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Segmentation of White Blood Cell Nucleus Using Active Contour

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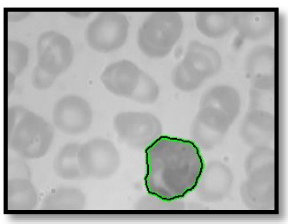
Graphical abstract



Abstract

Image processing comes with various techniques. It uses a series of framework to transform an input image into an output image. In recent times, image processing technique has been extensively used in medical area. In order to overcome the problems of manual diagnosis in identifying the morphology of blood cells, the automated diagnosis is often used. Manual diagnosis required the observation of blood sample by expert hematologist and pathologist. This method may suffer from the presence of non-standard precision of human visual inspection. Due to this problem, this paper focused on semi-automated diagnosis that used image processing technique to perform the segmentation of the nucleus in white blood cell (WBC). Several image processing techniques are used including the active contour method. The results obtained are based on the parameter values obtained from segmentation process. The parameter value is calculated from the roundness equation. The value of 0.80 can be used to describe as a single leukocyte.

Keywords: Image processing; white blood cell; active contour

Abstrak

Pemprosesan imej datang dengan pelbagai teknik. Ia menggunakan satu siri rangka kerja untuk mengubah imej input dalam menghasilkan imej output. Sejak kebelakangan ini, teknik pemprosesan imej digunakan secara meluas dalam bidang perubatan. Dalam usaha untuk mengatasi masalah diagnosis manual dalam mengenalpasti morfologi sel-sel darah, diagnosis automatik sering digunakan. Diagnosis manual memerlukan pemerhatian sampel darah dari pakar hematologi dan ahli patologi. Kaedah ini boleh menyebabkan kurang ketepatan dari piawai penglihatan manusia. Oleh kerana masalah itu, kertas kerja ini memberi tumpuan kepada diagnosis semi automatik yang menggunakan teknik pemprosesan imej untuk melakukan segmentasi pada nukleus sel darah putih (WBC). Beberapa teknik pemprosesan imej digunakan antaranya kaedah kontur aktif. Keputusan yang diperolehi adalah berdasarkan kepada nilai parameter yang dapat dari proses segmentasi. Nilai parameter dikira daripada persamaan bulat itu. Nilai 0.80 boleh digunakan untuk menggambarkan sebagai leukocyte tunggal.

Kata kunci: Pemprosesan imej; sel darah putih; kontur aktif

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1.0 INTRODUCTION

Blood is a life sustaining fluid which circulates through the heart and blood vessels [1]. It consists of plasma, buffy coat and red blood cells. The buffy coat composes of cells known as white cells. The white blood cell or leukocyte is produced in human body to provide immunity. In healthy human there are at least five types of white cell which are neutrophil, eosinophil, basophil, lymphocyte and monocyte. These types are named based on the shape of the nucleus itself. The nucleus is composed of chromatin, which are mainly deoxyribonucleic acid (DNA) carrying genetic messages.

There are many diseases related to red blood cells and white blood cells. One example is anemia, which is related to red blood cells. As the hemoglobin amount in the blood decreases, iron deficiency anemia happened. A common type of anemia is sickle cells anemia where the body of a patient produces sickle-shaped (‘C’ shaped) red blood cells rather than the normal disc-shape. These sickle cells can be examined under the microscope. Other than sickle cells, the malaria disease also attacks the red blood cells morphology. It is due to parasitemia of the blood. A common illness related to white blood cells is leukemia. It is a cancer type disease that develops in the bone marrow. There are four major types of leukemia such as acute lymphoblasticleukemia (ALL), acute myeloid leukemia (AML), chronic lymphocytic leukemia (CLL) and chronic myelogenous leukemia (CML). For ALL type, it will attack a group of leucocytes that call lymphocytes. It normally affects children and adults aged over 50 years [2].

These blood diseases are normally examined based on the morphology of the nucleus of white blood cells. It has a unique feature which can be observed visually via manual methods by using microscope by a hematologist or skilled laboratory officer.

In order to reduce errors in manual diagnosis, there are a lot of automated methods using image processing techniques that have been proposed in this medical diagnosis area. Most of these methods are used in order to diagnose the disease based on the morphological of blood cells. By applying image processing methods on blood cell images, clinical costs can be decreased for decision making by hematologist and pathologist. This is because it is a software based improvement compared to other methods using costly hardware for blood cell counting [3]. The benefits of visual sample inspection include identifying abnormalities in blood samples accurately, efficiently and faster detection [4].

1.1 Image Segmentation

Image segmentation is one of the crucial parts in image processing. It will subdivide an image into its constituent regions or objects. After the object of interest has been isolated, the process will stop. Based on existing research on image segmentation, there are about seven types of image segmentation [5]. First is segmentation based on edge detection, which is gray histogram technique and gradient based method. Thresholding method has widely been used in this area. Next is region based segmentation method which included region growing and region splitting and merging. Snakes, level set model, Mumford Shah model and C-V Model are examples of segmentation method based on PDE (Partial Differential Equation). Image segmentation based on PDEs is mainly carried out by active contour model or snakes. Other than that, there are also segmentations based on Artificial Neural Network. The segmentation based on clustering include of hard clustering and fuzzy clustering. Lastly is multi-objective image segmentation. These included the conventional Weighted Formula Approach (WFA) and Pareto Approach (PTA). There are also other image segmentation techniques including thresholding, such as Otsu's method; color based segmentation using K-means clustering, transform methods such as watershed segmentation, and texture methods such as texture filters.

1.2 Active Contour or Snake

For object segmentation, the active contours are well known and it is widely adopted in various forms for biological image analysis.The active contour models or snakes detect the objects in the image using evolving a curve. The curve is started around the detected object and moves toward its interior normal. When the curve reaches the boundary, it will stop from moving [6]. From that, the curves occur will present the shape of the object detected.

The snake model [7] is presented in Equation (1),

$$J_1(C) = \alpha \int_0^1 |C'(s)|^2\, ds + \beta \int_0^1 |C''(s)|\, ds - \lambda \int_0^1 |\nabla \mu_0(C(s))|^2\, ds \tag{1}$$

where α , β and λ are positive parameters. The first two terms control the smoothness of the contour (the internal energy), while the third term attracts the contour toward the object in the image (the external energy). By minimizing the energy in Equation (1), the curve is located by using the points of maxima $|\nabla \mu_0|$ which acts as an edge-detector while keeping the smoothness in the curve (object boundary).

In the study by Sadeghian *et al*. [8] the canny edge detection is applied besides the active contour method. The edges occur would not be missed out [8]. By that, the nucleus of white blood cell can be segmented from the cytoplasma.

1.3 Related Research

In order to count the red blood cells, the shapes of the cells are processed with the Hough Transform algorithm [9]. This technique is used with four other steps, namely, acquisition, segmentation, features extraction and estimating. The first process is acquisition, followed by image enhancement, red blood cells segmentation and extraction, and lastly, count and analyze the number of red blood cells.

During the enhancement process, an analysis was done in hue-saturation value color space (HSV) and the green component image. The saturation component,S, is processed because this S image can clearly show the bright objects for easy detection of red blood cells. Other than that, the Hough Transform is also used to detect the rough circular boundary of each blood cell [10]. It is a Hough Transform for circular shape detection to locate the circle shape [11]. This Hough Transform technique has been used in malaria diagnosis. The technique was used as the second step in segmenting red blood cells to determine the denominator of the parasitaemia percentage [12].

Global thresholding were implemented to obtain erythrocyte and other blood cell components in each image. These techniques were used to detect the presence of malaria parasite from *Plasmodiumfalciparum* species. By using multiple thresholds, the components of the parasite inside erythrocyte were segmented [13].

■2.0 EXPERIMENTAL

2.1 Experimental Setup

In order to do segmentation of white blood cell nucleus from a microscopic blood cell image, an experiment is carried out. The image of blood cell is focused to the area where white blood cells are detected. The blood images dataset from MATLAB file exchange are used in acquisition step. To acquire those dataset images from the blood slide, it needed a 100x objective lens and the resolution is 640x480 pixels [14]. In this experiment, the software used is MATLAB software.

2.2 Framework

The experiment framework shown in Figure 1 is used in the study. The steps are followed by original image acquisition, some preprocessing techniques and then process using snake algorithm and calculate the parameter of WBC. This original image is in conventional RGB (Red, Green, and Blue) color format.

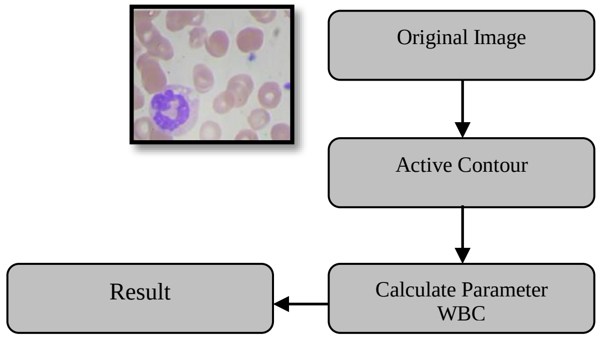


Figure 1 Proposed framework

For the preprocessing steps, it includes changing the images to grayscale. Then, the segmented images are converted into binary image in form of 0 and 1 where 0 represent black and 1 is white.

Next step is in quantitative part which is needed to calculate the parameter of the binary image. The parameter is calculated based on the roundness equation in Equation (2).

$$\text{Roundness} = \frac{4\, x\, \pi\, x\, area}{perimeter^2} \qquad (2)$$

In order to measure the circularity of the object, the roundness equation is used and can be obtained as the ratio of the area of an object to the area of the circle [2].The roundness value also can be used in order to classify the shape of the white blood cell nucleus.

■3.0 RESULTS AND DISCUSSION

The initial point is selected on original image by referring to the boundary edges. It is chosen randomly and can be at any part of the edges or even across the boundaries. This initial point is used to find the edges. Figure 2 shows the original image of white blood cell.

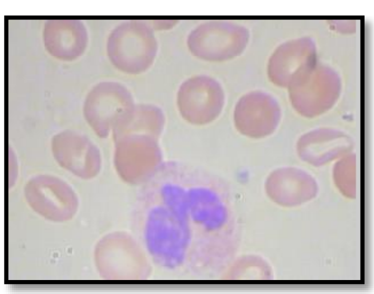
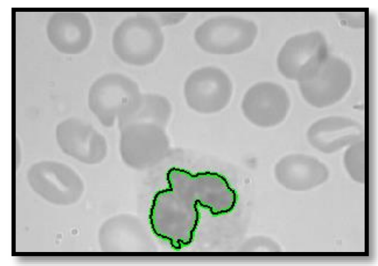


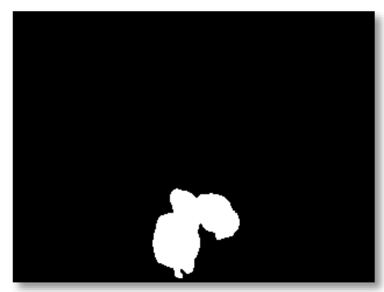
Figure 2 Original image of white blood cell

Figure 3(a) shows the image of segmented white blood cell. Those images are processes using the active contour or known also as snake algorithm. Then, the next step is converting those images to binary before the parameter of the cell is calculated. Figure 3(a) and (b) shows the binary image and image of calculated parameter. The calculated parameter is from the roundness equation. From the previous research, the roundness value of 0.80 can be used to describe as single leukocyte from groups of leukocytes [2]. In this research, the calculated parameter can be used as the parameter in order to classify between the normal nucleus and abnormal nucleus. For the other shape of white blood cell nucleus, the value can be determined by referring to value of normal white blood cell nucleus.

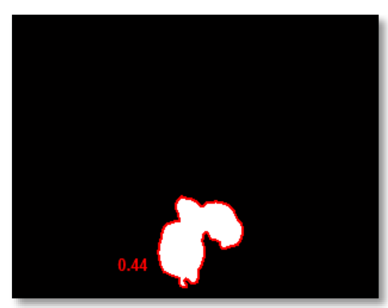
Figure 4 shows several segmented image white blood cell and calculated value of parameter of segmented image. The value of parameter can be used to classify the types of white blood cell. Based on the value of parameter get from experiment, the type of cell can be defined. Table 1 shows the value of parameter which represents the types of cell observed. From the result, the parameter values from 0.80 and above shows that it is a single leukocyte cell.



(a)



(b)



(c)

Figure 3 (a) Segmented image (b) binary image (c) calculated parameter of segmented image

■4.0 CONCLUSION

In this paper, an experiment was conducted to identify the white blood cell nucleus using active contour technique. This method provides an accurate curve of the boundary edge of the cells. By referring to the calculated parameter with previous research, the segmentation process for white blood cell nucleus is performed efficiently. The experiment will be continued with classification of the types of white blood cell.

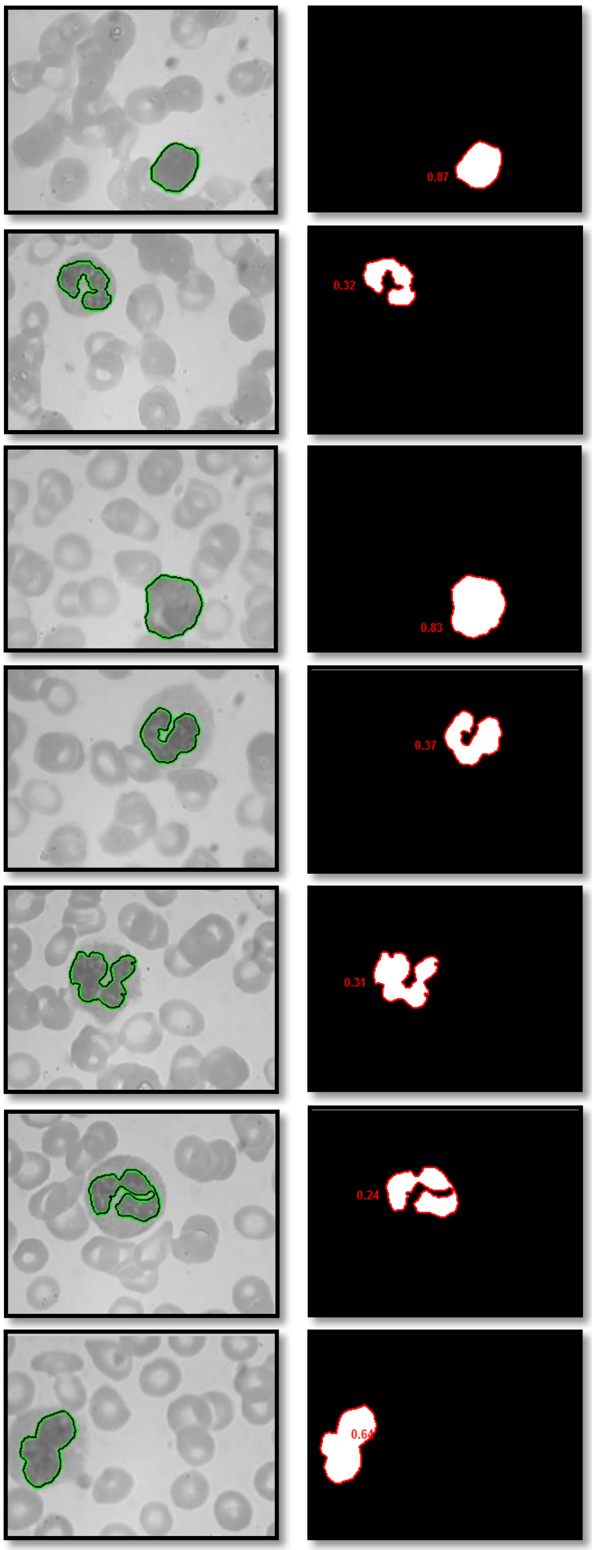


Figure 4 Several segmented image and calculated parameter of segmented image

Table 1 Value of parameter represent types of cell

Entry	Value of Parameter	Type of cell
1	0.44	Band Neutrophil
2	0.87	Lymphocyte
3	0.32	Eosinophil
4	0.83	Lymphocyte
5	0.37	Eosinophil
6	0.31	Eosinophil
7	0.24	Polymorphonuclear Neutrophil
8	0.64	Monocyte
9	0.41	Band Neutrophil
10	0.85	Lymphocyte
11	0.56	Monocyte
12	0.64	Monocyte

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