A Simple and Easy-to-Use Tool for Detecting Outer Contour of Leukocytes Based on Image Processing Techniques

Retno Supriyanti, Best Leader Nababan, Yogi Ramadhani, Wahyu Siswandari

***Abstract*—** Blood cell morphology is an important parameter in a hematology test. Currently, especially in developing countries, many hematology is done manually, either by physicians or laboratory staff. According to the limited ability of the human eye, therefore the examination based on manual method will resulting in a lower precision and accuracy of the results obtained. In addition, the limited number of medical personnel in developing countries, the hematology test by manual will further complicate the diagnosis in some areas that do not have competent medical personnel. This research aims to develop a simple tool in the detection of blood cell morphology-based computer. In this paper, we focus on the detection of the outer contour of leukocytes. The results show that the system that we developed is promising for the detection of blood cell morphology automatically. Thus the issue of accuracy, precision and limitations of competent medical personnel who can be resolved.

***Keywords*—**morphology operation, developing countries, hematology test, limitation of medical personnel

I. Introduction

BLOOD is a living tissue that circulates around the entire body with the intermediary network of arteries, veins and capillary, which carries nutrients, oxygen, antibodies, heat, electrolytes and vitamins to the tissues throughout the body. Blood in the human body contains 55% of blood plasma (blood fluid) and 45% of cells (blood solid). The amount of blood that is on the human body which is about 1/13 of the adult body weight or about 4 or 5 liters. Human blood consists of blood plasma, globules fat, chemical substances (carbohydrates, proteins and hormones), and gas (oxygen, nitrogen and carbon dioxide). While the blood plasma consists of red blood cells (erythrocytes), white blood cells (leukocytes) and platelets (thrombocytes) [1].

The process of leukocytes identification is one of the parameters within the scope of hematology. The process of leukocytes identification are useful for identifying the morphology of leukocytes which will be used for the calculation of the number of leukocyte cells.

In general, the medical team of both physicians and medical laboratory assistants identifying leukocyte cell morphology manually so the chances of identifying differences in results between physicians with each other**.**

According to this problem, there are some researches discuss about this topic. Ajala [2] analyzed a red blood cell image using watershed transformation, and edge based segmentation; their corresponding results were compared in which watershed transformation of the red blood cell outperformed the edge based segmentation of the red blood cell. Panchbhai [3] developed an automating process of blood smear screening for malaria parasite detection based on used of RGB color space, G layer processing, and segmentation of Red Blood Cells (RBC) as well as cell parasites by auto-thresholding with offset value and use of morphological processing. Madhloom [4] focuses on localization and segmentation of lymphoblast cells using microscopic images. The intended goal is to localize the blast cells, and then completely separate them from the image scene to be put on small sized sub-images that can fit a single cell. Djawad [5] conducted an experiment of rabbit liver reaction to the antioxidant from clove leaves using immune-histochemical techniques. The experiment revealed the effect of the antioxidant to the rabbit liver cells under hypercholesterolemia condition which showed by different color to the cell surface after the antioxidant has been given. Abbas [6] proposed an automated system for counting the number of red blood cells. Harbi [7] developed an application of image segmentation, feature extraction, selection and cell classification to the recognition and differentiation of normal cell from the blast cell. Liu [8] proposed an algorithm based on morphological segmentation and a fuzzy neural network. The morphological segmentation process comprises three operational steps: top-hat transformation, Otsu's method, and image binarization. Following initial screening by area and circularity, fuzzy c-means clustering and the neural network algorithms are used for secondary screening. Subsequently, the erythrocytes are screened by combining the results of five images obtained at different focal lengths. Reta [9] proposed a contextual analysis methodology for the detection of acute leukemia subtypes from bone marrow cells images. Su [10] proposed a new white blood

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cell classification system for the recognition of five types of white blood cells. They proposed a new segmentation algorithm for the segmentation of white blood cells from smear images. Maitra [11] proposed an approach to automatic segmentation and counting of red blood cells in microscopic blood cell images using Hough Transform. Detection and counting of red blood cells have been done on five microscopic images.

In our research we aim to develop a simple and easy-to-use tool for detecting and screening leukocytes in order to classify between normal and abnormal cell for diagnosing leukemia disease. In our previous research [12][13][14] we implemented image processing techniques for low resolution medical imaging. The results show that by implementing image processing techniques could improving image quality and very helpful in diagnosis in rural areas. However, because of the system we will develop quite widely, in this paper we will focus on the development of simple tools to detect outer ring contour of leukocyte cells.

II. METHODS

A. Data Acquisition

This data acquisition phase involves taking a microscopic image of white blood cells. Data retrieval performed in General Hospitals "Prof. Dr. Margono Soekarjo", Purwokerto, Central Java, Indonesia. Figure 1 shows an example of input image that will be use in our experiment.

Figure 1. An example of input image

B. Graphical User Interface Design

In this phase consists of, the process of making the required operation algorithm and user interface design, the detection of the outer contour of leukocytes by using the GUI (Graphical User Interface) in Matlab R2013a. GUI is a graphical user interface built with graphic objects such as buttons (push button), text boxes, sliders, menu and others [15]. The advantages of using GUI are follows: (i) GUI is widely used and is suitable for applications-oriented science. (ii) The GUI has a built-in function that is ready for use. (iii) The size of the file, both FIG-file and M-file, which generated a relatively small.

The operations required in the detection of the outer contour of leukocytes consists of template matching operation, setting the threshold value image, dilation, erosion, opening, and closing. After making algorithms such operations, and then create a user interface design of the outer contour detection of leukocytes with GUI. Figure 2 shows our GUI design.

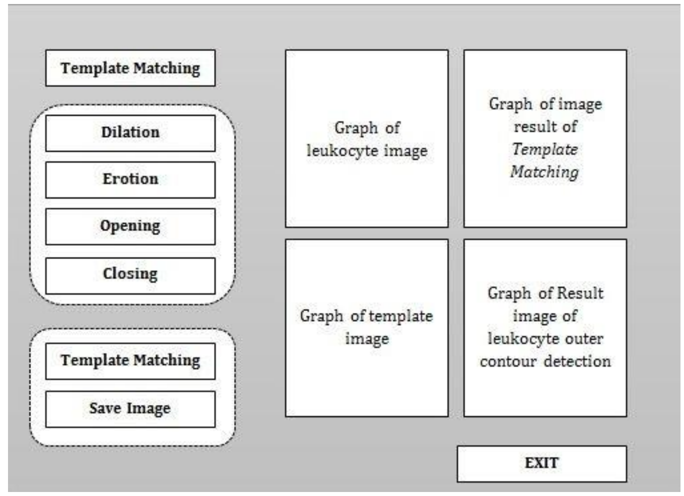


Figure 2. User interface design of leukocyte outer contour detection using morphology operation

C. Data Analysis

The first thing to do in analysis data phase is the reading of the image to be processed. In this case is a microscopic image of leukocyte cells. It also determines the image to be used as a template image for template matching process. The images are saved in .jpg format.

The next process is the template matching process. Template matching aims to detect microscopic image part leukocyte cell based databases that have been determined using a template image. After detection is successful, it will be cropping on the detected part for will be processed by morphological operations. Image cropping result is a grayscale image. The image is then converted into a binary scale. After cropping image is obtained, the image set its threshold value, by using adaptive threshold in which each image has a different threshold value. Setting the threshold value function to facilitate the detection of the outer contour of the image when done morphological operations. Then on that image, morphological operations will be carried out through several operations, namely dilation, erosion, closing and opening.

Dilation is the process of merging dots background (0) become part of the object (1), based on the structuring element S used and expressed by Equation 1.

$$A \oplus B = \left\{ z \middle| \left[\left(\hat{B} \right)_z \cap A \right] \subseteq A \right\} \quad \text{(Eq1)}$$

Erosion is the process of elimination of points of objects (1) to be part of the background (0), based on the structuring element S used and expressed by Equation 2.

$$A \ominus B = \{ z | (B)_z \subseteq A \} \quad \text{(Eq2)}$$

Opening a process of erosion followed by dilation. The resulting effect is the disappearance of small objects and thin, breaking objects at points thin, and generally smooth the boundary of a large object without changing the object area significantly and expressed by Equation 3.

$$A \circ B = (A \ominus B) \oplus B \quad \text{(Eq3)}$$

Closing is a process of dilation followed by erosion. The resulting effect is to fill small holes in objects, combine objects together, and generally smooth the boundary of a large object without changing the object area significantly and expressed by Equation 4.

$$A \bullet B = (A \oplus B) \ominus B \quad \text{(Eq4)}$$

III. RESULTS AND DISCUSSIONS

In our experiments the process of object recognition input image with templates take a long time, because the object recognition done per pixel. The greater input image pixels then the time required in the process of object recognition will be longer. And a pixel size image template matching leucocyte cells are shown in Table 1. selected. Pixel size and the time required to perform template matching process is shown in Table 1.

Table 1. Pixel size and time required

No	Image	Pixel size	Time
1.	IMG_0599.jpg	640x480	3 minute
2.	IMG_0622.jpg	640x480	3 minute
3.	IMG_0855.jpg	640x480	3 minute
4.	IMG_1914.jpg	640x480	3 minute
5.	IMG_2104.jpg	960x720	4 minute

According to Table 1, it can be seen that the quantity of time required by the image IMG_0599.jpg, IMG.0622.jpg, IMG_0855.jpg, and IMG_1914.jpg, is smaller than the image IMG_2014. This is caused by the pixel values of each image so that the image template matching process takes the longest is the image IMG_2104.jpg because it has the largest pixel size.

Through the template matching stage, can set the template most suited to recognize any image of leukocyte cells. Terms defined template for template matching stage is when the template is able to recognize and detect objects in each image of the leukocyte cell. Each image template will be tested to the individual leukocyte cell image and will be determined which of the most widely recognized and detect objects in the leucocyte cells images. Figure 3 shows an example of template matching process in our experiments.

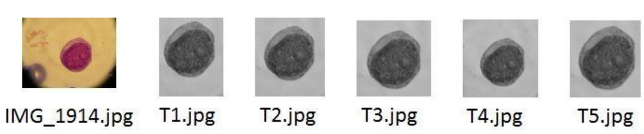


Figure 3. An example of template matching process

According to Figure 3, it can be seen that each template has different performance, which is based on the number of detection results of each template. Template to be set for the phase matching template is a template that has the best performance, which is close to 100%. Table 2 shown the performance of each template image in our experiments. According to Table 2, can be determined that the best template for all leukocyte cell image for template matching process is T4.jpg, because the image of the most widely recognized and detect objects in the leucocyte cells image with percentages close to 100%.

Table 2. Template image performance

No	Template Image	Performance
1	T1.jpg	80%
2	T2.jpg	80%
3	T3.jpg	80%
4	T4.jpg	98%
5	T5.jpg	85%

In this experiment, to determine the threshold value using Adaptive Threshold. The threshold value setting is done by shifting the Scroll buttons of Threshold set. Users are welcome to set the threshold value of the image itself for getting the best part. The result is an image in a binary scale. The aim to set threshold value for each image is to facilitate morphological operations therefore will give result as we desired. Figure 4 shows an example of setting threshold value in an image.

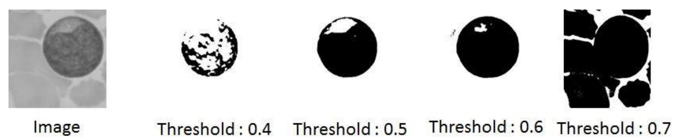


Figure 4. An example of setting threshold value

According to Figure 4, image threshold value corresponding to the morphology operation is carried out by 0.6. In this experiment to be detected is the outer contour of leukocyte cells, then the threshold value makes the image look more clearly with minimal noise around the object is 0.6 compared to the current threshold value of 0.4, 0.5, or 0.7.

The next stage is the detection of the outer contour of leucocyte cells with morphological operations, namely the operation of dilation, erosion, opening, and closing. Morphological operations require the element structure which will have an impact on the object. Type element structure used in this experiment is the 'disk' because the shape of an object to be analyzed is oval. In addition, the shape of the disk can provide a uniform effect in all directions

The first morphological operation is dilation. Template matching image result showed that leukocyte cell as an object is black while the object background is white. Based on the basic theory that has been described previously, when the dilation operation is applied then the object leukocyte cells is undermined as a result of their merger process background dots become part of the object. The amount of erosion is adjusted to the radius of the element structure. Radius structure element used is 2. The purpose of the small radius of the object is to avoid the erosion of leukocyte cells that are too big. Figure 5 shows an example of using dilation operation.

The next operation is erosion. Based on the basic theory that has been described previously, when the erosion operation is applied then the object leucocyte cells undergo broadening effects due to the elimination of points of the object to be part of the background.

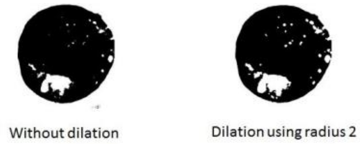


Figure 5. An example result of dilation operation

The amount of dilation is adjusted to the radius of the element structure. Similarly, the dilation operation, radius structure element used is 2. Figure 6 shows an example of erosion operation.

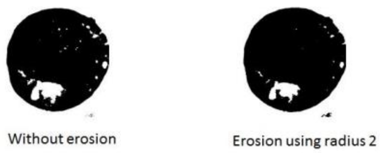


Figure 6. An example result of erosion operation

The next operation is opening. The resulting effect is the disappearance of small objects and thin, breaking objects at points thin, and generally smooth the boundary of a large object without changing the object area significantly. The magnitude of the effect is adjusted by the amount of structure element radius. Radius structure element used in the operation opening is 8. Using a larger radius than the radius of the operations of dilation and erosion is due to the nature of the operation opening is idempotent. Idempotent is the nature of the operation when repeated opening did not leave a lasting impact. Figure 7 shows an example of opening operation.

Figure 7, an example result of opening operation

The last operation is closing. Closing is a process of dilation followed by erosion. The resulting effect is to fill small holes in objects, combine objects together, and generally smooth the boundary of a large object without changing the object area significantly. Similarly, the opening operation, closing operation is idempotent ie when the closing operation is repeated does not provide a sustainable impact, so that the structure element radius used was 8. Figure 8 shows an example of closing operation.

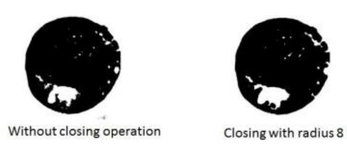
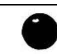
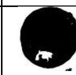


Figure 8. An example of closing operation

Table 3 shows an example of morphological operations are performed in this experiment. According to Table 3, it can be seen that not all images need morphological operations. To obtain the outer contour of leucocyte cells, Img 1 Img 2 Img Img 3 and 4, applying morphological operations. whereas Img 5 apply erosion operations only. This is caused by the threshold value setting, where the image of the threshold value setting outer contour has shown that quite clear.

Table 3. Examples of morphological operation result

No	Image	Number of operations				Result
		Dilation	Erosion	Opening	closing	
1.	Img1	13 x	1 x	2 x	2 x	
2.	Img2	1 x	7 x	2 x	2 x	
3.	Img3	1 x	1 x	1 x	1 x	
4.	Img4	1 x	1 x	1 x	1 x	
5.	Img5	-	2 x	-	-	

IV. CONCLUSIONS

Based on the findings outer contour detection of leukocytes with morphological operations, it can be concluded: (i) System User Interface, it can identify the outer contour of leukocytes with morphological operations such as the operation of dilation, erosion, opening, and closing. Each image morphology operation carried out with a number of different treatments, tailored to the needs of each image of the leukocyte cell. (ii) The system can detect the outer contour of leucocyte cells in large numbers, because the process of inputting the image data by the users themselves. (iii) Each image has a threshold value that is different so that the setting value using adaptive threshold method, ie setting the threshold value based on the pixel values of each image. (iv) The process of template matching, on each image takes a different, because the object recognition done per pixel. The greater the input image pixels, then the time required in the process of object recognition will be longer.

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