Segmentation Technique for Nucleus Detection in Blood Images for Chronic Leukaemia

N. H. M. Daud¹, R. A. A. Raof¹,², M. K. Osman³, N. H. Harun⁴

¹School of Computer & Communication Engineering, Universiti Malaysia Perlis, Pauh Putra Campus, Perlis, Malaysia
²Sports Engineering Research Centre, Universiti Malaysia Perlis, Pauh Putra Campus, Perlis, Malaysia
³Faculty of Electrical Engineering, Universiti Teknologi MARA Cawangan Pulau Pinang, Permatang Pauh, Pulau Pinang, Malaysia
⁴School of Computing, Universiti Utara Malaysia, Sintok, Kedah, Malaysia

Email : rafikha@unimap.edu.my

Abstract. Leukaemia is a disease which develops in the bone marrow, causing a large formation of abnormal cells and usually affected adults. The process of inspecting visually on the microscopic images is time consuming and a tiring process. The developed technique is aimed at assisting the haematologists upon identifying the presence of nucleus in blood cell images. Therefore, this technique is hoped to aid the haematologists in early and fast identification of leukaemia. This paper will be focusing on Acute Myeloid Leukaemia (AML). This research work proposed a combination of methods for the detection of Leukaemia using image processing techniques such as L*A*B colour-based thresholding algorithm, Sobel edge detection algorithm, and watershed distance transform to identify the nucleus blasts of leukaemia cells from blood cells image. The developed technique shows that it is able to produce the image of segmented nucleus blasts.

1. Introduction
Leukemia is a type of hematologic disease which affects blood, bone marrow, and lymph nodes. Leukemia emerges from the inner part of the bone marrow which comprises of white blood cells (WBC) or lymphocytes, platelets and red blood cells (RBC) which has their own roles in blood. However, in some cases, the myeloid cells (other blood cells except WBC of type T-lymphocytes and B-lymphocytes) may not develop normally or the differentiation is not completed. Leukemia is diagnosed by proliferation of abnormal myeloid cells in the bone marrow which later accumulates in the blood stream. These abnormal, immature myeloid cells are referred to as leukemia cells or “blasts”. The leukemia cells crowd out from other blood cells in the bone marrow, resulting in reduced production of WBC and platelets in the bone marrow [1].

Image processing is one of the most vital part under imaging research procedure. Some of its elements include feature extraction, enhancement, segmentation, filtering and other various stages.
which are beneficial in medicine sector especially in processing images such as MRI, CT, X-Ray or any other images which is acquired from imaging technology. The advantages of utilizing this procedure is that it can identify abnormality in those images compared to normal cells, parts, or organ of a healthy person. Tumor presence, broken bones or joints and cell detection are some of the application which incorporates image processing techniques.

Many techniques had been proposed in researches regarding leukemia cells detection in red blood cells in the past. All techniques are proposed either to yield a more accurate result or simply to introduce the techniques and evaluate it. Therefore, in this paper, a combination of techniques such as thresholding, edge detection and watershed transform for Acute Myeloid Leukemia (AML) nucleus segmentation system for leukemia cells is proposed in order to evaluate the accuracy of the technique from the analysis of the result.

2. Related Work
Jasmine et al. [2] in their research to diagnose leukemia from microscopic images using image processing techniques shows that contrast enhancement provides deeper and clearer color therefore provides better image for subsequent step. Khashman and Al-zgoul [3] proposed the method of bi-modal thresholding since the gray level intensities of both nuclei and cytoplasm are both uniform, therefore bi-modal thresholding are used to separate the two regions.

Alshorman et al. [4] focuses on edge detection technique. They review several edge detection techniques in detecting leukemia cell in an image, mostly on gradient based method. Some of the method which are evaluated are Ant Colony Optimization (ACO), Roberts Cross Operator, Sobel-Edge detector, and Prewitt Operator. The performance of each methods was compared to identify method which can produce the most optimal result. The comparison result shows that the Prewitt method generate the most positive and clear edges of leukemia cells.

T. Karthikeyan and N. Poornima [5] highlighting on thresholding technique in leukemia image segmentation. A. Kaur and Aayushi [6] was implementing watershed transform to distinguish connected objects along with other techniques as well. Most of previous researchers were implementing thresholding in image segmentation [7 – 9]. Therefore, in this project all these elements will be combined while implementing the L*A*B* color space and focusing on leukemia of type AML.

3. Methodology
The technique involves 4 phases which is image acquisition, image pre-processing, image segmentation and image post-processing. Image acquisition is done by gathering the microscopic images of blood cell obtained from the light microscope with 40x objective and stained by Wright-Geimsa stain. Figure 1 shows the system flow of this project. Image acquisition phase is not shown in this system flow because it is supposed to be completed before the image processing began.
3.1. Image Pre-processing
Contrast enhancement for color images is done by converting the image into color space that have been chosen, which are L*A*B* color space. It was then adjusted using one of the approaches of contrast enhancement adjustment in MATLAB which is by mapping the input intensity image to new values or linear contrast. The result of this procedure is expected to have lesser noise and image will be clearer toward further procedures.

3.2. Image Segmentation
Image segmentation is a series of steps which occur during image processing to generate detection of leukemia cells. Processes that are within the image segmentation step in this project are thresholding, morphological operations (dilation, filling holes, smoothing and area opening), masking, edge detection and watershed transform.

Image thresholding is a method that differentiates the image into background and foreground. Contrast are adjusted by adjusting the blue-yellow layer only. Adjusting luminosity affects the color
pixel while maintaining the original color of the image. Figure 2 shows how adjusting blue-yellow layer is done by using MATLAB. The values of adjustment are then exported to the system. In the threshold process, background and the presence of healthy cells in the blood cell image is intended to be removed.

![Fig. 2. Adjusting the blue-yellow layer in MATLAB](image)

Dilation and erosion are the basic step of morphological operations. Dilation adds pixel to the boundaries of objects in an image and erosion removes unwanted pixels on object outline [10]. After the image is dilated, it is expected to still have the holes in the interior part of cells in an image, therefore the holes still needed to be filled. Finally, in order to produce a rounder and natural shape of cells, smoothing is carried out by using erosion. In some image, the unwanted information in grains of pixels is still present even after dilation and erosion done. Therefore, area opening is done to remove the small objects.

After area opening, output is created as binary image. The binary image is regarded as region of interest (ROI) of an original image. The nucleus is masked as to convert it into white region while maintaining the black region as background area. The binary image is then masked onto the original image to identify the background area.

Figure 3 illustrate the flow of edge detection in this system. Based on Figure 3, for every pixel M (i, j) which are 2-D image, the gradient of the image is compared with the threshold values, T. If the gradient of a pixel is more than T it is regarded as edge. If not, the current pixel is compared with the maximum pixel exist on the image. If the current pixel does not equal with the maximum pixel, then the process proceeds to the next pixel. Next if the current pixel does equal to the maximum pixel the boundary tracing is complete. In the project, Sobel edge detection approach is going to be used.
The approach of watershed transform that is being used in this system is the distance transform approach. The watershed transform is popularly used in blood cell segmentation because it provides efficient separation of overlapping cells [11 - 14]. The distance transform had three approach which are Euclidean, chessboard and city block. However, for watershed process in this research is utilizing the Euclidean form. The distance transform assigns a number that is the distance between that pixel and the nearest nonzero pixel of BW.

3.3. Image Post-processing

Image post-processing is the process which takes place after the image segmentation had finished which is the watershed transform and cell counting process. Cell counting algorithm includes the counting and labelling of areas connected and calculation of size of object.

Binary image resulted from previous process produces image containing white and black area where the white area is the cells and black area in the background. Connected components are calculated by analyzing each pixel and using flood-fill algorithm to label all the pixels of the components. The process is repeated until all pixels are labelled. The process connected background pixels to foreground pixels and stopping when it reaches object boundaries.

The boundaries for the operation are depending on the pixel connectivity that had been specified. The term connectivity means when the pixels are connected to another pixel. There are two types of pixel connectivity which are 4-connected and 8-connected. The type of neighborhood that had been chosen depends on the number of objects exists in an image and the boundaries that had been specified. Therefore, the result of the morphological operations differs based on the type of connectivity.
The steps in system flow are elaborated in accordance with the project flow. There are 4 phases to
develop this system, firstly is image acquisition, secondly is image preprocessing stage, thirdly is
image segmentation stage and finally image post-processing stage. The flowchart of technique such as
edge detection, thresholding and watershed transform are laid out in such a way to produce a detailed
and accurate result. After the system is completed, the result of the image segmentation can be
evaluated.

4. Result and Discussion
This section will discuss and elaborate the findings throughout the completion of this project. There
are several processes involved in the segmentation of leukemia is red blood cell image which are
contrast enhancement, thresholding, morphological operations, edge detection, watershed transform
and counting of the leukemia cells present in the image. Figure 4 is the resulting image after contrast
enhancement. From the contrast enhanced image, the affected cell looked even clearer. The purpose of
contrast enhancement is to prepare clearer cells for the next process which is thresholding.

Fig. 4. Comparison between the original image (a) and contrast enhanced image (b)

After image is contrasted, the resulting image is brought to the next process which is thresholding.
The background and the healthy cells are removed from the resulting image. The color thresholder is
set using L*A*B color space. Ranges of background removal can be varied. Figure 5 shows the
resulting image after the image undergo thresholding process. The background of the contrasted image
had been removed.

However, there are still grains available in the background area. If the thresholding process is done
further, the region of interest which is the nucleus of the leukemia cells would be affected too. This
leads to another process which is morphological operations. The purpose of this process is to remove
the grain remained in the image after the thresholding process. Dilation, erosion, area opening and
flood fill algorithm was done in order to remove the grain in the image. Dilation is used to adds pixel
to the boundaries of objects in an image. Erosion removes unwanted pixels on object outline. Area
opening is used to remove unwanted pixel in the image. The result is also reflected in Figure 5.
Masking process is initially proposed to identify whether the nucleus shape is matching with the original image. The result of the image from morphological operations is masked onto the original image. However, after the masking process, the nucleus appears having irregular edges. Therefore, the edge detection technique is used in order to detect the edges of the nucleus and draw the edges of the nucleus onto the binary image.

In this step, Sobel edge detection approach is used in detecting the edges of the nucleus of the leukemia cells. Even though, the Sobel edge detection is known to having longer time of computations compared to other edge detection operator such as Robert or Canny, its larger convolution kernel smooths the input image to a greater extent and makes the operator less sensitive to noise [15]. Figure 6 shows the result after masking and edge detection process.

During the process, the operator identified the edges of the nucleus by performing a 2-D spatial gradient measurement on an image and emphasizes regions of high spatial frequency that correspond to edges. Typically, it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. The absolute magnitude is what the user seeks.

The watershed transform is then done in order to identify regions of cell, distinguish overlapping cells and mark the cell onto the image. By imagining the image as a surface, the area of lower minima will become the catchment basins and the area of higher area will become the watershed lines. The key of success in distinguishing overlapping cell is by identifying the watershed lines. Figure 7 shows the comparison between the original image and the final result where the image had been successfully segmented.
5. Conclusion
The result shows that the nucleus blast is successfully segmented using the image of AML type of leukemia. Overall, the leukemia image segmentation software had performed well using thresholding, edge detection, and watershed transform techniques.

References
[1] Raje, C., & Rangole, J. (2014). Detection of Leukemia in microscopic images using image processing. In International Conference on Communication and Signal Processing, ICCSP 2014 - Proceedings (pp. 255–259). Institute of Electrical and Electronics Engineers Inc.
[2] Jasmine Begum, A. R., & Abdul Razak, T. (2017). Diagnosing Leukemia from Microscopic Images Using Image Analysis and Processing Techniques. In Proceedings - 2nd World Congress on Computing and Communication Technologies, WCCCT 2017 (pp. 227–230). Institute of Electrical and Electronics Engineers Inc.
[3] Khashman, A., & Al-zgoul, E. (2010). Image Segmentation of Blood Cells in Leukemia Patients. Recent Advances in Computer Engineering and Applications, 104–109.
[4] Ali Alshorman, M., Kadri Junoh, A., Zuki Azman Wan Muhamad, W., Hafiz Zakaria, M., & Md Desa, A. (2018). Leukaemia’s Cells Pattern Tracking Via Multi-phases Edge Detection Techniques. Journal of Telecommunication, Electronic and Computer Engineering, 10(1–15), 33–37.
[5] Kumar, S., Mishra, S., Asthana, P., & Pragya. (2018). Automated detection of acute leukemia using K-mean clustering algorithm. In Advances in Intelligent Systems and Computing (Vol. 554, pp. 655–670). Springer Verlag.
[6] Kaur, A., & A. (2014). Image Segmentation using Watershed Transform. International Journal of Soft Computing and Engineering (IJSCCE), 4(1), March 2014.
[7] Aris, T. A., Nasir, A. S. A., & Mustafa, W. A. (2018). Analysis of Distance Transforms for Watershed Segmentation on Chronic Leukaemia Images. Journal of Telecommunication, Electronic and Computer Engineering, 10(1–16), 51–56.
[8] Mohapatra, S., Samanta, S. S., Patra, D., & Satpathi, S. (2011). Fuzzy based blood image segmentation for automated leukemia detection. In 2011 International Conference on Devices and Communications, ICDeCom 2011 - Proceedings.
[9] Petrou, M., & Petrou, C. (2011). Image Processing: The Fundamentals: Second Edition. Image Processing: The Fundamentals: Second Edition. John Wiley and Sons.
[10] Srisha, Ravi & Khan, Am. (2013). Morphological Operations for Image Processing : Understanding and its Applications, Proceedings of National Conference on VLSI, Signal
Processing & Communications.

[11] Ghane, N., Vard, A., Talebi, A., & Nematollahy, P. (2017). Segmentation of White Blood Cells From Microscopic Images Using a Novel Combination of K-Means Clustering and Modified Watershed Algorithm. Journal of medical signals and sensors, 7(2), 92–101.

[12] Mohamad S., Johan, Miswan M., & Ngadi, Abdul J., Muhammad M. (2012). Red blood cell segmentation using masking and watershed algorithm: A preliminary study. 2012 International Conference on Biomedical Engineering, ICoBE 2012.

[13] Savkare S. S. and Narote S. P. (2015), Blood cell segmentation from microscopic blood images, 2015 International Conference on Information Processing (ICIP), Pune, pp. 502-505.

[14] Winter, M., Mankowski, W., Wait, E., De La Hoz, E. C., Aguinaldo, A., & Cohen, A. R. (2019). Separating Touching Cells Using Pixel Replicated Elliptical Shape Models. IEEE transactions on medical imaging, 38(4), 883–893.

[15] Radhika C., Saurabh D., Vaibhav G., Deepika R., S. A. Tiwaskar (2013), Comparison Of Edge Detection Techniques, Proceedings Of Sixth Iraj International Conference.