bacteria.



(a) (b)

Figure 4. The results of the RGB image are segmented HSV color (a) RGB image, (b) Hue Channel/HSV

In Figure 4, color segmentation is performed using Hue Channel or HSV. For the RGB image to be converted into an HSV image, it is necessary to obtain the HSV filter object threshold value in the microscopic image. From Figure 4, the threshold results are 0.63 - 0.65, the value of the color depth of the hue channel.



(a) (b)

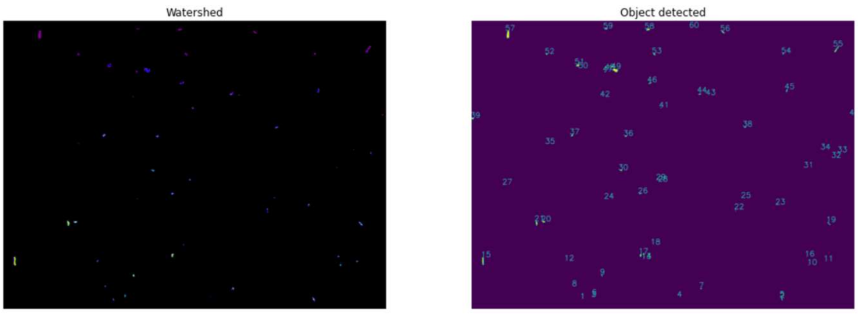
Figure 5. Hue Masked convert closing (a) hue masked, (b) closing image

In Figure 5, Hue Masked is done to get a complete object. Meanwhile, closing is needed to clarify and repair the detected TB artifacts and bacteria.

(a) (b)

Figure 6. Binary image convert threshold image (a) binary image, (b) threshold image

In Figure 6, the binary image shows a color change where previously the object detected was white and changed to black. Binary image conversion is done to show things in more detail and is used when transforming distances in the watershed method. Furthermore, the image is converted to a threshold image to obtain a grayscale image because the watershed method knows the depth of the grayscale color to get the contours of the detected object.



(a) (b)

Figure 7. The results of the contours of the Watershed method (a) the results of the watershed method, (b) Labeling of detected objects

In Figure 7 (a), the results of the contour of the watershed method are bounding boxes or markers for all objects, and in Figure 7 (b) are labels that identify an object on a microscopic image. There are 60 objects detected in the microscopic image above. From the number of objects detected, it still detects all objects, namely artifacts and bacteria. TB bacteria in the image can be identification like a capsule. Therefore we need a method to see the size of the thing so that it can be separated between TB bacteria objects and artifacts.

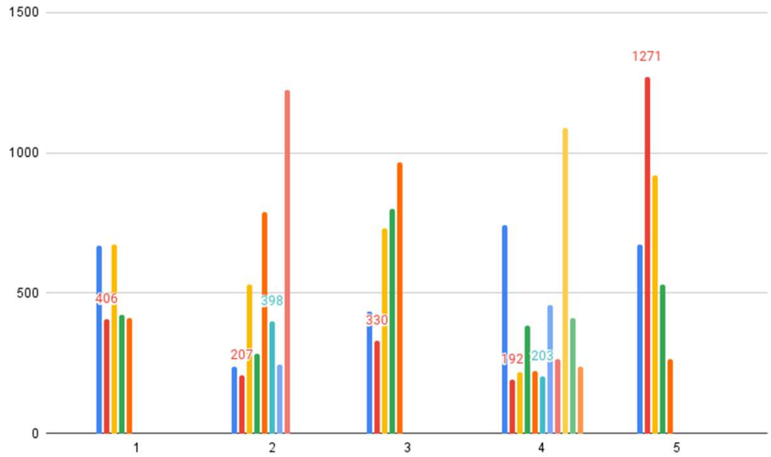


Figure 8. The results of the distribution of the detected contour area

From the output of the detected contour area, it can be seen the distribution of the area value of the TB bacteria, which can be seen in Figure 8, which is a minimum value of 203 pixels and a maximum area of 1271 pixels. The color bar diagram shown in Figure 8 shows the value of the detected contour area distribution from 5 microscopic image samples. The blue color is first order of the contour area, the red color is the second color of the contour area, the orange color is the third color of the contour area, and the next color also shows the order of the detected contour area. However, the total area contour object seen is from 0 to infinity. Therefore the presence of this bacteria system requires an additional area contour thresholding method to separate artifact objects and TB bacteria.

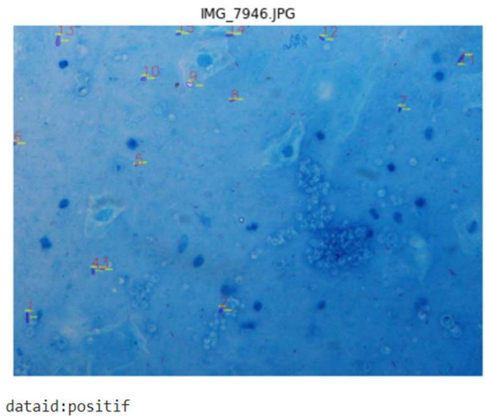


Figure 9. TB bacteria contour labeling results

Figure 9 above shows that the system can detect positive TB bacteria along with the estimated number of TB bacteria detected after thresholding the contour area. The following is the value of the contour area of the bacteria object that has been seen.

Table 2. Result Contour Area of TB Bacterium

No	Name Label	Contour Area TB Bacterium (*pixel*)
1	contourArea 1	741
2	contourArea 2	288
3	contourArea 3	217
4	contourArea 4	386
5	contourArea 5	223
6	contourArea 6	222
7	contourArea 7	221
8	contourArea 8	212
9	contourArea 9	874
10	contourArea 10	379

11	contourArea 11	456
12	contourArea 12	265
13	contourArea 13	1090
14	contourArea 14	411
15	contourArea 15	238

In Table 2 above, the total detected TB bacteria were 15 bacteria. At the beginning of the contour of the area, as many as 60 artifacts and TB bacteria turned into 15 detected TB bacteria. So that by doing thresholding area, the watershed method can separate artifact objects and TB bacteria objects.

3.2. Diagnosis TB Bacteria

Patients with TB are said to be TB positive if TB bacteria are detected in sputum preparations. At the same time, negative for TB is if no TB bacteria are detected from sputum preparations. In diagnosing TB disease, the accuracy and precision of the system that has been made will be calculated in this system. In this study, the system will provide the output of microscopic image detection, whether positive or negative TB. The validation in this study also refers to the results of the verification carried out by pathologists so that they can be mapped, as in table 3.

Table 3. Confusion Matriks Table

	Positive	**Negative**
Positive	True Positive 40	False Positive 0
Negative	False Negative 0	True Negative 50

3.2.1.Accuracy System

The calculation of the accuracy of the computer-assisted TB diagnosis system is carried out by taking into account information from a pathologist who explains that a person can be said to be TB positive if, in one field of view, there is at least 1 TB bacteria detected. Then by using the information in table 3, it can be seen that there are 40 True Positive images, 0 images False Positive, 0 False Negative photos, and 50 True Negative images. So the accuracy value of the developed computer-aided diagnosis system is 100%.

3.2.2.Precision System

From table 3 values are also used for system precision calculations. The results of the precision system obtained are 100%.

3.2.3.Time of Processing System

The results of the system process are mapped in table 4 below.

Table 4. Time of Processing System

	Time (s)	**∑ data**	**± (s)**
Positive and Negative Image TB	509	90	5.65
Positive Image TB	265	40	6.625
Negative Image TB	258	50	5.16
Average time of processing system			5.811

Table 4 shows the processing time value of the combination of positive and negative images. The system processing time is 5.65 seconds, a positive TBC image with 40 photos is 6.625 seconds, and a negative TBC image with 50 shots is 5.16 seconds. The calculation of the average total processing time of the method received the value of the system processing time, namely 5.811 seconds.

4. CONCLUSION

Based on the results of testing and research above, the TB Bacteria Presence Detection system using the Watershed Contour Method can detect microscopic images of positive and negative TB bacteria.TB diagnosis enforcement system developed has an accuracy of 100% and a precision of 100%, where the system can classify positive and negative TB images with an average processing time of 5.811 seconds. In the dataset used in this study, the system made using the watershed method is insufficient to detect TB bacteria, so preprocessing is added, such as hue channel/HSV, area contours, and thresholding of area object contours.

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