Implementation of Morphological To Detect Disease Based on Image of Red Blood Cells

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Abstract. Disease can be recognized visually because it has unique shape and color characteristics. The purpose of this study is to conduct research on malaria-based parasitic cell infections. In this research, there are 20 images used as malaria detection research data divided into 5 normal images and 15 malaria recovery images obtained through the dataset. The process carried out in malaria detection to input RGB image after that the image takes a grayscale image, then improve the image quality to eliminate noise that occurs in the image with the median filtering method. The results of these images are binary images. In the conversion process, the hole is carried out on the object so that the filling process is carried out. After that the cell count is done by the 4-connected method, the edge detection process uses the boundary, then the malaria collection using the color threshold and the malaria phase collection.

Keywords: image processing, disease, red blood cells, 4-connected method

1 Introduction

Malaria is a disease caused by the bite of a female Anopheles mosquito. There are 5 types of malaria that infect humans, namely Plasmodium falciparum, Plasmodium vivax, Plasmodium ovale, Plasmodium malariae, Plasmodium knowlesi. However, Plasmodium falciparum is the type that most commonly infects humans [1]. The morphology of Plasmodium falciparum is divided into three phases, namely Rings, Schizont and Gametocyte [2]. The problem found in malaria detection is that the current diagnosis still takes a relatively long time due to the limited number of experts and tools to detect malaria and its phases.

The system testing conducted in the research [3] used 70 plasmodium falciparum image data (12 gametocytes, 1 schizont, and 57 trophozoite phases). These data were then extracted for their characteristics based on the area ratio and eccentricity parameters. Both parameters serve as input in the artificial neural network built by the system training process. This research refers to previous researchs that use color and shape features where the color feature is used to detect images infected with malaria or not and the shape feature is used to detect the malaria phase. To detect malaria and the phase in red blood cell images, a system is designed

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that uses the Morphology and Boundary 4-Connected operation methods. The Morphology operations used in this research are erosion, dilation. Morphology operations will be combined with Boundary 4-Connected. The method used in the boundary is boundary extraction where the process is used to obtain the object's edge (boundary), 4-Connected is used for the object calculation process [4], which is used as the blood cell calculation process, then the shape of the object that has been identified will be known in number.

2 Related Work

Process analysis will explain the working process of malaria detection with color threshold, edge detection using boundary to detect malaria phase and 4-connected which is used as red blood cell calculation.

The working process of malaria detection using morphological operations and boundary 4 connected can be described in the form of a flowchart as shown in the following figure 2.1:

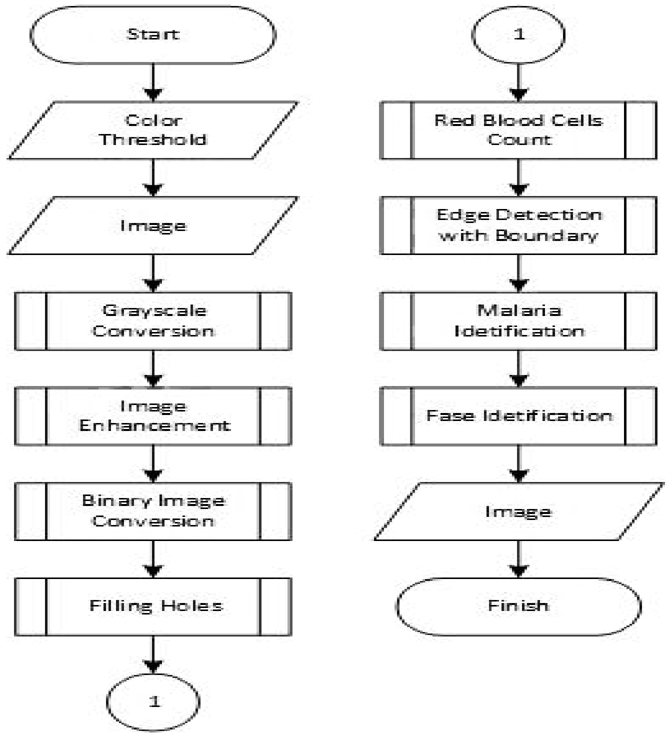


Fig. 1. System Flowchart

2.1 Convert Image to Grayscale

At this stage, the process of changing the RGB image into an image based on grayscale, by adding up all the R G B values, then dividing by 3, so that the average value of R G B is obtained, the average value is what can be said to be grayscale, by using the formula [5] To change the RGB image into a grayscale image using the equation.

$$Grayscale = (R + G + B) / 3 \quad (1)$$

The following is a flowchart for converting RGB images to grayscale images, as shown in the image.

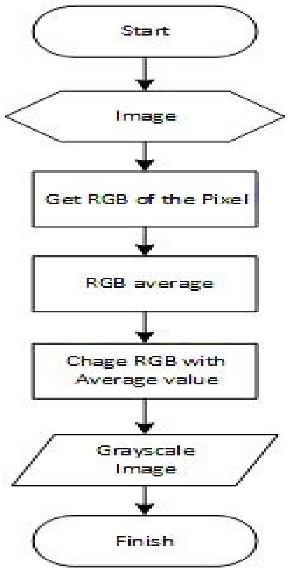


Fig. 2. Flowchart Conversion Image to Grayscale

2.2 Image Enchancement

The working process in this image enhancement system is by processing an image that has poor quality, then it will be processed using median filtering to reduce noise in the image and also improve the contrast in the image. The median is the middle value of a data set, to find the median of a data set then [6], by using the median filtering formula in the following equation.

$$x = (n+1) / 2 \quad (2)$$

2.3 Grayscale to Binary Image Conversion

Conversion of grayscale images by using the adaptive thresholding method. This image is usually displayed in black and white, in numeric form, the value 0 for black and 1 or 255 for white. If $f(x,y) < T$, then set 0. and if $f(x,y) > T$, then set 1.

2.4 Filling Holes

When thresholding, it is not uncommon to find holes in red blood cells. Holes in the image are defined as background areas surrounded by pixel borders connected to the foreground. Holes in the image are defined as background areas surrounded by pixel borders connected to the foreground. Filling holes is based on cell widening, complementation and intersection to fill holes [7].

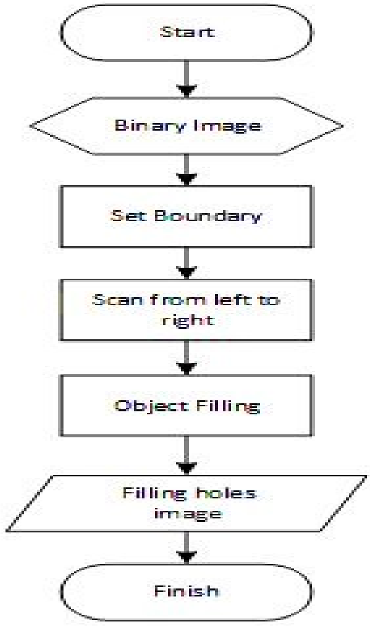


Fig. 3 Filling Holes Flowchart

2.5 Red blood cell calculation

The labeling process uses images that have been filled holes. The process is carried out by checking the 4 neighboring pixels of the main pixel and if there is a value of 1, then the value will be stored and stated as the same object. The process of calculating the number of cell is carried out using the labeling method, namely 4 - connected. The image that can be processed using the connected component labeling algorithm is a binary image [8]. The following is the connected component labeling algorithm [8].

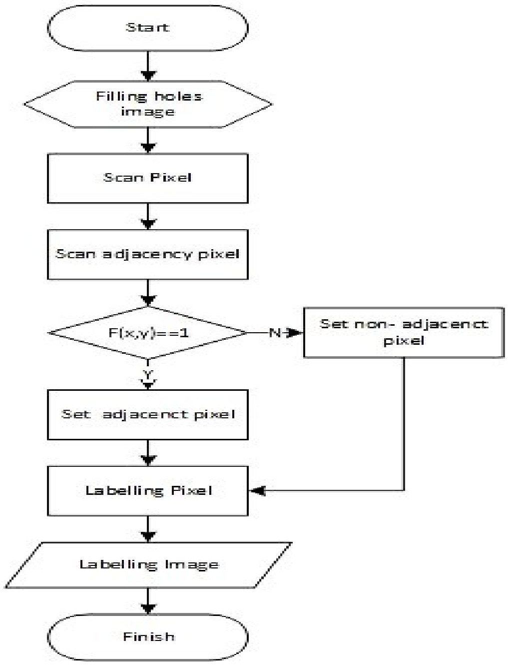


Fig. 4 Red Blood Cells Calculation Flowchart

2.6 Edge detection using boundary

Boundary is used for edge detection, this method uses binary images generated from binary threshold values. Boundary can be used by using the equation.

$$\beta(A) = A - (A \ominus B) \tag{3}$$

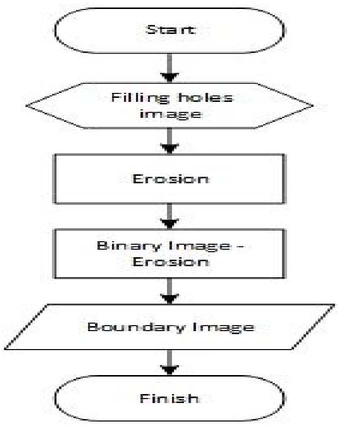


Fig. 5 Edge Detection Flowchart

2.7 Malaria identification

At the malaria identification stage, the process of classifying red blood cell images as infected with malaria or not based on the presence of parasites in the red blood cell image, by using a predetermined RGB color value threshold.

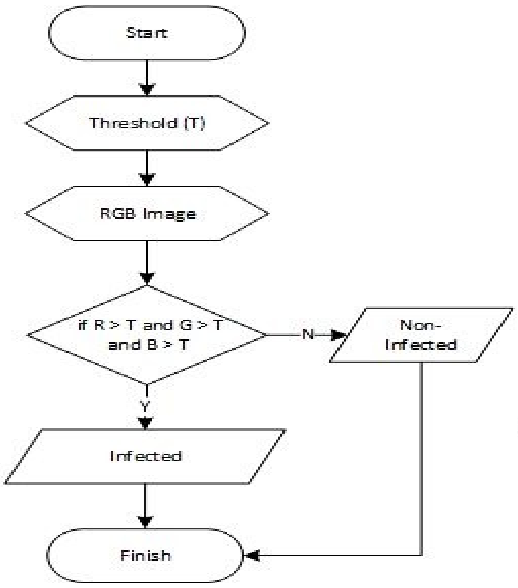


Fig. 6 Malaria identification flowchart

For the process of detecting whether red blood cell images are infected with malaria or not, it can be done using a color threshold with a threshold of T = 160 and by using the following classification rule:

Table 1. Classification rules for malaria infection

Infection	R	G	B
Malaria	> Threshold	> Threshold	> Threshold

2.8 Identification of Plasmodium falciparum Phase

After the malaria identification process is complete, the next step is to detect the phase of the parasite. By obtaining the value of the parasite area and the average area of normal red blood cells. In the process of determining the Plasmodium falciparum phase, the rings type is carried out by comparing the value of the parasite area and the average area of normal red blood cells, while in the Schizont and Gametocyte types, it is carried out using metric values.

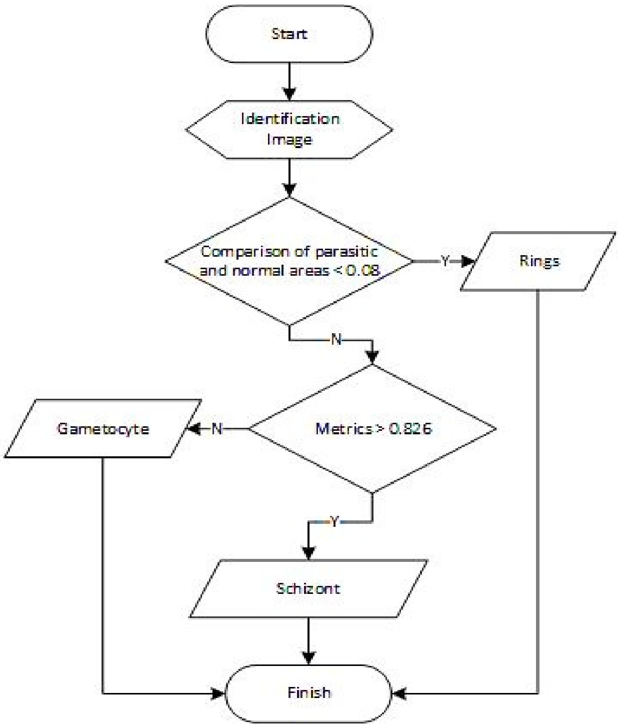


Fig. 7 Phase identification flowchart

Metric is a quantity that indicates the level of roundness of an object's shape. To find the metric value, you can use the following formula:

$$Metric = \frac{4\,\pi\; x\; parasite\; area}{(Parasite\; circumference)^2} \tag{4}$$

If the comparison value of the parasite area with the average normal cell in the same image is less than 0.08, then the parasite is identified as being in the rings phase. This value ranges from 0 to 1. The rounder an object is, the closer its metric value is to 1. Parasites that have a metric value of more than 0.826 are identified as being in the schizont phase and if it is less than that value, it is identified as being in the gametocyte phase [9].

3 Result

Testing was conducted using 20 images obtained through the Mamic database using 40x magnification so that the parasites in the image can be seen. 20 images consisting of 15 malaria images and 5 normal images. Then image from databset will be compared again with testing in the system. The data tested uses an image resolution of 500 x 500 pixels. The following is a sample of 1 image infected with malaria.

Table 2. Image Test

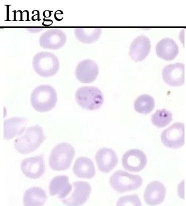
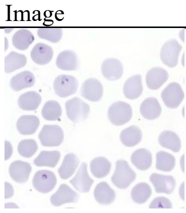
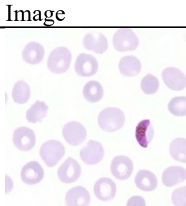
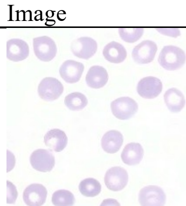
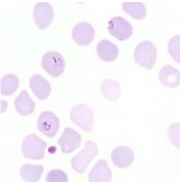
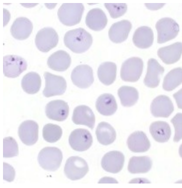
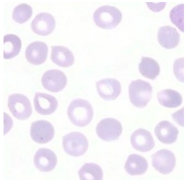
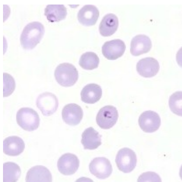
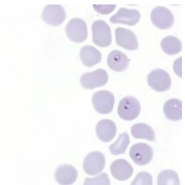
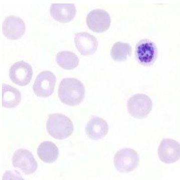
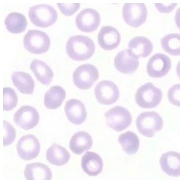
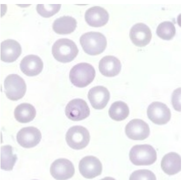
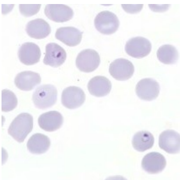
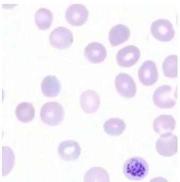
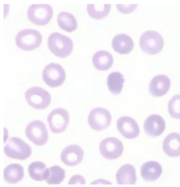
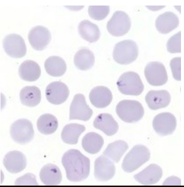
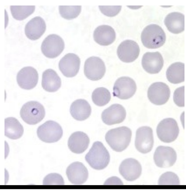
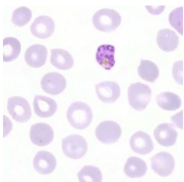
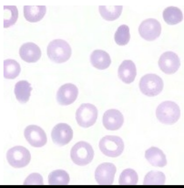
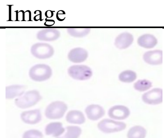
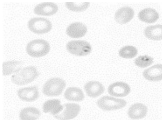
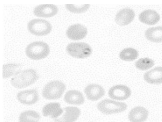
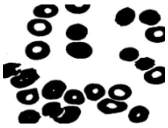
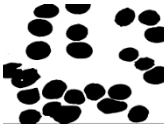
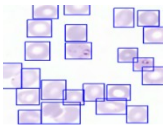
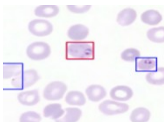
No	Image	No	Image	No	Image	No	Image
1		6		11		16	
2		7		12		17	
3		8		13		18	
4		9		14		19	
5		10		15		20	

Table 3. Infected Image Testing

Name	Image	Resolution (pixel)	Description
Image		500 x 500	the input image will be detected

Grayscale		500 x 500	Convert RGB-image to grayscale
Image Enhancement		500 x 500	Grayscale images are subjected to image enhancement to remove noise.
Binary Image		500 x 500	Convert grayscale image to binary image
Filling Holes		500 x 500	The holes in the black and white image will be filled to remove the holes.
Cell Calculation		500 x 500	The number of holes that have been filled will be counted.
Edge Detection		500 x 500	Search for object edges to get the area and perimeter of the object
Identification		500 x 500	Identification is carried out to obtain cells infected with parasites
Parasite		89 x 74	Parasite 1 results obtained
Binary Parasite		89 x 74	The resulting image of parasite 1 is converted to a black and white image.
Parasite Edge Detection		89 x 74	Parasite 1 image is subjected to edge detection

Result		-	Description of parasite 1 image results

Testing was carried out using a threshold of 160. Based on the test results on 20 images consisting of 15 malaria images and 5 normal images, the following results were obtained:

Table 4. Threshold testing with test image number 1.

Image	Threshold	System detected	Manual Detected	Result	Precision	Recall
1	65	0	3	False	0 %	0 %
1	84	0	3	False	0 %	0 %
1	103	0	3	False	0 %	0 %
1	122	2	3	False	66 %	66 %
1	141	2	3	False	66 %	66 %
1	160	3	3	False	100 %	100 %

Table 5. Threshold testing with test image number 2

Image	Threshold	System detected	Manual Detected	Result	Precision	Recall
2	65	0	3	False	0 %	0 %
2	84	0	3	False	0 %	0 %
2	103	0	3	False	0 %	0 %
2	122	1	3	False	33 %	33 %
2	141	3	3	True	100 %	100 %
2	160	3	3	True	100 %	100 %

Table 6. Threshold testing with test image number 3

Image	Threshold	System detected	Manual Detected	Result	Precision	Recall
3	65	0	3	False	0 %	0 %
3	84	0	3	False	0 %	0 %
3	103	0	3	False	0 %	0 %
3	122	2	3	False	66 %	66 %
3	141	3	3	True	100 %	100 %
3	160	3	3	True	100 %	100 %

Table 7. Threshold testing with test image number 4

Image	Threshold	System detected	Manual Detected	Result	Precision	Recall

4	65	0	1	False	0 %	0 %
4	84	0	1	False	0 %	0 %
4	103	0	1	False	0 %	0 %
4	122	0	1	False	0 %	0 %
4	141	1	1	True	100 %	100 %
4	160	1	1	True	100 %	100 %

Table 8. Threshold testing with test image number 5

Image	Threshold	System detected	Manual Detected	Result	Precision	Recall
5	65	0	7	False	0 %	0 %
5	84	0	7	False	0 %	0 %
5	103	0	7	False	0 %	0 %
5	122	5	7	False	0 %	0 %
5	141	7	7	True	100 %	100 %
5	160	7	7	True	100 %	100 %

This threshold test was conducted with a value range of 65 to 160. This test was conducted 5 times using 5 malaria images contained in the dataset. The first test was conducted starting from a value of 65, the result was that no parasites were found in the image with an average precision value of 0% and an average recall of 0%. Then the threshold value was increased to 84, the result was that no parasites were found in the image with an average precision value of 0% and an average recall of 0%. Then the threshold was raised again to 103, the result was that no parasites were found with an average precision value of 0% and an average recall of 0%. Furthermore, a test was conducted with a threshold value of 122, the result was that parasites were found but there were still errors in their detection with an average precision value of 33% and recall of 33%. Then the threshold was increased to 141, with the result that parasites had been found but there were still errors in their detection with an average precision value of 93% and an average recall of 93%. The best test was obtained by using a threshold of 160, from 5 tests using images, the average precision value was 100% and the average recall was 100%.

4 Conclusion and Suggestion

4.1 Conclusion

After conducting testing in this research, it can be concluded that the results of malaria detection with threshold values of 65, 84, 103, 122, 141, and 160 prove that the best detection is obtained by using a threshold of 160. This threshold can be used for disease detection because it is able to detect normal images and malaria images.

4.2 Suggestion

The suggestions that can be given are as follows:

1. Calculation of objects using the 4-Connected method should be carried out on objects that are not too close together, if the objects are too close together, then the object should be segmented first.
2. Testing can be further developed for malaria phase detection with pattern recognition that can be used to find object patterns and can classify an image.

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