Image Enhancement for Red Blood Cell Segmentation

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Abstract: A number of issues in blood cell image features such as illuminations, weak edge boundaries and color similarities especially between white blood cell (WBC) cytoplasm and red blood cell (RBC) which affect the accuracy of the segmentation of red blood cell image. This research aims to overcome the issue by applying image enhancement technique. Average filter, image contrast and median filter being proposed in this research. Each of the techniques help to eliminate fairly spread noises, display clear images and diminish single pixel noises. As the result, the quality image is increased and ready for the segmentation process.

Keywords: Blood cell, filter, illumination, noises, quality

1.0 INTRODUCTION

Recently, researchers show a great concern to do segmentation on blood cell images. It can be used for disease diagnosis like the segmentation on Red Blood Cell (RBC) to determine the abnormalities of the blood cell diseases like malaria which becomes the fifth ranking worldwide for the cause of death in the low-income countries. The research in this area is still running in order to search for a robust solution towards the problems in the segmentation process. One of the research have been done by Khoo Boon et al.[1] where nine different techniques for RBC image segmentation which consists of few operators and color transformation techniques. It becomes towards conclusion that none of the methods are good enough for RBC segmentation. R. Adollah et al.[2] said that there is no single technique can be considered suitable to segment the blood cells. It is because the aim of the blood cell segmentation is to make each component of the cells such as cytoplasm, nucleus of WBC, platelet, background and RBC can be perfectly segmented. Cell images possess a complex nature and hard to segment its from background and automatically counted. It is a big challenge to come up with a solution for such of problem.

Even though, blood cell image posses a complicated environment with a varies types of components, researchers still able to classify the component of the image based on several characteristics. R. Adollah et al. observed that the differences in the blood cell component features is in term of texture, color, size and morphology. In segmentation of RBC, these are the issues need to be considered. F. Sadeghian et al.[3] view the segmenting of blood cell is dealing with vary of shape, edge, position and size. S. S. Savkare and S. P. Narote[4] stated that the used of Giemsa stain for blood slides preparation is good in appearance of RBCs colors. In contrast, this technique shows clearly also the parasites, (WBC), platelets, and various artifacts which is make the segmentation process a trivial. G. Diaz and A. Manzanera[5] classified blood cell segmentation into region based and boundary based segmentation as the solution for the complexity appearance of blood cell images.

Fig. 1 Blood cell microscopic images consist of WBCs, RBCs and platelet

This paper will further discuss the solutions toward the related problem in the segmentation process of RBC. Moreover, this research leads to reach the aims by proposing a unique solution to enhance the image to be used for red blood cell (RBC) segmentation. The result has
used in the next process where information is extracted and analysed. From there, any abnormalities can be identified and it can be used as a health indicator.

2.0 MATERIALS AND METHODS

The software used in this research is MATLAB R2009b. There are twenty images with objectives of 40 times being used as the samples for the experiment. The sample is taken through one microscope slide from the blood smear process.

2.2 IMAGE ENHANCEMENT METHOD

A good selection of the segmentation method is important for the next process. E. Montseny et al. [6] said that segmentation process affects the feature extraction and classification process. He also stated that the previous works are mostly direct decision methods which lead to the difficulties for correction process after a wrong decision has been made. As example in clustering process, the region between RBC, WBC and background keep mixing together as their color component are very close. S. Chinwaraphat et al. [7] mentioned that a wrong clustering and scattering causes a similar color pixel between cell and plasma as a background and also causing unclear boundary between them.

That is why a good segmentation process must be organized so that a desired output can be produced. Image enhancement is one of the important and necessary step in image processing. It is implemented in the initial phase where image preprocessing is done. Image preprocessing involve image enhancement of digital image to a better quality of image for a specific application. Then, it will undergo the next process where segmentation take places. It is divided into two categories, spatial domain and frequency domain. Spatial domain is manipulating the pixel values of the image while frequency domain is processing Fourier transform of the image. The techniques involve in spatial domain are histogram processing, contrast and brightness adjustment, linear filter and so on. For frequency domain, it consists of smoothing and sharpening technique like low pass filter, high pass filter, gaussian filter and laplace filter.

Other approach for image enhancement is image restoration. It involves the process of reconstructing and denoising the image. This technique can improve the quality of image representation for the preprocessing image. Hence, a good combination of techniques in preprocessing image is important in representing the image for a better quality. In addition, it also helps in achieving higher accuracy percentage for segmentation technique.

In short, there are many techniques used for image enhancement including noise minimization and feature enhancement. Filtering often used to reduce the noises and enhancement process can be categorized into three groups which is tonal, spatial and domain methods. In this research, filter and enhancement process are being used to minimize the noises and increase the quality of image. The filters have average and median filter while contrast and brightness used for enhancement of image.

3.0 RESULTS

Average filter used in the beginning of the process is to filter a random noise in the image. It will be based on the equation 1.0 to filter M X N image with filter size of m x n.

\[ g(x,y) = \frac{\sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t)f(x+s,y+t)}{\sum_{s=-a}^{a} \sum_{t=-b}^{b} w(s,t)} \]  

Equation 1 Average filter formula where \( x = 0,1,2,...,M-1 \) and \( y = 0,1,2,...,N-1 \) and also \( a = (m-1)/2 \) and \( b = (n-1)/2 \).

In this step, 3x3 average filter has been used as the smallest mask and it can filter any random noise in small area. The filtering process makes the image getting blur and less detailed. This will diminished unimportant detail from the image. Next process, image contrast is being adjusted until it give a clear view of the cell from the background. Flowchart of the process is presented in the Fig. 2. Fig. 3 shows the result of the preprocessing step before color conversion step and Fig. 4 shows result for enhancement step after color conversion.

![Fig. 2 Flowchart of image preprocessing step](image-url)
DISCUSSION

The result shows the change of image appearance cannot be clearly observed. However, the result can give a different value if it being used in the next process. Additionally, the selection of the technique also is based on matching of the problems exist in the image. Moreover, it depends on the capability of the technique. Thus, in this section few problems related to the appearance of blood cell image are thoroughly discussed to give a clear reason for the proposed technique.

For color image, the selection of color space is critical to cluster. F. Sadeghian et al identified that close scales of color between the particle of cells will lead to a major error during thresholding method. This problem applies to region growing, morphological method and thresholding. Each of the techniques have weakness against the environments of the blood cell such as non-homogeneity of cells’ color, and inapplicable for multiple cases. G. Diaz and A. Manzanera analyzed region based segmentation including Thresholding, Region Growing and Watershed. Thresholding and Clustering function as Automatic Thresholding have problem in identifying border between plasma, cytoplasm and earlier stage of parasites. For Region Growing, it have problems to make a good criterion to synchronize a neighbour pixel and the seed. Plus, hard to find the suitable seed. Steven S.S. Poon et al have identified that the segmentation of blood cell is exposed to errors in segmenting RBC from cytoplasm region of WBC due to a close colour similarity between them in the complex nature of blood cells environment. As a solution, he proposed to examine boundary point and do a pixel adjustment. However, the errors keep occur in the process of differentiating a color pixel in RGB color spaces for color segmentation.

This is also may related to defocused image of the blood cell as stated by Steven S.S. Poon et al. where to define the boundary between cell might be difficult especially for nucleus and cytoplasm region if the transition of intensity levels is unclear. Moreover, there will be mistake in cytoplasm segmentation if that region covered by the background. R. Adollah et al. mentioned that for segmentation, edge detection is unsuccesful to get the information and determine the location of the cells due to the weak boundaries of certain component in the blood cells. F. Sadeghian et al. said that the problems exist in the lost of protuberances pale tips and weak edge between the cell and background. He listed some techniques to overcome the problems like new edge operator and shape analysis but each of them has problem in dealing with blood cell image which has weak boundary and non-circle cells’ shape structure. This is also supported by G. Diaz and A. Manzanera in analyzing the use of boundary based segmentation. It is basically dealing with great problems as boundaries between cells are not clear and edge detection work bad for blood cell image. The other technique like Active Countours is good in cells cluster segmentation. However, it posses a high computational cost and resulting contours fail to respond over cells borders.

Another issue is the uncertainty images come from staining and illuminating inconsistencies which make the task more challenging. For segmentation, the application of
each method shows that a robust segmentation method can be evaluated by validating the accurateness and effectiveness of computational time for segmenting several types of blood cells from different human blood cell background and classifying it into different classes. It is in order to obtain the best result for human blood cell segmentation and cell counting. E. Montseny et al. said that microscopic images of blood cell contains uncertainties from varies levels of cell maturity to be identifies, inconsistence illuminations, shadows and stains. R. Adollah et al. also said that image uncertainty comes from inconsistencies condition of staining and illumination. It makes blood cell image segmentation difficult and challenging task. Su M.-j. Et al. mentioned that “Cell images’ own complex nature (unevenly illuminated and low contrast), it is very difficult to segment cells from the background and count them automatically.” In certain images, they contain small noncell objects in the background which cannot be subtracted by a normal denoise technique and it effect cell counting. The statement is supported by G. Diaz and A. Manzanera which said that environment illumination conditions, dye durations, thickness films, or defects result in visual artifacts, non uniform background, or different image luminance and color distribution in digitized images. There are two major solutions to the problems which is noise reduction by using filtering and feature enhancement by using tonal and spectral domain.

Steven S.S. Poon et al. stated that to make contrast and illumination in equilibrium point, it needs a good process of image acquisition. Although random noise can be minimized, fixed pattern noise is still exist and must be fixed. Basically there are three main sources of fixed pattern noise which is detector elements unequal sensitivity, systematic errors in camera control circuitry and shading and aberration effects resulted from optic. To overcome this, optical densities decalibration and background subtraction are being used. One of the approach is involving bright image subtracted from the test image and an offset which have same value with bright image average value is added to produce a bright background image that have equal grey level value for all pixels. However, maximum 10 percent errors may exist from calculation of similar features and optical density which affected by absolute intensities multiplication or division.

Saravana Kumar Kumarasamy et al. stated that low contrast, poorly illuminated, unfocussed images and overlapped RBCs make a fully automated system for blood cell analysis development remains complicated. Detecting RBCs and parasites using histogram based thresholding method is highly depend on quality of image and require distinct valleys to succes. To separate RBCs from background using Zack’s histogram thresholding algorithm is not robust if histogram profiles is in wide range to characterize the digitized images. More robust segmentation is resulted from the level set approach which detecting objects in low contrast and noisy biomedical images. Unfortunately, it is computationally intensive and have poor convergence problem. In cell clumping condition, Morphological methods fail to get closed contour in overcome constituent cells contours result from poor and vary image contrast. The lack of robustness continue to be an issue in detecting parasites within the RBCs. It is still a problem to differentiate the blue and the green channels for Giemsa stained nucleated due to variations in image contrast.

False negative and false positive may be resulted if a wrong indication is being made. False negative is the situation where the undetected important part of cell is ignored while false positive is where a detected ignored cell like Debris is being interpret as abnormal condition. Most major segmentation errors were due to cells with irregularly shaped nucleus and cells with typical cytoplasm colour which are characteristics of some types of normal cells in the bone marrow. Most debris have approximately equal intensity in all three colour images and hence were easily eliminated by the subtraction of the blue image from the red. However, this process does not remove many regions in the image which belong to parts of red blood cells, platelets, and other debris. These were generally very small and were thus eliminated by the erosion process and the size criterion imposed on each isolated object. These include overlapping nucleated cells or cells which were so close together that even a human observer would have difficulty in segmentation.

As a solution, average filter which is a linear spatial domain filter and function in decreasing fairly all the noises spreading in the sample image. It is using a defined filter mask to average grey level pixel in the neighbourhood. This will lead to reduce sharp transition and cause blurring process. The blurring process help to represent image with less irrelevant detail which might come from the random noise. Contrast and brightness adjustment used in the next process to give a clear view of the color representation image. The used of median filter is to filter any noise without require any blurring process. This will further enhance the appearance of the image. For median filter, it is a nonlinear spatial filter which changing the value of the gray value at the center pixel with median value of the gray value of the pixel group. This help to diminish spikes and single pixel noises without blurring process.

5.0 CONCLUSION

As conclusion, close color similarity, weak edge boundary, quality image, contrast, illuminance and noise are the usual issues occur in image processing area. In the microscopic image, noises and quality of image will depend on the way of sample being handled like staining solution used until handling microscope. As solution,
image enhancement has been used starting from filtering, contrast bright adjustment and histogram. This research is hoped to be a fundamental step to create a novel RBC analysis like counting application, disease identification and health indicator. For this reason, further study must be done towards the issue to build a strong analysis approach in the medical diagnosis area especially in hematology. In addition, it is hoped that a mixing method will help to improve the current method to be more capable, robust and effective. Moreover, an automated segmentation can be applied to give a better support for the future research. This research will be initiated move towards the development of the automated analytic for the blood cell.

REFERENCES


