Comparison of Malaria Parasite Image Segmentation Algorithm Using Thresholding and Watershed Method

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Abstract. Malaria is an infectious disease caused by plasmodium that lives and breeds in the red blood cells, transmitted by the Anopheles mosquito. During this time, the paramedics to diagnose symptoms use any imagery that is done manually. In the identification analysis of the malaria parasite cell infection, there is a possibility of human error factor done by paramedics because of the number of samples analyzed. This case is because the human eye tends to be tired while working continuously, leading to misclassification and treatment that is not right. Therefore, it takes a computer-based system that facilitates image processing to paramedics or laboratory technicians to identify the parasite cells and reduce human error instances. This research conducted on identification of the thresholding and watershed of segmentation method for three types of plasmodium parasite, namely Plasmodium falciparum, Plasmodium malaria, and Plasmodium vivax. This study offered modifications thresholding and watershed algorithm. The results showed the success of the technique that can effectively segment on the three types of Plasmodium malaria, which has an accuracy rate above 90% as well as the results of the computation time between the thresholding method could segment imagery for 1-2 seconds and the watershed method intelligent segmented representation for 3-4 seconds.

1. Introduction

Malaria parasite infection causes malaria to the red blood cells, classified as a parasite of the genus Plasmodium parasite. The genus plasmodium is divided into four species that can infect human blood cells, which are Plasmodium falciparum, Plasmodium vivax, Plasmodium ovale, and Plasmodium malaria. Malaria is fatal if not treated appropriately, such as severe anemia, kidney failure, and death. Based on the WHO report in 2016, there were 212 million malaria cases, with an estimated 429,000 deaths worldwide. The World Health organizations (WHO) recorded 3.3 million deaths caused by this disease.

Similarly, malaria in Indonesia recorded 400 thousand humans who had developed malaria infection symptoms, although cases tended to decrease yearly. However, some eastern regions in Indonesia, such as Papua province, still suffer from malaria. Referred from a central source of information data to the Indonesian health ministry, nationally, 90% of the cases are from West Papua and East Nusa Tenggara.
Clinical diagnostic techniques performed against malaria infection were done by identifying the species and the parasite's development phase through blood preparations tested by taking a sample of his blood [1]. Efforts have been made in the medical field to continue treatment for an outbreak of malaria infection is one of them is using the power of existing technologies such as technologies microscopic imaging that produces medical images on which to base decision-making in a way to visualize abnormalities in the model through a microscope is based on science and knowledge owned viewpoint in terms of intensity, texture, etc. There are still some differences at the time of identification; usually, small-scale differences in features tend to be overlooked by the human eye. To prevent this, it would be better to develop computer-based automatic screening systems that scan abnormalities that fail to make decisions.

Much research has developed intelligent computational techniques are often called Computer-Aided Design (CAD), which implements the image processing method to improve the quality paramedics to diagnose. Some of the methods used in such image processing are the digital image acquisition process, the separation process object (segmentation), the process of defining features - object features (feature extraction), and the process of classifying the similarities and differences between objects (classification). Some research has been done related to the use and watershed thresholding method used to image in some applications, which can be seen in [2], [3], [4].

Based on background and references, this research is conducted to identify the malaria parasite that infects red blood cells using a CAD-based segmentation method with species plasmodium falciparum, vivax, malaria, and as research material because this species can cause death if it is late in its handling.

2. Methodology

2.1. System planning

The system's design in this study is done by using software MATLAB R2014a which there are methods and algorithms for image processing. The design of the overall system is shown by the whole system block diagram in Figure 1.

![Block Diagram](image)

**Figure 1.** Block Diagram.

The block diagram shown in Figure 1 has a simple system consisting of input, process, and output. The first channel is input in the form of a digital image of gametes Plasmodium falciparum, malaria, and vivax obtained from the Universiti Sains Malaysia Hospital laboratory. The process flow stage is the process image segmentation method that uses a modified thresholding and watershed algorithm. The initial process carried out steps of pre-processing before the segmentation process. The last groove is the output of an action where the product will produce a detectable plasmodium parasite image.
2.2. Pre-processing

Pre-processing stages consist of processes that will reduce the original image (24-bit RGB images) into a grayscale image (8-bit). Usually, it will be adding some algorithms such as morphological operations to clarify the parts of the individual images or reduce the 3-dimensional image into a one-dimensional with the same intensity value. The visualization of the original image is changed to grayscale is shown in Figure 2.

![Figure 2](image-url)  
**Figure 2.** Convert Image (a) RGB to (b) Grayscale Processing Pre-Processing.

2.3. Thresholding Segmentation Process

After passing through the stage of pre-processing, thresholding segmentation poses the rebrand to shape BW (black and white). The thresholding method used in this study is a blend of global thresholding and Otsu method, which way is chosen because it is considered as the best technique and most commonly used in global thresholding [5]. The first channel is input in the form of a digital image of Plasmodium falciparum, malaria, and vivax obtained from the Universiti Sains Malaysia Hospital laboratory. To simplify the process of image segmentation, given a value of 0.8 on a level [5]. The initial process carried out steps of pre-processing before the segmentation process. The last groove is the output of an action where the product will produce a detectable plasmodium parasite image.

2.4. Watershed Segmentation Process

In general workflow execution system in this method is almost the same as the thresholding method, which distinguishes the segmentation process longer. The thresholding process also takes in a series of grooves segments watershed, and this is because the poses will be more comfortable and faster. After that, the information obtained has been more focused on the plasmodium parasite in administering the previous threshold value. After thresholding, a process aims to refine the object's morphology and removes pixels too small, called opening operation. Morphological closing and opening operating profit smoothing function contours and eliminate small holes. In the controller watershed marker method, segmented image going through forming the marker generated by the image enhancement process results in morphological operations.

2.5. Analysis Method

The method of analysis in this study using qualitative and quantitative analysis. Qualitative analysis is the visual analysis by looking at the direct object of observation, in this case, the objects in the form of the original image of plasmodium falciparum, Plasmodium malaria, Plasmodium vivax, and image segmentation results of each method, in this case, thresholding and watershed segmentation method. The quantitative analysis was performed by discussing the use of numbers, which are the value of the calculation as to the accuracy of the data being tested, and the results of the two methods of computing time and Watershed thresholding method of each plasmodium.
3. Results and Discussion

3.1. Qualitative analysis of images of Plasmodium falciparum

Visualization analysis is displayed in images of plasmodium falciparum, segmented using the thresholding and watershed methods. The results segmented image that has been presented in Table 1.

| No Image | The First Image of Plasmodium | Segmentation Thresholding | Watershed Segmentation |
|----------|-------------------------------|---------------------------|------------------------|
| 302      |                               |                           |                        |
| 108      |                               |                           |                        |
| 7        |                               |                           |                        |
| 170      |                               |                           |                        |

Based on Table 1, the result of the segmentation method that uses the thresholding algorithm visible parasites segmentation results follows the layout, and its position is good for the image of the original image file with the numbers 302, 108, 7, and 170. The difference in color in the original image that impressed plasmodium falciparum darker (as indicated by the orange arrows) is shown as a parasite value of a specific color. The thresholding segmentation process will segment the original image based on the black and white to detect color differences, resulting in an image that is segmented and can be regarded as a parasite is detected.

The results of the segmentation method are visualized in Table 1, that shows that the main focus is segment parasite Plasmodium falciparum by using information such as the value of the high frequency of each object with a process that is done which is to make an object that has a degree of gray the same into an area restricted same "checkerboard" or a boundary line as can be seen in the black arrows. Dam line or a boundary line in the column shown Watershed segmentation results tend to congregate and have a line of the highest dam in an area only objects that have the same degrees of gray, it can be said that the segmented line is the parasite plasmodium.
3.2. Qualitative analysis of images of *Plasmodium falciparum*

The process is done the same as the previous step, where the second test is a test of the original image *Plasmodium malaria* segmented using thresholding and watershed segmentation method. The results of which have been segmented image are presented in Table 2.

### Table 2. Results Visualization Malaria Plasmodium Image Segmentation.

| No Image | The First Image of Plasmodium | Segmentation Thresholding | Watershed Segmentation |
|----------|-----------------------------|--------------------------|------------------------|
| 289      | ![Image 289](289)            | ![Segmentation 289](289) | ![Watershed 289](289)  |
| 294      | ![Image 294](294)            | ![Segmentation 294](294) | ![Watershed 294](294)  |
| 306      | ![Image 306](306)            | ![Segmentation 306](306) | ![Watershed 306](306)  |
| 307      | ![Image 307](307)            | ![Segmentation 307](307) | ![Watershed 307](307)  |

Based on Table 2, visualization of all four sample images taken, the results of field image segmentation thresholding can be said appropriate layout and position of objects parasites are consistent with the image of the parasite designated at arrows orange is good for images with file numbers 505, 541, 552, and 564. The shape seen in any *Plasmodium vivax* malaria plasmodium looks similar to but slightly inclined oval. The results of the Watershed segmentation methods are visualized in Table 2 is a clearer segmented part of its parasites, although there is still a noise that helped segmented other cells. The results of this segmentation method can be said to successfully visualize the image of the parasites that make up the dam on a certain object, as shown in black arrows.

The total of testing samples are used to segment images using the thresholding and watershed methods amounted to 20 samples in each plasmodium, which in this chapter is only displayed by 4 sample images of each plasmodium to simplify and clarify the image visualized. Overall image data *Plasmodium falciparum*, malaria, and vivax has a total of 60 samples of plasmodium images.

3.3. Qualitative analysis of *Plasmodium Vivax* image

The last test is a test of the original image of the *Plasmodium vivax* segmented using thresholding segmentation method and Watershed segmentation method. The results of the segmented image that has been presented in Table 3.
Table 3. Results of Visualization Image Segmentation Plasmodium vivax.

| No Image | The First Image of Plasmodium | Segmentation Thresholding | Watershed Segmentation |
|----------|-------------------------------|---------------------------|------------------------|
| 505      | ![Image of 505]               | ![Thresholding of 505]    | ![Watershed of 505]    |
| 541      | ![Image of 541]               | ![Thresholding of 541]    | ![Watershed of 541]    |
| 552      | ![Image of 552]               | ![Thresholding of 552]    | ![Watershed of 552]    |
| 564      | ![Image of 564]               | ![Thresholding of 564]    | ![Watershed of 564]    |

Based on Table 3, visualization of all four sample images taken, the results of field image segmentation thresholding can be said appropriate layout and position of objects parasites are consistent with the image of the parasite designated at arrows orange is good for images with file numbers 505, 541, 552, and 564. The shape seen in any Plasmodium vivax malaria plasmodium looks similar to but slightly inclined oval. The results of the watershed segmentation methods are visualized in Table 3 is a clearer segmented part of its parasites, although there is still a noise that helped segmented other cells. The results of this segmentation method can be said to successfully visualize the image of the parasites that make up the dam on a certain object, as shown in black arrows.

The total of testing images are used to segment image using the thresholding and watershed method actually amounted to 20 samples in each plasmodium image, which in this chapter is only displayed by 4 sample images of each plasmodium as to simplify and clarify the image visualized. Overall image data Plasmodium falciparum, malaria, and vivax has a total of 60 samples.

3.4. Quantitative analysis of Plasmodium image

Quantitative analysis includes a discussion of average results of the accuracy of segmented images and the computation time of methods to segment each plasmodium image. The following results of accuracy values shown in Table 4. Based on Table 4, the accuracy of each plasmodium images is obtained from 20 samples of malaria image with a total of 60 images that have been segmented using two algorithms. The final result shows that the thresholding method can segment 100% accuracy for the plasmodium falciparum, malaria, and vivax images. The accuracy of watershed methods produces a value of 90% on the segmentation of plasmodium falciparum images. There are 2 data from the 20 images that do not succeed in segmentation using this method, but the results can be good for the accuracy level is still at the level of 90 to 100%. Averages of computing time for both methods are presented in Table 4.
Table 4. Value Segmentation Accuracy

| Image Type        | Accuracy (Correct / Total P * 100% * 100)% |
|-------------------|--------------------------------------------|
| Thresholding      | Watershed                                  |
| Plasmodium falciparum | 100% / 90%                                 |
| Malaria Plasmodium | 100% / 100%                                |
| Plasmodium vivax   | 100% / 100%                                |

Table 5. Average Value Time Computing Plasmodium

| Type Plasmodium | Average Time |
|-----------------|--------------|
|                 | Thresholding | Watershed   |
| Plasmodium falciparum | 1.64±0.12    | 3.87±0.10   |
| Malaria Plasmodium   | 1.56±0.07    | 3.91±0.13   |
| Plasmodium vivax     | 1.53±0.04    | 3.84±0.18   |

The average value of the thresholding segmentation method's computing time is for 1-2 seconds with a standard deviation value with a range that is not too much different. The watershed segmentation method has an average computing time of 3-5 seconds. This is due to the segmentation process has stages that are more complex than the thresholding segmentation method.

4. Conclusion

Based on the results of research and design that has been done, it can be concluded that the method of thresholding segmentation generates value accuracy and better computing that is equal to 100% by the average value of computation time for 1-2 seconds, compared to using watershed segmentation method that is equal to 90% the accuracy of the average computation time for 3-4 seconds for the image of the type of malaria parasite plasmodium falciparum, plasmodium malaria, and plasmodium vivax. The results of this study are expected to be improved and developed for future research. Therefore, it is very expected to do an advanced stage development through the classification system and a sample of the parasite plasmodium variations, such as plasmodium ovale.

5. References

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