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Research paper

Blood Cells Counting Using Modified Circular Hough Transform

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Abstract

The number, size and shape of blood cells are used to diagnose the various types of diseases such as leukemia, dengue, malaria and etc. Manual cell counting is a traditional method to count the number of cells and to acknowledge the state of a person's health conditions based on the blood content. Problems using the manual cell counting under the microscope are time consuming and able to give errors. Therefore, we proposed a method to detect and determine the total number of blood cells by using Modified Hough transform (MHT) method. The blood cells image is analyzed using the developed algorithm in MatLab. In image processing, the process involves preprocessing and segmentation to find the radius range of cells. Then, MHT method is used to determine the number of blood cells based on the radius range of cells. Sixty samples of human blood cell image were tested and the accuracy is 94%

Keywords: *Blood cell; Modified Hough Transform; Image Processing; MatLab, Peripheral Blood Smear*

1. Introduction

Human blood cell mainly contains erythrocytes (RBC), leukocytes (WBC) and thrombocytes (platelets) [1]. The types of diseases can be identifying by observing and counting the blood cells. Blood cell count is one of the methods used in medicine to detect a variety of diseases such as dengue, thalassemia, leukemia and etc. Nowadays, hematology analyzer machine performs an accurate determination of blood cell count. However, the machine is very expensive and unaffordable by the third-world country. Furthermore, it requires a large volume of samples, bulky and requires competent personnel for operations and special maintenance.

Manual cell counting using hemocytometer is a common procedure in medical facilities. It is performed by a hematologist to estimate the number of cells in a sample given and it depends on physician skills to prepare the blood cell samples. The disadvantage using manual counting of blood cells is totally time consuming, tedious, possibility to give inaccurate result and human errors [2]. The problem using manual counting is time consuming because if any interruption during the counting process will effected the result accuracy and need to repeat the process which is wasting both time and energy. Besides that, the identification of disease cells is a difficult task that is normally done by an experienced human using an optical microscope. For example, 100 samples of blood need to be analyzed and the amount of cell counting depends on the hematologist. The problem is the manual cell counting is not computerized. Therefore, hematologist needs to enter the data into a computer system manually and this is a very time-consuming task.

Image processing techniques can help the hematologist in their analysis and diagnosis. Image processing is used to modify a cell picture to enhance the image quality that able to be can be analyzed in various applications for example in the result accuracy and time consuming [3]. The major steps in image analysis are pre-processing, image segmentation, feature extraction and counting [4].

This study is to upgrade the capability of existing hematological microscopic systems. A simple and easy maintenance method of cells counting system is to be developed. The system is operated by capturing blood smear slides using a camera that attached on the microscope. The image taken is analyzed and counted the total blood cells number using Modified Hough transform (MHT) method.

2. Related Work

Recently, researchers tend to use image processing as the method for counting the cells automatically. The method has the advantages of reducing the time and effort required for counting, price of the system and also gives us a non-biased. From the image of blood cells RBC, WBC and platelets several analysis has been conducted to automate the process of analyzing cells. The information features of cell such as shapes, sizes, area, perimeter, color and the number of cell can be analyze and extracted by using image processing.

There are several methods for detection and counting blood cells. The process of counting blood cells on the smear image requires four steps; acquisition (input image), image enhancement, segmentation and extraction, and counting. Image segmentation is the process of

partitioning the image into a set of object and background. The most popular techniques for image segmentation are Hough transform [5][6][7][8][9][10], watershed [3], K-means clustering [11][12], neural network [13][14][15], active contour [16] and border detection.
In segmentation process, previous researches have suggested different methods for blood cell segmentation. Chitade *et al.* [11] present the image segmentation based on the color features from the image by using Lab color space and K-means clustering to extract the interest cell from the other cells.
Mahmood *et. al* [5] used the Hough transform to count the number of RBC. The process was started with the image enhancement process which were the hue saturation color space (HSV) and the component image of green color to differentiate the RBC with other cells giving the result of bright objects. Then, the images go through the segmentation process to extract the object from the background. The final process is to perform the Hough transform (HT) technique. The radius of RBC was determined by using the MatLab function 'imdistline' and used as the input parameter for HT to find the center point of the circle of cells. This work is able to estimate the number of RBC and the segmentation process to extract the RBC from the other cells. However, the time taken to obtain the input parameter such radius of the cell is longer and the improvement is needed. Considering that the most of the cells are circular shapes, the circular Hough transform detection algorithm is employed in this project for segmentation cell.

3. Method

3.1. Sample Image

The blood smear slide is obtained from the KPJ Specialist hospital Johor Bahru and Kempas Medical Centre as the blood sample images. The blood smear had been stained by Leishman stain giving WBC and platelet purplish in colour. The blood cell's image (Figure 3.1) is captured in RGB format by using the inverted fluorescence microscope (Olympus BX51, Japan). These image setup and maintained by a haematologist from Institute Medical Molecular Biotechnology, UITM Sungai Buloh Campus, Selangor.

3.2. Image Processing

The first steps is the blood cell image as shown in Figure 3.1 is converted into a grayscale image used the 'rgb2gray' function in MatLab.

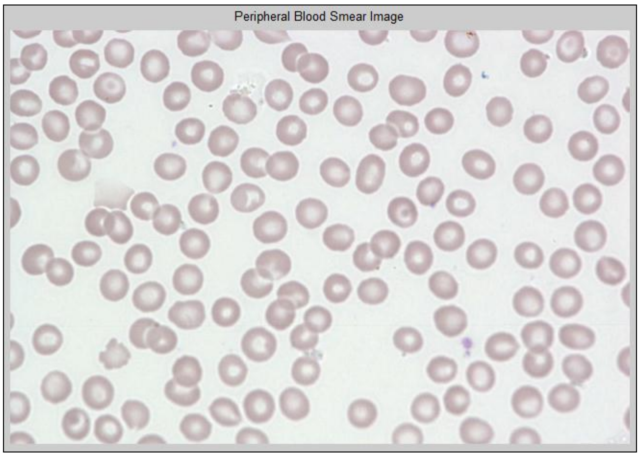

Figure 3.1: Input image

Next step is to convert the greyscale image into binary image as shown in Figure 3.2. The step is continued to clear the border image to obtain the accurate result during measure the minor axis length of RBC. The result is shown in Figure 3.3.

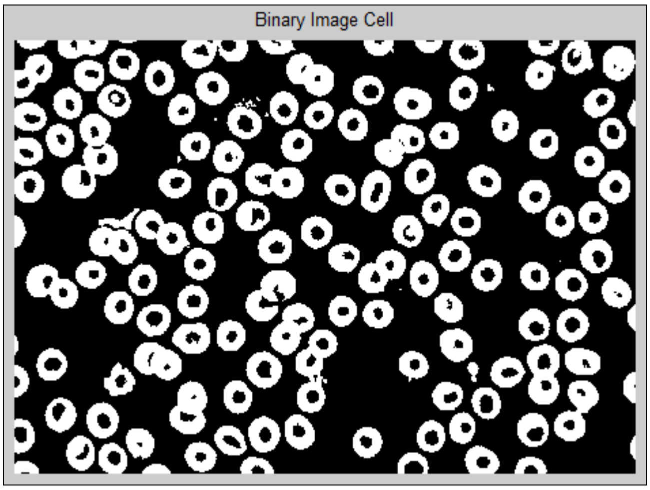

Figure 3.2: Binary image of blood cell

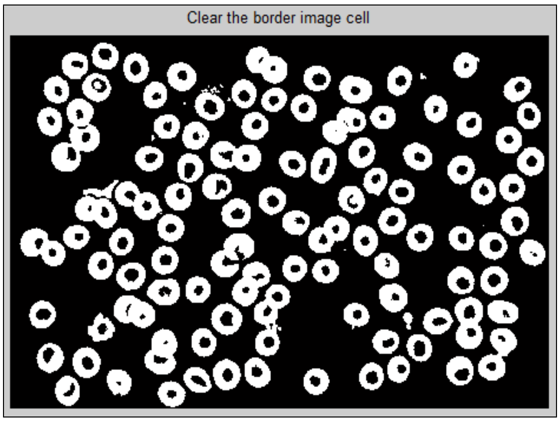

Figure 3.3: Clear the border of blood cell image

The internal holes are filled with the biggest area in the processed image as shown in Figure 3.4. However, the image still has small particles (solid red circle). Therefore, the morphology operation opening was applied to remove smaller particles. Figure 3.5 is the blood cell image after smaller particles were removed. The segmented image for each cell is labelled using 'bwlabel' function and 'regionprops' function was used to measure the minor length axis as the diameter of cell. Figure 3.6 shows minor and major length axis of RBC.

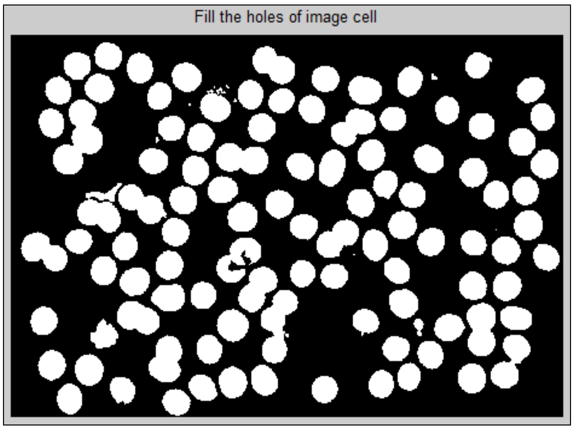

Figure 3.4: Fill the holes

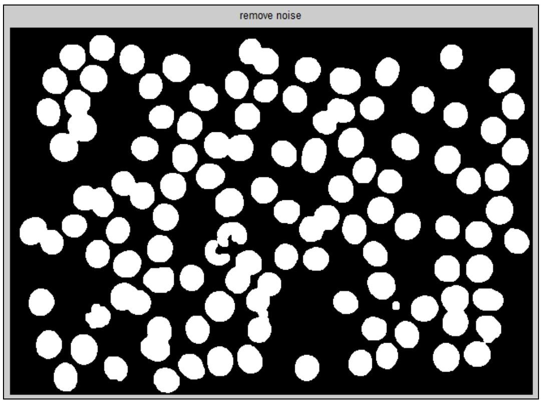

Figure 3.5: Blood cell image after the noise was removed

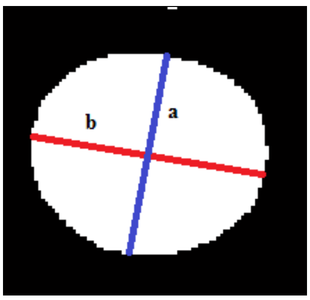

Figure 3.6: a. Minor axis length of RBC (blue line) b. Major axis length of RBC (red line)

Then, determine the mean, standard deviation, minimum and maximum radius of cells using equation (1), (2) and (3) respectively. MHT is applied to draw the circle of cell based on the minimum and maximum radius of cells as an equation (4) and (5).

Measure the radius of RBC

$$Radius = \frac{\text{Minor length axis (diameter)}}{2} \quad (1)$$

Calculate mean and standard deviation:

$$Mean, M = \frac{\sum(X)}{n} \quad (2)$$

Where:
X is radius of the cell
n is the number of cells.

$$Standard\ deviation, S^2 = \frac{\sum(X-M)^2}{n-1} \quad (3)$$

Where,
X is radius of the cell
M is mean of radius of the cell
n is the number of cells

Minimum radius, $MinR = M - S^2$ (4)

Maximum radius, $MaxR = M + S^2$

3.3. Cell detection and counting using Circular Hough transforms

Hough transform (HT) is a feature extraction technique used in image analysis for detection lines and can be modified to detect other shapes such as circles and ellipse using the concept of parameter space [6, 7]. HT has advantages over the image with noise.
Circular Hough Transform (CHT) is a feature extraction technique used to identify the circular shape images. The circle parametric form as an equation (6) and the locus of point (*x*,*y*) centred on an origin (*a*,*b*) and radius, *r*.

$$(x-a)^2 + (y-b)^2 = r^2 \quad (6)$$

The circle is describe by equation (7) and (8)

$$x = a + r\cos\theta \quad (7)$$

$$y = b + r\ \sin\theta \quad (8)$$

A CHT depends on 3 parameters (*a*,*b*,*r*), which require a larger time to compute and storage memory which complexity of extracting information from the image is increased. CHT programs is mostly set the radius to a constant value or provide the user with the option of setting a range (maximum and minimum) before the application.is runs.
In this study used CHT to identify the *a* and *b* locations (centred point) throughout the image given a range of *r* corresponding to the minimum and maximum radius of the platelet and RBC. There are three basic steps of the CHT algorithm which contain the centre estimation radius and accumulator array. The algorithm is used in MatLab software.
In order to identify the circles in an image using CHT, there are numerous of steps used. First, all edge in the image is detected. Next, the desired radius is drawn in circle at point each edge as origin in the parameter space as shown in Figure 3.7. Figure 3.7 is the edge point in the image space and parameter space with constant or known radius. The first two dimension in CHT uses an array 3D with represents the coordinates of the circle meanwhile the last third is specifying the radii. The value possessed in the accumulator array is increasing each time a circle is drawn with the preferred radii over all edge point. The accumulator array kept count of several circles pass through coordinates of each point, it then are proceeds to a vote to discover the highest count. The centre of the circle can be estimated via high vote count, the centre of the circles coordinate in the images can coordinated using highest count. Finally, algorithm performs radius estimation.

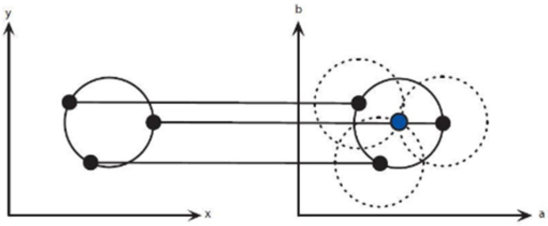

Figure 3.7: Accumulation array for a single circle with constant radius. CHT from x,y-space (left) to the parameter space (right).

Figure 3.8 present the accumulation array for multiple of circles. Multiple circles which possessed the same radius can be identify with the same technique. Based on the Figure 3.10, each point in x-y space (left) generates circles in the parameter space (right). The circles in parameter space intersect at (*a*,*b*) is the centre points represented as red cells in space drawing. Overlap circles may lead to spurious centre, namely at the blue cell. Spurious circles can be detached by matching to circles in the original image.

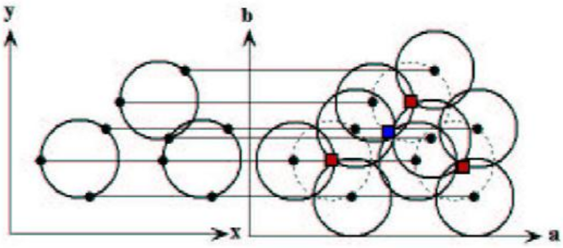

Figure 3.8: Accumulation array for multiples circles (Liangwongsan et al. 2011)

There are two cases in CHT which are circle detection with both known and unknown radius. Circle detection with known radius, the CHT is used to find the centre point (a,b) of the circle if a number of point that fall on the perimeter is knew.
The same procedure for the circle detection with unknown radius like circle detection with known radius. However, the process for unknown radius are quite challenging because it used three dimensions to search parameter space (a,b,r) where a and b are the centre point of the circle and r is the radius. For each point of the image space will match a cone in parameter space, as the radius, r varied from 0 to a given value (Figure 3.11). After transforming of all point of contour in the same way, the intersection will give a spherical surface corresponding to the maximum of accumulator.

Finally, the CHT is applied to grayscale image and analyzes the RBC based on both maximum and minimum radius of RBC. If the radiuses of RBC are found not in range, it will be removed. Figure 3.9 shows the sample output after the CHT technique was used.

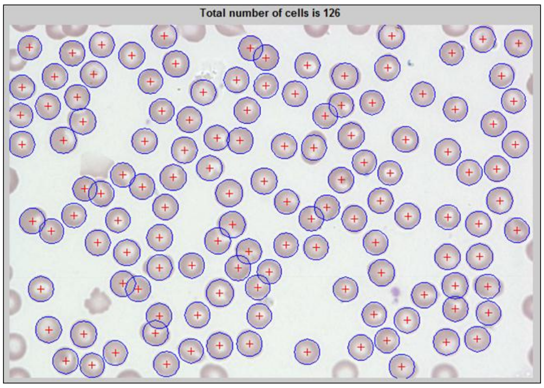

Figure 3.9: Sample output

4. Result and Discussion

There are 60 samples of blood smear image were counted via this technique. The percentage of accuracy is determined based on the result of RBC counted using the CHT technique compare with manual calculation. Table 4.1 shows the summary of the average accuracy result. Figure 4.1 presents the pie chart result of average accuracy on RBC counted using CHT of the same data. In table 4.1, the number of images within range refers to the number of images that has the number detected cells falls within the related accuracy range. For example, there are 44 images and 73% that have 91% to 100% of their RBC accurately detected using CHT.

Table 4.1: Summary of the result

Accuracy range	Number of images within range
61% - 70%	2
71% - 80%	6
81% - 90%	8
91% - 100%	44

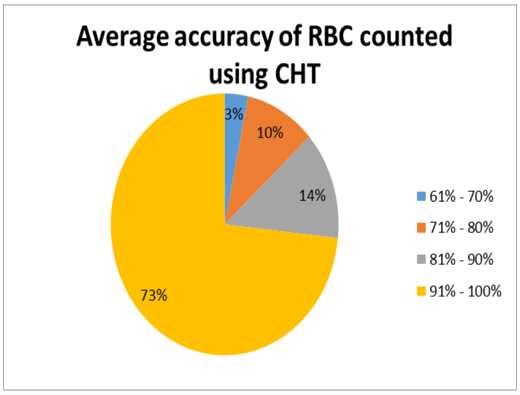

Figure 4.1: Result of average accuracy of red blood cell counted.

During the algorithm development, many changes and improvement have been made, and the result can be said to have achieved their goal, which is to detect and count the number of RBC. Based on the 60 samples, the accuracy is 94% were achieved. Comparing the input image with the image after applying CHT, we couldn't achieve 100% of accuracy because some of RBC is not counted properly due to incompleteness of circle drawing and the radius is out of range. The cell's image is not quite clear because the cell had long been immersed as shown in Figure 4.2. Therefore, the CHT algorithm could not detect the edge of the cells.

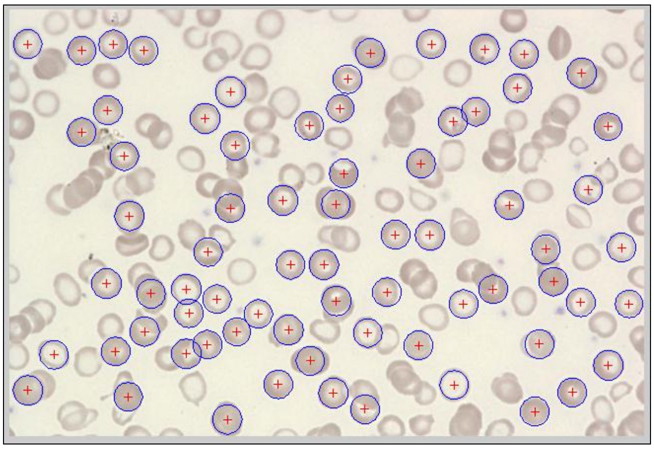

Figure 4.2: Image of blood cells immersed

5. Conclusion

In conclusion, the goal of this study is to detect and count the number of RBC and platelet in a blood smear image using Circular Hough transform. Applying this study has successfully developed a cost effective tool and an alternative method in recognizing, analysing and counting the circular cell. The method concentrates on measuring diameter and radius of cells. The circle is drawn based on the range of radius of cells to recognize and counted from the drawn of the circle. This method also can acknowledge and calculates the overlapping cells separately.

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