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Image Segmentation Approach for Acute and Chronic Leukaemia Based on Blood Sample Images

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Abstract. The uncontrolled development of abnormal white blood cells (blast) in bone marrow is the starting point where leukaemia cancer begins. It does not die like it should. Instead, it goes on dividing and crowding out the healthy blood cells, making it difficult for these healthy bloods to function normally. The diagnosis process from haematologist consumes a lot of time. Therefore, a good segmentation procedure is necessary in order to successfully identify and diagnose leukaemia cells automatically from blood sample images. This paper proposes segmentation procedures which consist of contrast enhancement, extraction of hue component information, as well as segmentation based on Otsu's thresholding and watershed technique. The experimental results shows that the proposed segmentation procedure has successfully segmented 200 images consisting of acute and chronic leukaemia with average accuracy, sensitivity and specificity obtained of 98.90%, 82.14% and 99.49%, respectively. The result of segmentation performance achieved shows the significant of this approach. Based on results obtained, this segmentation technique is applicable to segment both acute and chronic leukaemia images with good segmentation performance.

1. Introduction

Leukaemia can be classified into acute and chronic leukaemia based on how quickly the disease develops. Acute leukaemia occurs in a short period of time while chronic leukaemia takes time to fully develop. Besides, leukaemia cells can spread to other body part, such as the spleen, lymph nodes and brain. Acute leukaemia can be divided into two classes which are acute lymphocytic leukaemia (ALL) and acute myeloid leukaemia (AML), while chronic leukaemia can be divided into chronic lymphocytic leukaemia (CLL) and chronic myeloid leukaemia (CML). Leukaemia recognition starts by a complete blood count (CBC) process. If any abnormality appears, a study of morphological bone marrow smear analysis is arranged to check the present of a leukaemia cell [1]. Problem starts when some haematologists still conduct the complete blood count process manually using light microscope which may cause their eyes get tired when concentrating at the blood sample too long [2]. As a result, the procedure to obtain the outcome is slow and the accuracy obtained is not standardized [3].

These limitations trigger the development of digital image processing for blood cells recognition through computer algorithms and several processes [4]-[9]. Chen *et al.* [4] have measured the difference between the performances of watershed segmentation with different distance transforms for binary image. A successful segmentation result obtained from combination of watershed and chessboard distance transforms. Meanwhile, Mohammed *et al.* [5] have suggested watershed



algorithm and optimal threshold to segment CLL and the proposed method has produced 99.92% for nucleus segmentation performance.

Image segmentation on white blood cells (WBCs) based on global Otsu's thresholding has been used for acute leukaemia detection based on blood sample images [6]. The proposed method has produced accuracy of 93% when applied onto 108 images. Prasad *et al.* [7] generated an automatic segmentation by using watershed segmentation, threshold and chessboard distance measurement on blood stream images. A minimum counting error reached +0.5% for 200 objects in the dataset to count the blood cells by automatic segmentation that consist three colour images of blood cells.

Image segmentation is an important technique that is required in accomplishes leukaemia diagnosis through digital image processing. This paper aims to improvise the segmentation technique in order to increase the segmentation performance of leukaemia diagnosis process.

2. Methodology

In this paper, image processing techniques are separated into two parts which are pre-processing and image segmentation parts. In pre-processing, contrast enhancement and colour component from HSV (Hue, Saturation, Value) colour space are applied on acute and chronic leukaemia images. As for the image segmentation part, Otsu's thresholding and watershed algorithms are used to segment the abnormal white blood cells (blast) in leukaemia images. Preparations are taken to separate the blast from other components in blood image such as platelets, red blood cells (RBCs) and background region. Starting with preparation of blood slide, it will undergo a few processes until the blast are segmented. Then, the segmentation performance for each type of leukaemia will be analysed.

2.1. Image acquisition

The blood samples of ALL, AML, CLL and CML were provided by Hospital Universiti Sains Malaysia (HUSM). These blood samples were prepared on slides and being analysed at 40X magnification by using a Leica DLMA digital microscope. The staining process helps to get a clear vision of the blast cell. In this study, a total of 200 leukaemia images were captured by a resolution setting of 808x608 and saved in bitmap (*.bmp) format.

2.2. Image processing

In this study, several image processing techniques have been implemented to obtain the segmented blast on leukaemia images. The proposed procedures are summarized as follows:

- Step 1 :** Original image undergoes enhancement by using linear contrast stretching (LCS) technique to increase the quality of the image.
- Step 2 :** Extract the hue component information of HSV colour space.
- Step 3 :** Apply the image segmentation technique by using Otsu's thresholding to segment the blast.
- Step 4 :** Remove noises and unwanted region from the target image in order to clean the image.
- Step 5 :** Separate the touching cells by using watershed segmentation.

2.2.1. Contrast enhancement using LCS technique for leukaemia image

Linear contrast stretching (LCS) technique is carry out in order to improve the brightness level and contrast level of the image because some images are blur. This technique is based on the original brightness and the contrast level of images to be adjusted [10]. The algorithm of LCS is defined in equation (1).

$$out_{RGB}(x,y) = 255 * \left[\frac{(in_{RGB}(x,y) - a_{RGB})}{b_{RGB} - a_{RGB}} \right] \quad (1)$$

Where $in_{RGB}(x,y)$ is the pixel value of original RGB, $out_{RGB}(x,y)$ is the pixel value of a new RGB, a_{RGB} is minimum RGB value and b_{RGB} is maximum RGB value.

2.2.2. HSV colour space on the enhanced image

HSV colour space mostly used to improve the RGB colour space. Hue corresponds directly to the concept of hue in the colour basics section [11]. The advantage of HSV is it has a simple conceptual

which each of its element attributes directly correspond to the basic colour models. The disadvantage is saturation attributes which correspond to the mixture of a colour with white (tinting), so desaturation colours increase the total intensity. Based on analysis of leukaemia images, it has been found that hue component in HSV colour space covers most information of the blast. Thus, the procedure is developed by using hue component according to the following equations [12]:

$$Hue = \begin{cases} \theta & \text{if } B \leq G \\ 360^\circ - \theta & \text{if } B > G \end{cases} \quad (2)$$

$$\theta = \cos^{-1} \left\{ \frac{1/2 [(R - G) + (R - B)]}{[(R - G)^2 + (R - B)(G - B)]^{1/2}} \right\} \quad (3)$$

2. 2. 3 Segmentation of blast using Otsu's Thresholding

Otsu's thresholding [13] helps minimize variance within class and perform the image in a binary image. The optimum threshold is calculated to separate the image that contains two classes of pixels so that their combined spread become equivalents or minimal in order for inter-class variance is maximal. Equations (4) and (5) show the algorithms of class probability. Weights ω_0 and ω_1 are the possibilities of the two classes differentiate by a threshold t and σ_0^2 and σ_1^2 are variances of these two classes. The class possibility $\omega_{0,1}(t)$ is computed from the histograms.

$$\omega_0(t) = \sum_{i=0}^{t-1} p(i) \quad (4)$$

$$\omega_1(t) = \sum_{i=t}^{L-1} p(i) \quad (5)$$

2. 2. 4 Separating overlapping cells using watershed segmentation process

In order to separate a joint blast on the image, watershed segmentation is used. The contours are calculated correspond to the blast to the catchment basins and watershed lines by them. The gradient makeover of the original image often suits this condition. The morphological gradient based on 3x3 square structuring element of the initial grey-level image is defined as the difference between the dilation and the erosion of the grey value image [14]. The detail descriptions of this method can be found in [15].

2.3 Segmentation performance for the proposed method

Segmentation performance acts as a bench mark for the competency of the proposed method. It can be classified based on accuracy, specificity and sensitivity of the segmented region. The quality of the segmented image is performed based on similarity of pixels by comparing the results of segmented image against the manual segmented image. Accuracy, specificity and sensitivity [16] are obtained based on the following equations:

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \times 100 \quad (6)$$

$$Specificity = \frac{TN}{TN + FP} \times 100 \quad (7)$$

$$Sensitivity = \frac{TP}{TP + FN} \times 100 \quad (8)$$

Accuracy is the percentage of pixels that is correctly classified to the entire area of the cell. Sensitivity is a true positive measure in which refers to the amount of images that contain a cancerous

masses which have been classified correctly. Specificity is a true negative measure that refers to the proportion of images containing a cancerous masses that have been incorrectly classified. TP is for true positive, TN is for true negative, FP is for false positive and FN is for false negative [16].

3. Results and Discussions

In this research, the proposed segmentation procedures for both acute and chronic leukaemia images have been tested on 50 images of ALL, AML, CLL and CML. The results of pre-processing process are shown in figure 1. Starting with original image for each class which states by images (a)-(d), the brightness level and contrast level of blast are increased through LCS process as shown in images (e)-(h). LCS is reflected to each range of RGB colour space that appears in the image. The range of each colour space is used for contrast stretching process to represent each range of colour and set the minimum and maximum values of each colour space.

Hue component covers most of the information of blast cell. After the hue component has been applied on LCS image, the blast appeared as a brighter part and the unwanted region appeared as a darker part and almost similar with the background image. As a result, the blast can easily be seen after applying hue component as presented in images (i)-(l). Based on the observation, the shapes of the blast in AML images are almost unchanged which may enhance in next segmentation process. Meanwhile, the hue component is only able to highlight the nucleus area of the blast in ALL, CLL and CML images, which results on the missing cytoplasm area of the blast.

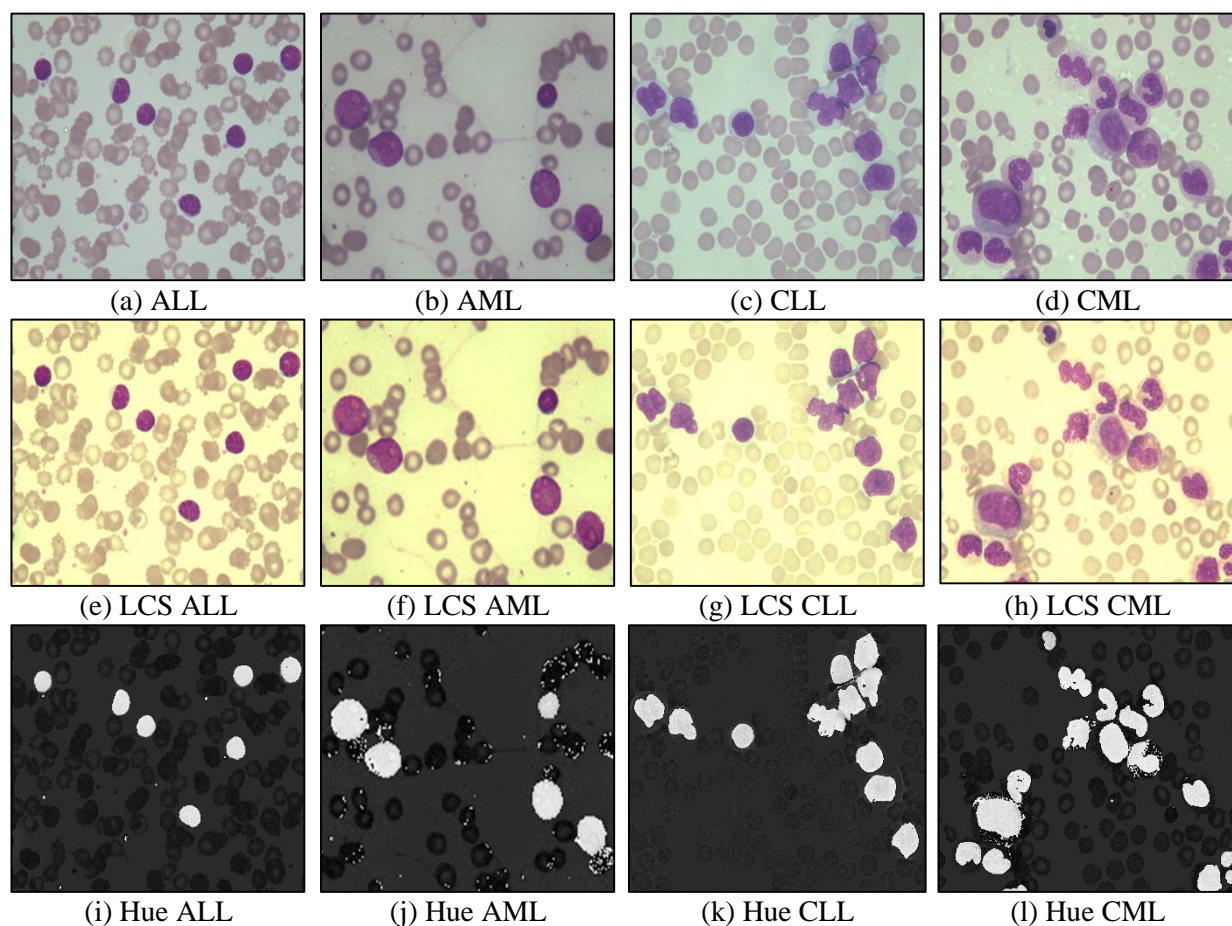


Figure 1. Original images and results of images after the pre-processing process.

Later, the blast images have been segmented using Otsu's thresholding technique. By using Otsu's thresholding technique, the blasts have been segmented from the RBCs and background regions which results on the form of binary image as shown in figure 2. From these images, the desired segmented

objects are represented by white colour, while the rest has been represented by black. The unwanted regions are still appeared on the segmented image but in the forms of small pixels region. Therefore, image filtering and object remover have been applied to smoothen the image and to remove the unwanted regions from the images. Finally, the targeted images have been segmented through watershed process, in order to separate the touching cells. The final segmented images obtained after separating the touching cells are presented in figure 3. Qualitatively, the proposed segmentation approach has successfully produced fully segmented blasts for AML images. However, this approaches only suitable for segmenting the nucleus in ALL, CLL and CML images.

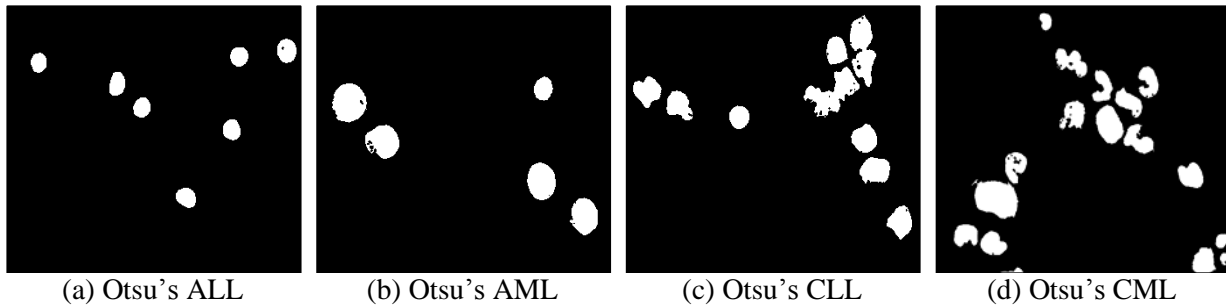


Figure 2. Results of segmentation using Otsu's thresholding on hue images.

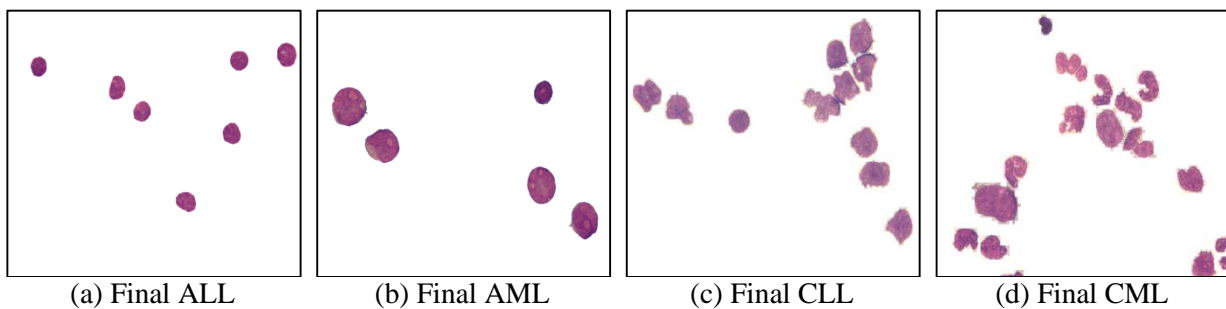


Figure 3. The final segmented images after separation of touching cells using watershed.

Table 1. Leukaemia segmentation performance.

Class of Leukaemia	Accuracy	Sensitivity	Specificity
ALL	99.54%	78.60%	98.63%
AML	99.37%	83.55%	100%
CLL	98.98%	81.40%	99.99%
CML	97.71%	85.00%	99.33%
Total 200 images	98.90%	82.14%	99.49%

Segmentation performance is obtained from the comparison result of segmented image with manual segmented image. The results of segmentation performance based on accuracy, sensitivity and specificity percentage is tabulated in table 1. The results show that the proposed segmentation approach gave a satisfied result with the highest value on specificity with 99.49%, followed by accuracy of 98.90% and sensitivity of 82.14%.

4. Conclusion

The results show accomplishment in improvising segmentation technique for leukaemia images through the segmentation performance. Linear contrast enhancement and hue colour component are able to highlight the targeted image. Meanwhile, each class of leukaemia cell is able to fully segment and separated by using Otsu's thresholding technique combined with watershed segmentation. Overall, the proposed segmentation procedure has produced segmentation performance with average accuracy, sensitivity and specificity obtained of 98.90%, 82.14% and 99.49%, respectively. The

percentage results of segmentation performance achieved concluded that proposed segmentation procedure is applicable for segmentation both acute and chronic leukaemia images.

References

- [1] Abdul Nasir A S, Mashor M Y and Rosline H 2011 Detection of acute leukaemia cells using variety of features and neural networks *The 5th Kuala Lumpur International Conference on Biomedical Engineering (BioMed 2011)*
- [2] Chung J, Ou X, Kulkarni R P and Yang C 2015 Counting white blood cells from a blood smear using fourier ptychographic microscopy *PloS One* **10**
- [3] Meera V and Mathew S A 2014 Fuzzy Local Information C Means Clustering For Acute Myelogenous Leukaemia Image Segmentation *Proceeding of the International Conference on Innovation and Advances in Science Engineering and Technology*
- [4] Chen Q, Yang X and Petriu E M 2004 Watershed Segmentation for Binary Images with Different Distance Transforms *Proceedings of the 3rd IEEE International Workshop on Haptic, Audio and Visual Environments and Their Applications*
- [5] Mohammed E A, Mohamed M M A, Naugler C and Far B H 2013 Chronic lymphocytic leukaemia cell segmentation from microscopic blood images using watershed algorithm and optimal thresholding *2013 26th Annual IEEE Canadian Conference on Electrical and Computer Engineering (CCECE)*
- [6] Joshi M D, Karode A H and Suralkar S R 2013 White Blood Cells Segmentation and Classification to Detect Acute Leukaemia *International Journal of Emerging Trends & Technology in Computer Science (IJETTCS)* **2**
- [7] Prasad A S, Latha K S and Rao S K 2013 Separation and counting of blood cells using geometrical features and distance transformed watershed *International Journal of Engineering and Innovative Technology (IJEIT)* **3**
- [8] Halim N H A, Mashor M Y, Nasir A S A and Hassan R 2018 The Effectiveness of Colour Constancy on Segmenting Leukemia Cells Using Unsupervised Clustering Technique *Journal of Physics: Conference Series* **1019**
- [9] Rodellar J, Alf  rez S, Acevedo A, Molina A and Merino A 2018 Image processing and machine learning in the morphological analysis of blood cells *International journal of laboratory hematology* **40**
- [10] Abdul-Nasir A S, Mashor M Y and Mohamed Z 2012 Modified global and modified linear contrast stretching algorithms: New colour contrast enhancement techniques for microscopic analysis of malaria slide images *Computational and Mathematical Methods in Medicine*
- [11] Sharma B and Nayyer R 2016 Use and Analysis of Color Models in Image Processing *Journal of Food Processing & Technology*
- [12] Gonzalez R C and Woods R E 2007 *Digital Image Processing* (Pearson)
- [13] Otsu N 1979 A threshold selection method from gray-level histograms *IEEE transactions on systems, man, and cybernetics* **9**
- [14] Malpica N, de Solorzano C O, Vaquero J J, Santos A, Vallcorba I, Garc  a- Sagredo J M and Del Pozo F 1997 Applying watershed algorithms to the segmentation of clustered nuclei *Cytometry* **28**
- [15] Aris T A, Nasir A S A and Mustafa W A 2017 Analysis of Distance Transforms for Watershed Segmentation on Chronic Leukaemia Images *Journal of Telecommunication, Electronic and Computer Engineering* **10**
- [16] Kourou K, Exarchos T P, Exarchos K P, Karamouzis M V and Fotiadis D I 2015 Machine learning applications in cancer prognosis and prediction *Computational and structural biotechnology journal* **13**

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