ABNORMAL SHAPE SEGMENTATION OF RED BLOOD CELL USING IMAGE PROCESSING

Nur Raihan Ja'afar [1], Siti Nazifah Zainol Abidin[1], Nur Nabilah Abu Mangshor[1], Siti Aisyah Abdul Kadir[1] and Nurul Hidayah Ahmad Zukri[2]

[1]Faculty of Computer and Mathematical Sciences,
Universiti Teknologi MARA Melaka, Jasin Campus, 77300 Merlimau, Melaka, Malaysia
[2]Faculty of Computer and Mathematical Sciences,
Universiti Teknologi MARA Perlis, Arau Campus, 02600 Arau, Perlis, Malaysia
Author Correspondence, e-mail: sitinazifah@melaka.uitm.edu.my

Received: 10 April 2019 / Accepted: 15 May 2019 / Published online: 15 June 2019

ABSTRACT

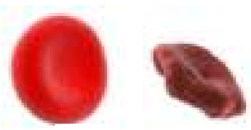
A healthy red blood cell functions to transfer oxygen from lungs to tissues and organ. The biconcave-disc shape of red blood cell maximizes the surface area to increase efficiency of oxygen absorption. Otherwise it is considered as abnormal which leads to blood disorder. Identification of blood disorders often starts with a complete blood count and supplemented by an examination of blood cells under a microscope. Some health centers provide additional tests and imaging procedures to further diagnosis. High cost of advanced instruments and expertise brings to diagnosis using existence tools which maybe imprecise, inconsistent and has low reliability. Therefore, a system using technique of image processing is proposed to segment the abnormal shape of red blood cells. Thresholding morphological operation and segmentation using morphological watershed transformation was applied in this study. The thresholding is the pre-processing method in eliminating unintended figures, while morphological operation and morphological watershed transformation are processing methods where segmentation of the abnormal shape of red blood cell is performed. The amount of red blood cell images tested in this system was 40 images. The result of the system is the segmented image of abnormal red blood cells. The accuracy rate of the resulted segmented image is 48.124%. This study is hoped to be useful in identification of abnormality of red blood cells for medical experts.

Keywords: Red Blood Cell; Image Processing; Shape Segmentation; Thresholding Watershed Morphological.

1. INTRODUCTION

Red blood cells, also known as erythrocyte in scientific term, are a normal shape of biconcave, cover of a less of cell nucleus and most organelles [1-3]. The edges are thicker and rounder than the inside that it would seem like a sunken formed [4]. The apparent shape of red blood cells helps in maximizing the surface area which efficiently absorbs oxygen. The internal and external layer of the cell is made up of special protein which contributes red color of blood and this protein is called as hemoglobin [4].

The hemoglobin level is identified to measure quantity of blood in human body which could influence human well-being [4]. Hemoglobin level can be measured through Complete Blood Count (CBC) test, taken from sample of blood cell which aid detection of specific illness [5]. Figure 1 shows two types of the shape of red blood cell.



A B

Fig.1. Red blood Cell, (a) healthy red blood cell (b) unhealthy red blood cell

Source: [6]

The red blood cell shape highly influences health condition of a patient. Patients with blood disorder regularly diagnosed initially from complete blood count (CRC) test. This blood test is to check the condition of blood and disease might be suffered by the patient [1]. The test identifies compilation test of red blood cells, white blood cells, and platelet. Medical experts such as haematologist will make further examination such as bone marrow test and many other tests and imaging procedures for more definitive diagnosis. These tests would require higher cost for the tools and expertise [7, 4]. Thus, this study aims in developing and designing a system that can segment the abnormal shape of red blood cell.

According to [3], the shape of red blood cells could be analyzed, and their structures can be identified with the aid of image processing technique. To get clearly view about blood cell shape, segmentation in image processing can be used. Image segmentation involved isolation of input image into a region of interest (ROI) and take out interest object [3, 5, 8].

The simplest method is thresholding which applied to set the blood pixels with the value 1 and 0 for the background and the cell shapes will be detected and identified [9]. As similar to thresholding, Canny edge method also can be used to extracts the feature in an image without affecting its features [10]. This is crucial which encompasses cells without clearly defined edges such as some red blood cells which almost coalition in with the background [11]. However, thresholding required less time to implement compared to canny edge.

Mean Shift Clustering is a calculation used to smooth image based on hue and space in image segmentation. The Mean Shift procedure is used to cluster data points, whose directions of the gradient rise lead to the similar mode. This technique is greatly helpful for grouping statistics iteration. For clustering, the visual image acquired from the segmentation method is merged with the hue and space data [12]. However, the window size is important as it could cause modes to be clubbed or creates shallow modes and eliminates several alteration required.

Morphology is used for segmenting images such as hole filling, dilation and erosion with disk shaped structuring element of size to acquire binary image of blood cells subsequent isolation of overlapping cells [13]. Segmentation of blood cell is carried through using K-Mean clustering. These clusters are segmented using watershed transform [13]. Marker controlled watershed segmentation is applied to overlapping erythrocytes to control resistance of the process of shape detection [14].

To this end, this study produced a system that could segment abnormal shape of red blood cell using thresholding morphological watershed transformations and morphological operation. The performance of the algorithms is measured using quantitative evaluation. Quantitative evaluation of the lesions detection methods is conducted by comparing the results obtained by the system with the gold standard which is obtained from a hematologic science officer.

2. METHODOLOGY

This section discusses the methodology used in this study. Thresholding techniques used to convert the grayscale image into binary image which would make the process segment easier. Segmentation using morphological watershed transformations was better as it handled overlapping image. In microscopic blood image, overlapping red blood cell cannot be avoid, thus this problem was overcome by segmentation using morphological watershed transformations. By the same token, morphological operation was applied to segment abnormal shape of red blood cell. Figure 2 shows the process flow for the proposed algorithm to segment the abnormal shape of red blood cell.

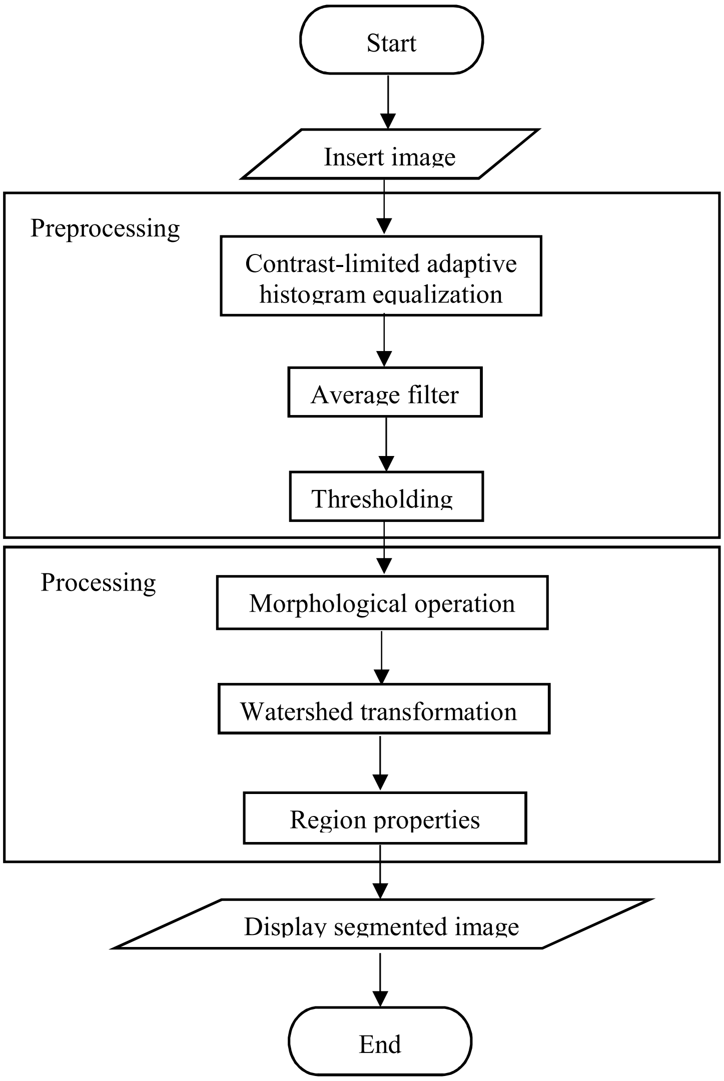


Fig.2. Red Blood Cell Segmentation Flowchart

2.1 Data Collection

In this study, 40 images were captured with a conventional microscope with 40 times (40X) objective which equals to approximately 400 magnification. An expert from Centre for Pathology Diagnostic and Research Laboratories (CPDRL) in Universiti Teknologi MARA (UiTM) Sungai Buloh validated the data.

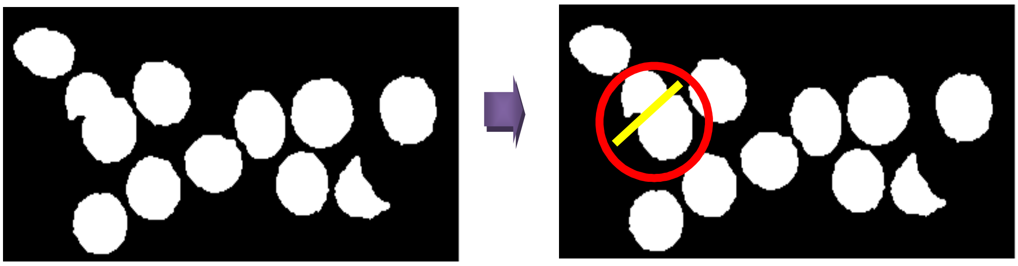
2.2 Pre-Processing

The purpose of the pre-processing phase was to remove unwanted effects such as noise from the image and transform or adjust the image as necessary for further processing. The contrast-limited adaptive histogram equalization (CLAHE) method was used to provide a good presentation of colour spread of the image.

An 3×3 average filter was used as it was the smallest mask and it can filter any random noise in a small area. This will destroy non important detail from image. Thresholding was applied to convert the image to binary image. From the binary image, it differentiated the foreground and background of image where the value are 0s and 1s where represent black and white respectively.

2.3 Processing

After completion of pre-processing, the image was continued to processing phase which is segmentation. The image was first done by morphological operation were fill holes on the image. After that watershed was applied for an overlapping image and Figure 3 shows the red circle indicates overlap image for two blood cells.

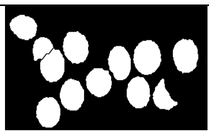
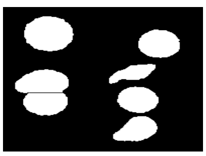


(a) (b)

Fig.3. Image of overlapping Red Blood Cell (a) and image perform watershed transformation (b).

Lastly region properties are perform to eliminate normal shape and display abnormal shape of red blood cell. To do elimination normal shape in region properties, it must have property known as parameter and for this study the parameter is Extend and Area as shown in Table 1.

Table 1. Experiment Result minExtent = N

No	Input image	minExtent =0.6	minExtent =0.7	minExtent =0.8
1.				
2.				

3.

4.

Based on the observation, minExtent value = 0.6 gives almost desirable results but it still cannot isolate between abnormal and normal blood. Meanwhile minExtent = 0.8 has clearly given the wrong decision where the result given still has normal blood, it seems minExtent = 0.7 is the precious value to eliminate normal shape and left the abnormal shape only.

3. TESTING AND EVALUATION

A quantitative evaluation of the lesions detection methods is conducted by comparing the results obtained by the system with the gold standard which is obtained from a hematologic. The Area Overlap (AO), False Positive Rate (FPR) and False Negative Rate (FNR) are applying to assess the result abnormal shape of red blood cell segmentation [15]. Equation (1) shows the formula to calculate the AO where S_1 represent the area of image gain by proposed method and S_2 represent area of ground truth.

$$AO = \frac{|S_1 \cap S_2|}{|S_1 \cup S_2|} \times 100 \tag{1}$$

Equation (2) and (3) show the formula to calculate FPR and FNR respectively where $S_1^{'}$ is the inverse of S_1 and $S_2^{'}$ is the inverse of S_2.

$$FPR = \frac{|S_1 \cap S_2^{'}|}{|S_1 \cup S_2|} \times 100 \tag{2}$$

$$FNR = \frac{|S_1^{'} \cap S_2|}{|S_1 \cup S_2|} \times 100 \tag{3}$$

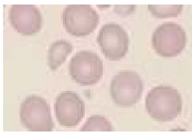
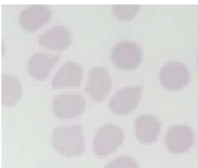
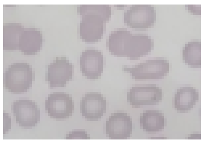
4. RESULTS AND DISCUSSION

This section discusses the results obtained from the experiments conducted. A complete system to segment the abnormal shape of red blood cell has been developed on the

MATHLAB platform using the proposed methodology in Figure 2. The total of 40 tested images is used to evaluate the result of abnormal shape of red blood cell segmentation. Table 2 shows the sample testing output.

Overall for the test accuracy of AO, FPR and FNR was acquired are 48.12%, 15.61% and 36.26% respectively.

Table 2. Sample Output Abnormal Shape of Red Blood Segmentation with AO, FPR and FNR

No	Original Image	Ground Truth	Segmented Image	AO (%)	FPR (%)	FNR (%)
1.				100	0	0
2.				32.41	2.73	64.86
3.				22.62	1.62	75.76

5. CONCLUSION

The proposed algorithm of thresholding using morphological watershed transformation for segmenting abnormal red blood cell has utilized the percentage of AO, FPR and FNR from 40 tested images. Overall, the performance of the proposed algorithms achieved 48.12% for AO and 15.61% for FPR as well as 36.26% for FNR respectively. Hence, the future work is to hybridize the proposed algorithm with optimization techniques to increase the accuracy.

6. ACKNOWLEDGEMENTS

The authors would like to thanks Universiti Teknologi MARA (UiTM) Melaka and Universiti Teknologi MARA Sungai Buloh, Selangor campus, Malaysia.

7. REFERENCES

[1] MedlinePlus (2015, December 11). *Blood.* Retrieved from https://medlineplus.gov/blood.html

[2] Leaving Certificate Biology (n.d.). *Blood*. Retrieved from http://www.leavingbio.net/Blood.htm Leaving Certificate Biology

[3] N. D. Jambhekar (2011). Red blood cells classification using image processing. *Science Research Reporter*, *1*(3), 151-154.

[4] B. Venkatalakshmi and K. Thilagavathi (2013, April 11-12). *Automatic red blood cell counting using hough transform*. Paper presented at 2013 IEEE Conference on Information & Communication Technologies (ICT). doi: 10.1109/CICT.2013.6558103.

[5] H. Tulsani, S. Saxena and N. Yadav (2013). Segmentation using morphological watershed transformation for counting blood cells. *IJCAIT*, 2(3), 28-36.

[6] Dreamstime (n.d.). *Healthy and Unhealthy Blood Cell*. Retrieved from https://www.dreamstime.com/photos-images/healthy-unhealthy-blood-cell.html

[7] J. Linder and D. J. Zahniser (2012). Digital imaging in hematology. *MLO Med Lab Obs*, 44, 14-16.

[8] J. M. Sharif, M. F. Miswan, M. A. Ngadi, M. S. H. Salam and M. M. Abdul Jamil (2012, February 27-28). *Red blood cell segmentation using masking and watershed algorithm: A preliminary study*. Paper presented at International Conference on Biomedical Engineering (ICoBE). doi: 10.1109/ICoBE.2012.6179016.

[9] K. Parthenis and C. Metaxaki-Kossionides (1992). Blood analysis using black and white digital images. *Journal of biomedical engineering*, 14(4), 287-292.

[10] P. Dhankhar and N. Sahu (2013). A review and research of edge detection techniques for image segmentation. *International Journal of Computer Science and Mobile Computing (IJCSMC)*, 2(7), 86-92.

[11] N. H. Mahmood, P. C. Lim, S. M. Mazalan and M. A. A. Razak (2013). Blood cells extraction using color based segmentation technique. *International journal of life sciences biotechnology and pharma research*, 2(2), 2250-3137.

[12] Z. Liu, J. Liu, X. Xiao, H. Yuan, X. Li, J. Chang and C. Zheng (2015). Segmentation of White Blood Cells through Nucleus Mark Watershed Operations and Mean Shift Clustering. *Sensors*, 15(9), 22561-22586.

[13] S. S. Savkare, A. S. Narote, and S. P. Narote (2016, September 21-24). *Automatic Blood Cell Segmentation Using K-Mean Clustering from Microscopic Thin Blood Images*. Paper presented at the 3rd International Symposium on Computer Vision and the Internet. doi: 10.1145/2983402.2983409.

[14] V. Sharma, A. Rathore and G. Vyas (2016, August 26-27). *Detection of sickle cell anaemia and thalassaemia causing abnormalities in thin smear of human blood sample using image processing*. Paper presented at International Conference on Inventive Computation Technologies (ICICT).
doi: 10.1109/INVENTIVE.2016.7830136

[15] R. Roslan, N. Jamil and N. Za'ba (2013). *Spectral Texture Segmentation for Glioma Brain Tumour Detection.* Shah Alam, Selangor: UiTM Institutional Repository.